I

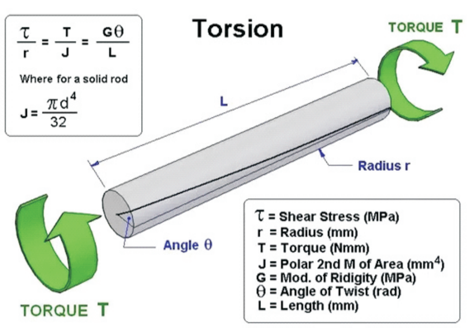
Name

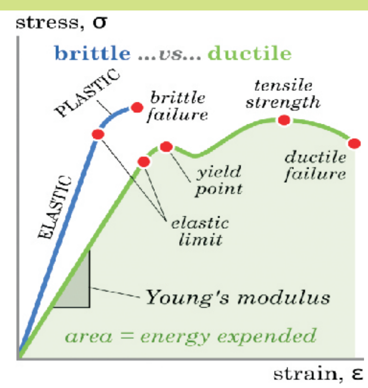
Roll No. Year 20 20

Exam Seat No.

CIVIL GROUP | SEMESTER - III | DIPLOMA IN ENGINEERING AND TECHNOLOGY

# A LABORATORY MANUAL FOR STRENGTH OF MATERIALS (22306)





MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI

(Autonomous) (ISO 9001 : 2015) (ISO / IEC 27001 : 2013)

## VISION

To ensure that the Diploma level Technical Education constantly matches the latest requirements of technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

## MISSION

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the changing technological and environmental challenges.

## QUALITY POLICY

We, at MSBTE are committed to offer the best in class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation, evaluation and monitoring system along with adequate faculty development programmes.

## CORE VALUES

MSBTE believes in the followings:

- Education industry produces live products.
- Market requirements do not wait for curriculum changes.
- Question paper is the reflector of academic standards of educational organization.
- Well designed curriculum needs effective implementation too.
- Competency based curriculum is the backbone of need based program.
- Technical skills do need support of life skills.
- Best teachers are the national assets.
- Effective teaching learning process is impossible without learning resources.

A Laboratory Manual

for

# Strength of Materials

# (22306)

## Semester-III

**(ME/AE/PT/PG)**

**Maharashtra State**

**Board of Technical Education, Mumbai**

**(Autonomous) (ISO:9001:2015) (ISO/IEC 27001:2013)**

Maharashtra State Board of Technical Education,
(Autonomous) (ISO:9001:2015) (ISO/IEC 27001 : 2013)
4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra ( East ), Mumbai - 400051.
(Printed on June, 2018 )

# MAHARASHTRA STATE

# BOARD OF TECHNICAL EDUCATION

## Certificate

This is to certify that Mr. / Ms. ……………………………………..……… Roll No. ……………….…., of Third Semester of Diploma in ……………………..…………………………………………… of Institute, ……………..……………………..………………………………………..… (Code: …………...) has completed the term work satisfactorily in course **Strength of Materials (22306)** for the academic year 20…….. to 20…….. as prescribed in the curriculum.

Place: …………… Enrollment No:.……………

Date: …………… Exam. Seat No: ……………

**Subject Teacher** **Head of the Department** **Principal**

Seal of Institution

# Preface

The primary focus of any engineering laboratory/ field work in the technical education system is to develop the much needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'I' Scheme curricula for engineering diploma programmes with outcome-base education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher; instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a ***'vehicle'*** to develop this industry identified competency in every student. The practical skills are difficult to develop through 'chalk and duster' activity in the classroom situation. Accordingly, the 'I' scheme laboratory manual development team designed the practicals to ***focus*** on the ***outcomes***, rather than the traditional age old practice of conducting practicals to 'verify the theory' (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

**Rationale**

Strength of Material is a core technology subject which aims at enabling the student to understand and analyze various types of loads, stresses and strains along with main causes of change in physical properties and failure of machine parts. All Mechanical Engineering components are subjected to different loadings and behave in a specific way. The subject is pre-requisite for understanding principles of machine design and strengths of various materials used in industries. Understanding mechanical properties of materials will help in selecting the suitable materials for various engineering applications.

Although best possible care has been taken to check for errors (if any) in this laboratory manual, perfection may elude us as this is the first edition of this manual. Any errors and suggestions for improvement are solicited and highly welcome.

## Programme Outcomes (POs) to be achieved through Practical of this Course:-

Following POs and PSO are expected to be achieved through the practicals of the Strength of Materials course.

**PO 1. Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Mechanical engineering problems.

**PO 2. Discipline knowledge**: Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

**PO 3. Experiments and practice**: Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.

**PO 4. Engineering tools**: Apply relevant Mechanical technologies and tools with an understanding of the limitations.

**PO 5. The engineer and society**: Assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to practice in field of Mechanical engineering.

**PO 6. Environment and sustainability**: Apply Mechanical engineering solutions also for sustainable development practices in societal and environmental contexts.

**PO 7. Ethics**: Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Mechanical engineering.

**PO 8. Individual and team work**: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

**PO 9. Communication**: Communicate effectively in oral and written form.

**PO 10. Life-long learning**: Engage in independent and life-long learning activities in the context of technological changes also in the Mechanical engineering and allied industry.

### Program Specific Outcomes (PSOs):-

**PSO 1. Modern Software Usage**: Use latest Mechanical engineering related softwares for simple design, drafting, manufacturing, maintenance and documentation of mechanical engineering components and processes.

**PSO 2. Equipment and Instruments:** Maintain equipment and instruments related to Mechanical Engineering.

**PSO 3. Mechanical Engineering Processes**: Manage Mechanical engineering processes by selecting and scheduling relevant equipment, substrates, quality control techniques, and operational parameters.

************

# List of Industry Relevant Skills

The following industry relevant skills of the competency ‘Estimate stresses in structural members and mechanical properties of materials.’ are expected to be developed in you by undertaking the practicals of this practical manual.

1. Selection of suitable material for the given loading.
2. Handling of instruments
3. Interpretation of result.
4. Setting up the instruments

# Practical- Course Outcome matrix-

**Course Outcomes (COs)**

a. Compute Moment of Inertia of symmetric and asymmetric structural sections.
b. Estimate simple stresses in machine components.
c. Perform test to evaluate mechanical properties according to Indian Standards.
d. Compute shear force and bending moment and corresponding shear and bending stresses in beams subjected to point and uniformly distributed load.
e. Estimate stresses in shafts under twisting moments.
f. Estimate stresses in short member subjected to eccentric loading.

| S. No. | Practical Outcome | CO a. | CO b. | CO c. | CO d. | CO e. | CO f. |
|---|---|---|---|---|---|---|---|
| 1. | Determine yield stress, ultimate stress and breaking stress of Mild Steel by conducting Tension test (Part I) as per IS432 (I) | - | √ | √ | - | - | - |
| 2. | Determine yield stress, ultimate stress and breaking stress of Mild Steel by conducting Tension test (Part II) as per IS432 (I) | - | √ | √ | - | - | - |
| 3. | Plot stress-strain diagram for Aluminium by conducting Tension test (Part I) as per IS 1608 | - | √ | √ | - | - | - |
| 4. | Plot stress-strain diagram for Aluminium by conducting Tension test (Part II) as per IS 1608 | - | √ | √ | - | - | - |
| 5. | Calculate compressive strength of Ductile such as Mild Steel (MS), Aluminium (Al), Brass (Br), Copper (Cu), using Compression testing machine as per IS 14858 | - | √ | √ | - | - | - |
| 6. | Calculate compressive strength of Brittle materials such as Cast Iron (CI), High Carbon steel using Compression testing machine as per IS 14858 | - | √ | √ | - | - | - |
| 7. | Determine shear strength of various metals such as MS, Al, Br and Cu, (Any two metals) by Single Shear test as per IS 5242 | - | √ | √ | - | - | - |
| 8. | Determine shear strength of various metals such as MS, Al, Br and Cu, (Any two metals) by Double Shear test as per IS 5242 | - | √ | √ | - | - | - |
| 9. | Evaluate toughness of Ductile and Brittle materials such as MS, Al, Br and Cu, by conducting Izod Impact test as per IS 1757 | - | √ | √ | - | - | - |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 10. | Determine energy absorption capacity of Ductile and Brittle materials such as MS, Al, Br and Cu, by conducting Charpy Impact test as per IS 1598 | - | √ | √ | - | - | - |
| 11. | Draw Shear force and Bending moment diagrams of given loading using open source SF/BM simulation software. | - | - | - | √ | - | - |
| 12. | Find flexural strength by conducting Bending Test on timber beam of Rectangular cross section with shorter side horizontally oriented as per IS 1708, IS 2408 | √ | - | √ | √ | - | - |
| 13. | Find flexural strength by conducting Bending Test on timber beam of Rectangular cross section with shorter side vertically oriented as per IS 1708, IS 2408 | √ | - | √ | √ | - | - |
| 14. | Determine modulus of rigidity by conducting Torsion Test on MS (Part I) as per IS 1717 | √ | - | √ | - | √ | - |
| 15. | Determine modulus of rigidity by conducting Torsion Test on MS (Part II) as per IS 1717 | √ | - | √ | - | √ | - |
| 16. | Determination of Direct stress, Bending strum and Resultant Stresses for a given practical approach. | √ | √ | - | - | - | √ |

## Guidelines to Teachers

1. Teacher need to ensure that a dated log book for the whole semester, apart from the laboratory manual is maintained by every student which s/he has to submit for assessment to the teacher in the next practical session.
2. There will be two sheets of blank pages after every practical for the student to report other matters (if any), which is not mentioned in the printed practicals.
3. For difficult practicals if required, teacher could provide the demonstration of the practical emphasizing of the skills which the student should achieve.
4. Teachers should give opportunity to students for hands-on after the demonstration.
5. Assess the skill achievement of the students and COs of each unit.
6. One or two questions ought to be added in each practical for different batches. For this teachers can maintain various practical related question bank for each course.
7. If some repetitive information like data sheet, use of software tools etc. has to be provided for effective attainment of practical outcomes, they can be incorporated in Appendix.
8. For effective implementation and attainment of practical outcomes, teacher ought to ensure that in the beginning itself of each practical, students must read through the complete write-up of that practical sheet.
9. During practical, ensure that each student gets chance and takes active part in taking observations/ readings and performing practical.
10. Teacher ought to assess the performance of students continuously according to the MSBTE guidelines

## Instructions for Students

1. For incidental writing on the day of each practical session every student should maintain a dated log book for the whole semester, apart from this laboratory manual which s/he has to submit for assessment to the teacher in the next practical session.
2. For effective implementation and attainment of practical outcomes, in the beginning it self of each practical, students need to read through the complete write-up including the practical related questions and assessment scheme of that practical sheet.
3. Student ought to refer the data books, IS codes, Safety norms, Electricity act/rules, technical manuals, etc.
4. Student should not hesitate to ask any difficulties they face during the conduct of practicals.

# Content Page

List of Practicals and Progressive Assessment Sheet



| S. No | Practical Outcome | Page No. | Date of performance | Date of submission | Assessment marks (25) | Dated sign. of teacher | Remarks (if any) |
|---|---|---|---|---|---|---|---|
| 1. | Determine yield stress, ultimate stress and breaking stress of Mild Steel by conducting Tension test (Part I) as per IS432 (I) | 1 | | | | | |
| 2. | Determine yield stress, ultimate stress and breaking stress of Mild Steel by conducting Tension test (Part II) as per IS432 (I) | 1 | | | | | |
| 3. | Plot stress-strain diagram for Aluminium by conducting Tension test (Part I) as per IS 1608 | 16 | | | | | |
| 4. | Plot stress-strain diagram for Aluminium by conducting Tension test (Part II) as per IS 1608 | 16 | | | | | |
| 5. | Calculate compressive strength of Ductile such as Mild Steel (MS), Aluminium (Al), Brass (Br), Copper (Cu), using Compression testing machine as per IS 14858 | 28 | | | | | |
| 6. | Calculate compressive strength of Brittle materials such as Cast Iron (CI), High Carbon steel using Compression testing machine as per IS 14858 | 36 | | | | | |
| 7. | Determine shear strength of various metals such as MS, Al, Br and Cu, (Any two metals) by Single Shear test as per IS 5242 | 45 | | | | | |
| 8. | Determine shear strength of various metals such as MS, Al, Br and Cu, (Any two metals) by Double Shear test as per IS 5242 | 52 | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 9. | Evaluate toughness of Ductile and Brittle materials such as MS, Al, Br and Cu, by conducting Izod Impact test on as per IS1757 | 59 | | | | | |
| 10. | Determine energy absorption capacity of Ductile and Brittle materials such as MS, Al, Br and Cu, by conducting Charpy Impact test as per IS 1598 | 64 | | | | | |
| 11. | Draw Shear force and Bending moment diagrams of given loading using open source SF/BM simulation software. | 70 | | | | | |
| 12. | Find flexural strength by conducting Bending Test on timber beam of Rectangular cross section with shorter side horizontally oriented as per IS 1708, IS 2408 | 77 | | | | | |
| 13. | Find flexural strength by conducting Bending Test on timber beam of Rectangular cross section with shorter side vertically oriented as per IS 1708, IS 2408 | 77 | | | | | |
| 14. | Determine modulus of rigidity by conducting Torsion Test on MS (Part I) as per IS 1717 | 87 | | | | | |
| 15. | Determine modulus of rigidity by conducting Torsion Test on MS (Part II) as per IS 1717 | 87 | | | | | |
| 16. | Determination of Direct stress, Bending stress and Resultant Stresses for a given practical approach. | 98 | | | | | |
| **Total** | | | | | | | |

***Note: To be transferred to Proforma of CIAAN-2017.***

# Practical No.1 & 2: Tension test of ductile materials

## I Practical Significance:

Selection of a material or item for an application depends on its mechanical properties such as ultimate tensile strength, modulus of Elasticity, percentage of elongation, performance of material under uniaxial tensile loading. The test enables to find out the properties. The data thus available can be provided for other scientific, engineering, and quality assurance functions and also the comparison of several options can be made.

## II Relevant Program Outcomes (POs):

PO1 - ***Basic knowledge:*** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems.

PO3 - ***Experiments and practice:*** Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems.

PO 4- **Engineering tools:** Apply relevant Mechanical technologies and tools with an understanding of the limitations.

PO 7- **Ethics:** Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Mechanical engineering.

PO 8- **Individual and team work:** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PO 9- **Communication:** Communicate effectively in oral and written form.

## III Competency and Skills:

This practical is expected to develop the following skills for the industry identified competency

"Estimate stresses in structural members and mechanical properties of materials."

1. Selection of suitable material for the given loading.
2. Handling of instruments
3. Interpretation of result.
4. Setting up the instruments

## IV Relevant Course Outcome(s):

- Perform test to evaluate mechanical properties according to Indian Standards.
- Estimate simple stresses in machine components

## V Practical Outcome:

Determine yield stress, ultimate stress and breaking stress of Mild Steel by conducting Tension test as per IS432 (I)

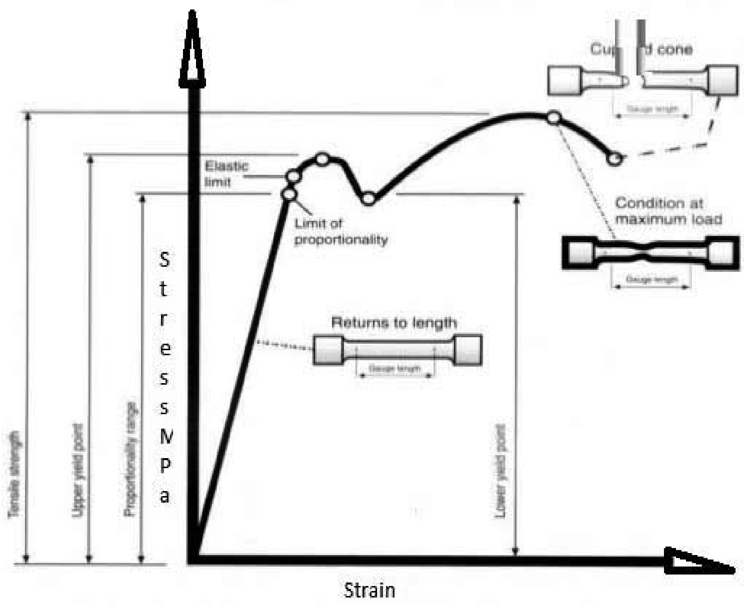
**VI Relevant Affective domain unrelated outcomes:**

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices

**VII Minimum Theoretical Background:**

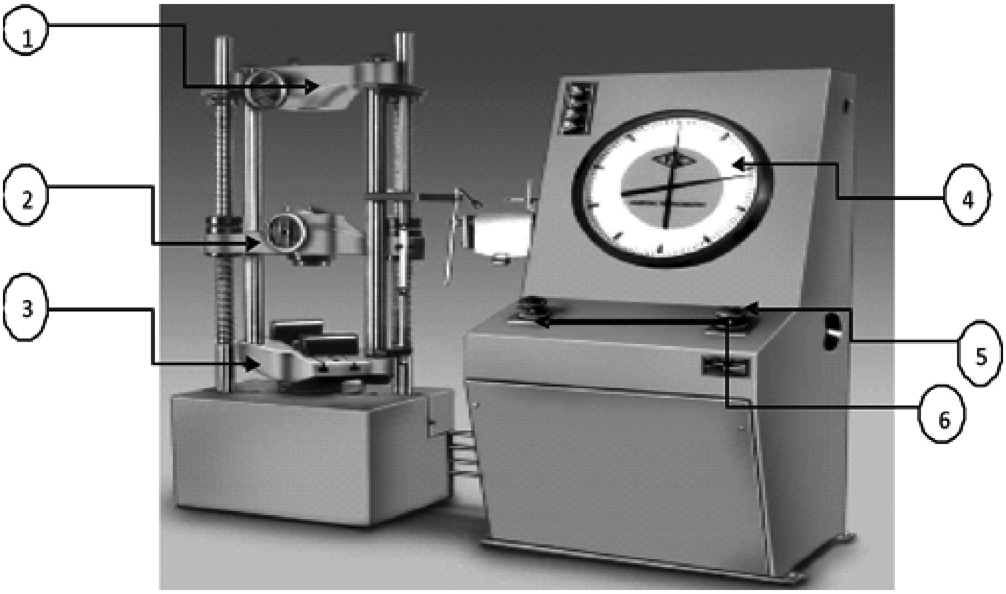
1. **Stress**: When a material is subjected to external loading, then the internal resistance per unit cross section, set up in the material to deformation is called as stress.
2. **Ultimate tensile strength** of a material is maximum load carrying capacity of the material per unit cross sectional area, in tension.
3. **Tensile strain ( $\epsilon$ )** = Elongation in length / Original length.
4. **Robert Hook's law**: Within elastic limit, stress is directly proportional to strain.
5. **Modulus of Elasticity** : The ratio of stress to strain within elastic limit of a material is called as Modulus of Elasticity.
6. **Percentage of elongation** : The percentage change in gauge length with reference to the original gauge length is called as Percentage of elongation.
7. **The gauge length** for tension test specimen shall be 5.65 x $A_0$ where $A_0$ is the cross- sectional area. For round bar gauge length is 30-40 times the nominal diameter of bar.

**VIII Block diagram / Setup:**




Graph similar to that for a low carbon steel, that has a definite yield point

**Stress -Strain Graph for mild steel specimen**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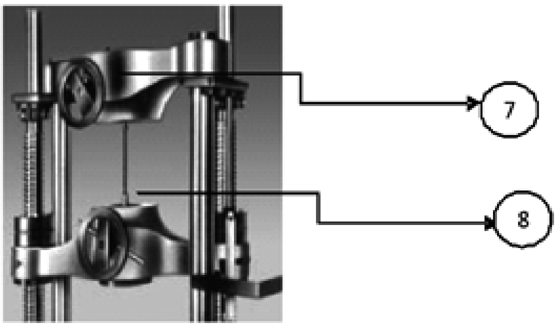
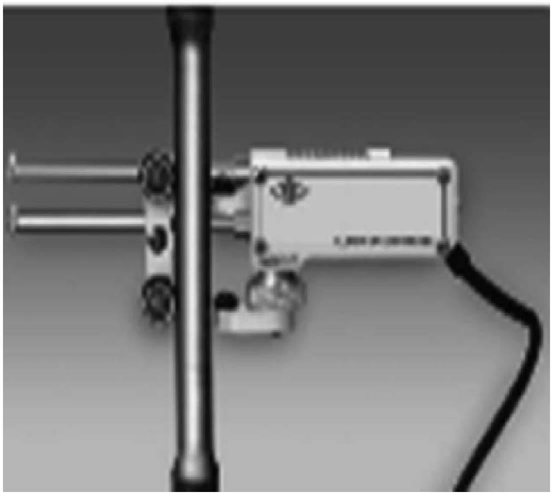
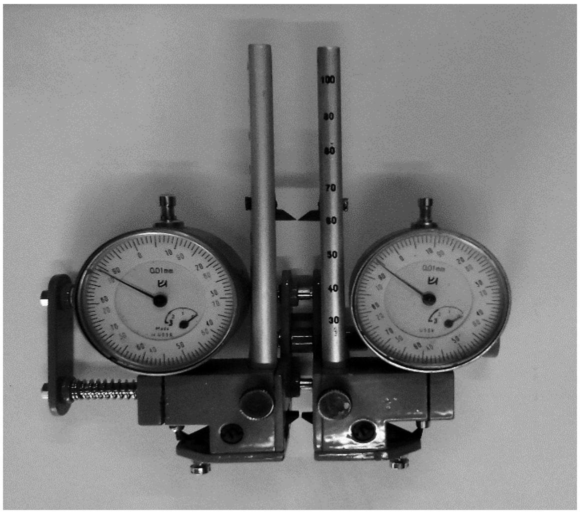


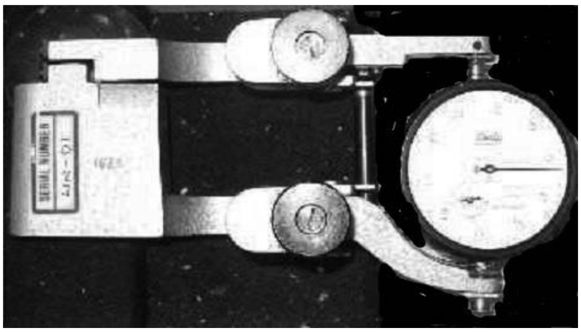

Arrangement for tension test



**Electronic Extensometer**



**Mechanical Extensometer**



**Lindlay's Extensometer**

## IX Resources Required:

| S. No. | Name of Resource | Suggested Broad Specification | Quantity |
|---|---|---|---|
| 1 | **Universal Testing Machine** | **Universal Testing Machine:** Capacity – 40 or 100 tonnes. Type: Mechanical type digital, electrically Operated. Accessories: (1) Tensile test attachment for flat and round specimen up to32 mm. | 1 No. |
| 2 | **Digital Extensometer OR Mechanical Extensometer** | **Digital Extensometer:** Least count - 0.001 mm. Max. Extension = 5 mm. Single /double dial gauge for 30,40 mm. 60 mm, 80 mm, 100 mm, 125 mm gauge length. | 1 No. |
| 3 | **Vernier caliper** | Least count of 0.02 mm and measuring range of 0.02 mm to 150mm. | 1 No. |
| 4 | **Mild Steel Specimen** | Perfect straight bar of mild steel of uniform 10 mm diameter. Length of rod shall be around 40 times diameter The length shall be sufficient enough to fix bar in the grips plus clear space between cross heads. | 1 No. |
| 5 | **Punch & hammer** | Tip hardened punch to mark gauge length on the specimen. | 1 No. |

## X Precautions to be Followed:

1. Avoid over accelerating of UTM and maintain proper rate of loading.
2. Place the sample exactly at the center of grips of cross heads in case of flat grips
3. The Zero of dial gauge for elongation should match with the zero of load display to have the Stress - Strain graph starting from origin.
4. The extensometer from sample should be removed well before ultimate point is reached. Or otherwise the extensometer may be damaged.
5. At the time of operation keep safe distance from the machine or use caging.
6. The actual extension on the specimen is taken as half of L.C x Extensometer Division for Lindlay's Extensometer as per the manufracture's instruction.(The specimen is fixed at x distance and the dial gauge is at 2x distance from the hinge of the Extensometer )

## XI Procedure:

**(Part 1):**

1. Ensure that the release valve and the control valve mounted on control unit are closed.
2. Put the electric switches on. Move the middle crosshead of loading unit up or down with the help of UP /DN press- button on the control unit. Thus, the space

between upper crosshead and middle crosshead decreases or increases to cope up with the length of the specimen.

3. Press button- switch of the motor of hydraulic oil on the control unit .Open the control valve slowly. Observe the upward movement of upper and lower crosshead together. The middle crosshead will remain stationary. The rate of movement of moving crossheads can be controlled by control valve.
4. As soon as the control valve is opened observe the changes on load dial / display along with displacement dial/display. The readings will increase till the dead weight of lower cross head is lifted. The readings for displacement will go on increasing. Now make the load reading zero with the help of tare switch. Shut down the machine.
5. Take the mild steel specimen, measure the diameter at three different places. Record the average diameter. Also measure the overall length of specimen. Calculate the gauge length according to diameter of the specimen. For strain calculation the gauge length shall be used as initial length.
6. Mark the gauge points over the grip length, with the punch such that the distance between two consecutive points is half the gauge length. If Lindlay's Extensometer is used then the gauge length is 50 mm.
7. The gauge points shall be sufficiently deep so that they would not vanish after the elongation.
8. Select the proper extensometer from available extensometers. Note the least count of the dial gauge. In the case of extensometer with double dial gauge, the two stems of extensometer used for fixing the bar should be of appropriate length according to the gauge length of the specimen. The pivots on the stems also can be adjusted according to the gauge length of the specimen. If electronic extensometer is used then note the least count on the display window at the control unit.

**(Part 2):**

1. Select a suitable loading range depending on the diameter of specimen. Start the UTM and adjust the dead weight of movable heads and then set the load pointer to zero.
2. Fix the specimen bar between the grips of top and middle cross heads of loading frame.
3. Attach the extensometer on the bar at the central portion of the bar. The distance between upper and lower pivots of extensometer shall be equal to gauge length. Rotate the dial gauge till the Pointer reads zero .
4. Switch on the machine and open the control valve so that the load is increased gradually and at the required rate.
5. Record the loads at suitable interval on the digital display unit or the load dial.
6. Corresponding to loads, note the readings of extensometer.

7. For initial few observations, load and extension are in pace with each other. Record the yield point load by observing the hesitation of load pointer. The extension readings are faster at this moment.
8. Remove the extensometer; and measure extension by divider or suitable scale, till ultimate load.
9. Record the maximum load. Observe the decrease in load and neck formation on the specimen.
10. Record the load at fracture and switch off the machine.
11. Remove the specimen. Observe the cup and cone formation at the fracture point. Rejoin the two pieces, measure the final gauge length and the reduced diameter (for calculation of reduced cross sectional area).
12. Switch off the machine. Close the control valve and open the release valve. Observe the downward movement of the lower and upper cross heads when there is the backward flow of hydraulic oil.
13. Plot the graph of stress v/s strain with suitable scales. (Stress on Y- axis and strain on X-axis) Mark elastic limit, upper yield point, lower yield point, ultimate stress point, nominal breaking stress point, actual breaking stress point on it.
14. Draw another graph of stress within elastic limit on Y-axis v/s corresponding strain on X-axis with suitable scales. Calculate the slope of the graph which is Modulus of Elasticity.
15. Compare the results obtained with the standard values of IS specifications. See annexure.
16. Label the different parts 1to 8 of UTM state the functions of each in the space provided adjacent to figure of UTM

## XII Resources Used :

| S. No. | Name of Resource | Broad Specifications | | Quantity | Remarks (If any) |
|---|---|---|---|---|---|
| | | Make | Details | | |
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## XIII Actual Procedure Followed:

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**XIV Precautions Followed:**

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**XV Observations and Calculations:**

**a) Observations:**

Observations before test:

1. Diameter of bar-
   a) $d_1$ =………..mm, b) $d_2$ =……….. mm, c) $d_3$ =………… mm
2. Average diameter = d = $(d_1+d_2+d_3) / 3$ =……………..mm
3. Gauge length = $L_0$ = 5d = ………………… = …………….mm
4. Least count of extensometer = L. C. = ……………….mm

**Observations during test:**

1. Range of loading = …………………………
2. Load at elastic limit = ………………………... kN
3. Load at upper yield point = ……………………..… kN
4. Load at lower yield point = ……………………..… kN
5. Ultimate load = ……………………….... kN
6. Breaking load = …………………………. kN

**Observation table for tension test:**

| Sr. No. | Load in kN (P) | Extensometer reading in divisions (EMD) | | | Extension (L.C x EMD) (mm) | Stress ($\sigma$ =P/A) ($N/mm^2$) | Strain (Extension) / gauge length) ($\varepsilon$) |
|---|---|---|---|---|---|---|---|
| | | Left reading | Right reading | Average | | | |
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**Observations after test:**

Final gauge length = L………….........mm

Reduced diameter= $d_R$= ..........................mm

**b) Calculations:**

1. Cross sectional area = $A_0 = \pi d^2/4$ = ………….. = ……………….$mm^2$
2. Reduced cross sectional area = A = $\pi d_R^2/4$

   = ………………..= ……………….$mm^2$
3. Yield stress = Yield load / cross sectional area

   = …………………/……………….

   = …………………$N/mm^2$

**4.** Ultimate stress = Ultimate load / cross sectional area

= ……………../ …………….. = …………………. $N/mm^2$

**5.** Breaking stress = Breaking load / cross sectional area

= ………………/… ………….. = ……….……… $N/mm^2$

**6.** Actual breaking stress = Breaking load / reduced cross sectional area

= …………... /…. ………… = ………… $N/mm^2$

**7.** % Elongation $= \left(\frac{L - L_0}{L_0}\right) \times 100$ = **…………..…**

= **…………….. %**

**8.** Reduction in area $= \left(\frac{A_0 - A}{A_0}\right) \times 100$ = **……………..%**

= **……………..%**

**9.** (Within Elastic limit)Stress = **σ** = …………..$N/mm^2$
**10.** Corresponding strain = e = ……………
**11.** Modulus of Elasticity, E = **σ** / e = ................/……...….
= …………….. $N/mm^2$

## XVI Results:

1. Yield stress = ……………….. $N/mm^2$
2. Ultimate tensile stress = ……………….. $N/mm^2$
3. Nominal Breaking stress = ………………. $N/mm^2$
4. Actual breaking stress = ……………… $N/mm^2$
5. % Elongation = ………………..%
6. % reduction in area = ………………..%
7. Modulus of Elasticity, E =………………… $N/mm^2$ (By graph)
8. Modulus of Elasticity, E =………………… $N/mm^2$ (By calculation)

## XVII Interpretation of Results: (Giving meaning to the results)

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**XVIII Conclusions:** (Actions to be taken based on the interpretations)

…………………………………………………………………………………………..
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**XIX Practical Related Questions:**

***Note:*** *Below given are few sample questions for reference. Teachers* *<u>must design</u>* *more such questions so as to ensure the achievement of identified CO.*

1. Explain, how can you use the extensometer available in your laboratory for square bars?.
2. If the change in diameter for the round bar is 0.02mm calculate Poisson's ratio.
3. If the stress strain graph that you have drawn doesn't pass through origin then correction is to be applied on which side, strain or stress. Suggest how?
4. Explain the reason of lowering the values of load after ultimate load during the test.
5. Explain the reason of large sound at the instance of fracture of the specimen.
6. Draw the location of Yielding, strain hardening, necking on stress strain graph.

[Space for Answers]

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## XX References / Suggestions for Further Reading:


1. https:/www.youtube .com /watch?v=D8U4G5kcpcM for tension test on mild steel.
2. Brochure supplied with the machine.
3. I.S. 1608. 2005 and I.S. 432 (Part I) 1982 R 1995.


## XXI Assessment Scheme:

| | Performance Indicators | Weightage |
|---|---|---|
| | **Process Related (10 Marks)** | **(40%)** |
| 1 | Handling of the UTM and Dial gauge | 20% |
| 2 | Loading of the specimen | 10% |
| 3 | Taking readings using dial indicator | 10% |
| | **Product Related (15 Marks)** | **(60%)** |
| 4 | Determination of tensile stress, strain , strength | 20% |
| 5 | Interpretation of result | 20% |
| 6 | Conclusions | 10% |
| 7 | Practical related questions | 10% |
| | **Total (25 Marks)** | **100 %** |

***Names of Student Team Members***

1. ……………………..
2. ……………………….
3. …………………………
4. ………………………….

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| Process Related(10) | Product Related(15) | Total (25) | |
| | | | |

# Annexure

## (BIS Standards and Requirements)

Requirements as per IS: 432-1982 (Part I)

| Requirements as per IS: 432 -1982 (Part I) Sr. No. | Type of steel | Bar diameter | Yield stress ($N/mm^2$) | Ultimate stress ($N/mm^2$) | Minimum elongation on gauge length |
|---|---|---|---|---|---|
| 1 | Mild steel Grade - I | ≤ 20 mm<br>>20 mm and ≤ 50 mm | 250<br>240 | 410<br>410 | 23 %<br>23 % |
| 2 | Mild steel Grade II | ≤ 20 mm<br>>20 mm and ≤ 50 mm | 225<br>215 | 370<br>370 | 23 %<br>23 % |

Scale

X-axis -

Y-axis -

# Practical No. 3 & 4: Tension test on aluminium

**I Practical Significance:**

The tensile strength of a metal is essentially its ability to withstand tensile loads without failure. Ductility, on the other hand, measures a material's ability to deform under tensile stresses. This is an important factor in metal forming processes since brittle metals are more likely to rupture. Metals that break or crack when stressed cannot be transformed during hammering, rolling, or drawing.

Metal fabricators are challenged to provide materials to the automotive, aerospace, and construction sectors that have the right strength and ductility. These sectors follow stringent safety regulations. The performance of their materials are a matter of life or death .Aluminium is more ductile than mild steel .The behavior of it under gradual loading is different than mild steel.

**II Relevant Program Outcomes (POs):**

PO1 - ***Basic knowledge****:* Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems.

PO3 - ***Experiments and practice:*** Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems.

PO4- ***Engineering tools:*** Apply relevant Mechanical technologies and tools with an understanding of the limitations.

PO7- ***Ethics:*** Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Mechanical engineering.

PO8- ***Individual and team work:*** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PO9- ***Communication:*** Communicate effectively in oral and written form.

**III Competency and Skills:**

This practical is expected to develop the following skills for the industry identified competency : **"Estimate stresses in structural members and mechanical properties of materials."**

1. Selection of suitable material for the given loading.
2. Handling of instruments
3. Interpretation of result.
4. Setting up the instruments

**IV Relevant Course Outcome(s):**

1. Estimate simple stresses in machine components.
2. Perform test to evaluate mechanical properties according to Indian Standards.

**V Practical Outcome:**

- Plot stress-strain diagram for Aluminium by conducting Tension test as per IS 1608

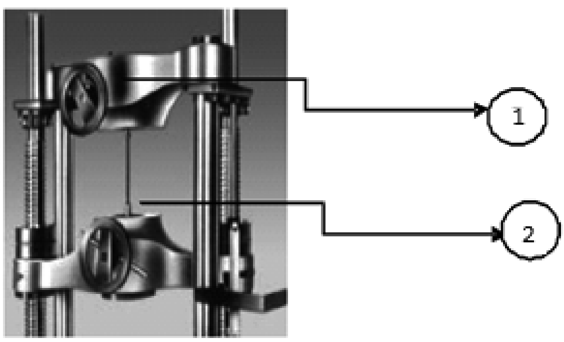
**VI Relevant Affective domain unrelated outcomes:**

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices

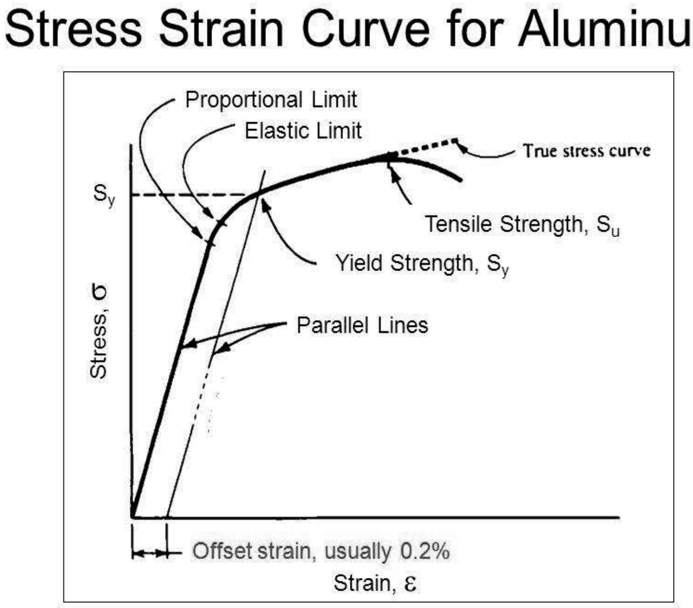
**VII Minimum Theoretical Background:**

1. **Stress**: When a material is subjected to external loading, then the internal resistance per unit cross section, set up in the material to deformation is called as stress.
2. **Ultimate tensile strength** of a material is maximum load carrying capacity of the material per unit cross sectional area, in tension.
3. **Tensile strain ( $\epsilon$ )** = Elongation in length / Original length.
4. **Robert Hook's law**: Within elastic limit, stress is directly proportional to strain.
5. **Modulus of Elasticity** : The ratio of stress to strain within elastic limit of a material is called as Modulus of Elasticity.
6. **Percentage of elongation** : The percentage change in gauge length with reference to the original gauge length is called as Percentage of elongation.
7. **The gauge length** for tension test specimen shall be 5.65 x $A_0$ where $A_0$ is the cross - sectional area. For round bar gauge length is 5 times the nominal diameter of bar.

**VIII Block diagram / Setup:**




Arrangement for tension test




**IX Resources Required**:

| S. No. | Name of Resource | Suggested Broad Specification | Quantity |
|---|---|---|---|
| 1 | **Universal Testing Machine** | **Universal Testing Machine:** Capacity – 40 or 100 tonnes. Type: Mechanical type digital, electrically Operated. Accessories: (1) Tensile test attachment for flat and round specimen up to32 mm. | 1 No. |
| 2 | **Digital Extensometer OR Mechanical Extensometer** | **Digital Extensometer:** Least count - 0.001 mm. Max. Extension = 5 mm. Single /double dial gauge for 30,40 mm. 60 mm, 80 mm, 100 mm, 125 mm gauge length. | 1 No. |
| 3 | **Vernier caliper** | Least count of 0.02 mm and measuring range of 0.02 mm to 150mm. | 1 No. |
| 4 | **Aluminium Specimen** | Perfect straight/ required shape bar of Aluminium of uniform cross-section. Length of rod shall be around 40 times diameter. The length shall be sufficient enough to fix bar in the grips plus clear space between cross heads. | 1 No. |
| 5 | **Punch & hammer** | Tip hardened punch to mark gauge length on the specimen. | 1 No. |

## X Precautions to be Followed:

1. Avoid over accelerating of UTM and maintain proper rate of loading.
2. Place the sample exactly at the center of grips of cross heads in case of flat grips
3. The Zero of dial gauge for elongation should match with the zero of load display to have the Stress - Strain graph starting from origin.
4. The extensometer from sample should be removed well before ultimate point is reached. Or otherwise the extensometer may be damaged.
5. At the time of operation keep safe distance from the machine or use caging.

## XI Procedure:

**(Part 1):**

1. Ensure that release valve and the control valve mounted on control unit are closed.
2. Put the electric switches on. Move the middle crosshead of loading unit up or down with the help of UP /DN press- button on the control unit. Thus, the space between upper crosshead and middle crosshead decreases or increases to cope up with the length of the specimen.
3. Press button- switch of the motor of hydraulic oil on the control unit .Open the control valve slowly. Observe the upward movement of upper and lower crosshead together. The middle crosshead will remain stationary. The rate of movement of moving crossheads can be controlled by control valve.
4. As soon as the control valve is opened observe the changes on load dial / display along with displacement dial/display. The readings will increase till the dead weight of lower cross head is lifted. The readings for displacement will go on increasing. Now make the load reading zero with the help of tare switch. Shut down the machine.
5. Take the aluminium specimen, measure the diameter at three different places. Record the average diameter. Also measure the overall length of specimen. Calculate the gauge length according to diameter of the specimen. For strain calculation the gauge length shall be used as initial length.
6. Mark the gauge points over the grip length, with the punch such that the distance between two consecutive points is half the gauge length. If Lindlay's Extensometer is used then the gauge length is 50 mm.
7. The gauge points shall be sufficiently deep so that they are not vanished after the elongation.
8. Select the proper extensometer from available extensometers. Note the least count of the dial gauge. In the case of extensometer with double dial gauge, the two stems of extensometer used for fixing the bar should be of appropriate length according to the gauge length of the specimen. The pivots on the stems also can be adjusted according to the gauge length of the specimen. If electronic extensometer is used then note the least count on the display- window at the control unit.

**(Part 2):**

1. Select a suitable loading range depending on the diameter of specimen. Start the UTM and adjust the dead weight of movable heads and then set the load pointer to zero.
2. Fix the specimen bar between the grips of top and middle cross heads of loading frame.
3. Attach the extensometer on the bar at the central portion of the bar. The distance between upper and lower pivots of extensometer shall be equal to gauge length. Rotate the dial gauge till the Pointer reads zero .
4. Switch on the machine and open the control valve so that the load is increased gradually and at the required rate.
5. Record the loads at suitable interval on the digital display unit or the load dial.
6. Corresponding to loads, note the readings of extensometer.
7. For initial few observations, load and extension are in pace with each other.
8. Remove the extensometer when the specimen starts yielding and measure extension by divider or suitable scale, till ultimate load.
9. Record the maximum load. Observe the decrease in load and neck formation on the specimen.
10. Record the load at fracture and switch off the machine.
11. Remove the specimen. Observe the cup and cone formation at the fracture point. Rejoin the two pieces, measure the final gauge length and the reduced diameter (for calculation of reduced cross sectional area).
12. Switch off the machine. Close the control valve and open the release valve. Observe the downward movement of the lower and upper cross heads when there is the backward flow of hydraulic oil.
13. Plot the graph of stress v/s strain with suitable scales. (Stress on Y- axis and strain on X-axis) Mark elastic limit, 0.2% proof stress point, ultimate stress point, nominal breaking stress point, actual breaking stress point on it.
14. Draw another graph of stress within elastic limit on Y-axis v/s corresponding strain on X-axis with suitable scales. Calculate the slope of the graph ,which is the Modulus of Elasticity.
15. Compare the results obtained with the standard values of IS specifications. See the annexure.
16. Label the parts of UTM and state it’s functions.

**XII Resources Used:**

| S. No. | Name of Resource | Broad Specifications | | Quantity | Remarks (If any) |
|---|---|---|---|---|---|
| | | Make | Details | | |
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**XIII Actual Procedure Followed:**

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**XIV Precautions Followed:**

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**XV Observations and Calculations:**

**a) Observations:**

Observations before test:

1. Diameter of bar-

   a) $d_1$ =………..mm, b) $d_2$ =……….. mm, c) $d_3$ =………… mm

2. Average diameter = d = $(d_1+d_2+d_3) / 3$ =……………..mm
3. Gauge length = $L_0$ = 40 d = ………………… = …………….mm
4. Least count of extensometer = L. C. = ……………….mm

**Observations during test:**

1. Range of loading = …………………………
2. Load at elastic limit = ………………………... kN
3. Load at 0.2% proof stress point = ……………………….… kN
4. Ultimate load =………………………....kN
5. Breaking load =…………………………. kN

**Observation table for tension test:**

| Sr. No. | Load in kN (P) | Extensometer reading in divisions (EMD) | | | Extension (L.C x EMD) (mm) | Stress ($\sigma$ =P/A) ($N/mm^2$) | Strain (Extension) / gauge length) ($\varepsilon$) |
|---|---|---|---|---|---|---|---|
| | | Left reading | Right reading | Average | | | |
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| 2 | | | | | | | |
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**Observations after test:**

**1.** Final gauge length L………….........mm

**2**. Reduced diameter $d_{R}$= = ..........................mm

**b) Calculations:**

1. Cross sectional area = $A_0 = \pi d^2/4$ = ………….. = ……………….$mm^2$
2. Reduced cross sectional area = $A = \pi d_R^2/4$

= ………………..= ……………….$mm^2$

3. 0.2% proof stress from graph

= …………………/……………….

= …………………N/mm$^2$

4. Ultimate stress = Ultimate load / cross sectional area

= ……………../ …………….. = …………………. N/mm$^2$

5. Breaking stress = Breaking load / cross sectional area

= ……………../… ………….. = ……….……… N/mm$^2$

6. Actual breaking stress = Breaking load / reduced cross sectional area

= ………….... /…. ………… = ……….… N/mm$^2$

7. % Elongation $= \left(\frac{L-L_0}{L_0}\right) \times 100$ = **…………...…**

**= …………….. %**

8. Reduction in area $= \left(\frac{A_0-A}{A_0}\right) \times 100$ **= ……………..%**

**= ……………..%**

9. (Within Elastic limit)Stress = **σ** = …………..N/mm$^2$

10. Corresponding strain = e = ……………

11. Modulus of Elasticity, E = **σ** / e = ................/……...…

= …………….. N/mm$^2$

**XVI Results:**

1. 0.2% proof stress = ……………….. N/mm$^2$
2. Ultimate tensile stress = ……………….. N/mm$^2$
3. Nominal Breaking stress = ………………. N/mm$^2$
4. Actual breaking stress = ……………..…. N/mm$^2$
5. % Elongation = ………………..%
6. % reduction in area = ………………..%
7. Modulus of Elasticity, E =………………… N/mm$^2$ (By graph)
8. Modulus of Elasticity, E =………………… N/mm$^2$ (By calculation)

**XVII Interpretation of Results:** (Giving meaning to the results)

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**XVIII Conclusion:** (Actions to be taken based on the interpretations)

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**XIX Practical Related Questions:**

***Note:*** *Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.*

1. Draw sketches of specimen before and after the test showing details at fracture for ductile and brittle specimens.
2. Compare the difference between stress-strain graphs for Aluminium & Mild steel with reference to the points of elastic limit, yield point, ultimate point, breaking point.
3. Explain the necessity of yield stress in design of structural components of machines.
4. Plot a nature of stress-strain graph for aluminium, copper, cast iron and brass on the same page.
5. Compare Modulus of elasticity of rubber with plastic and metals.

[Space for Answers]

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## XX References / Suggestions for Further Reading:


1. https:/www.youtube .com /watch?v=hD_NJaZIpTO
2. Brochure supplied with the machine.
3. I.S. 1608. 2005 and I.S. 432 (Part I) 1982 R 1995.


## XXI Assessment Scheme:

| Performance Indicators | | Weightage |
|---|---|---|
| **Process Related (10 Marks)** | | **(40%)** |
| 1 | Handling of the UTM and Dial gauge | 20% |
| 2 | Loading of the specimen | 10% |
| 3 | Taking readings using dial indicator | 10% |
| **Product Related (15 Marks)** | | **(60%)** |
| 4 | Determination of tensile stress, strain , strength | 20% |
| 5 | Interpretation of result | 20% |
| 6 | Conclusions | 10% |
| 7 | Practical related questions | 10% |
| **Total (25 Marks)** | | **100 %** |

***Names of Student Team Members***

1. ……………………..
2. ……………………….
3. …………………………
4. ………………………….

| **Marks Obtained** | | | **Dated signature of Teacher** |
|---|---|---|---|
| **Process Related(10)** | **Product Related(15)** | **Total (25)** | |
| | | | |

### Annexure: Abstract of IS 1608

| **S. No.** | **Material** | **Aluminium** | **Aluminium** |
|---|---|---|---|
| 1 | Type | EC-H 19 | 2024-T 351 |
| Yield strength $N/mm^2$ | | | |
| 2 | Grand average | 158.4 | 362.9 |
| Tensile strength $N/mm^2$ | | | |
| 3 | Grand average | 176.9 | 491.3 |
| | | | |

Scale

X-axis -

Y-axis -

# Practical No. 5: Compression test of ductile materials

**I Practical Significance:**

The uniaxial compression test provides knowledge of failure pattern in ductile materials. It also provide information about yield and ultimate compressive strength which is further utilized in designing and manufacturing components with same material. Increase in lateral dimension due compression can be compared to the reduction in lateral dimension, in the case of tensile loading. The contraction of linear side also can be studied, which is in contrast to extension in tensile test. The materials which are strong in tensile strength may not be strong in compression. The mechanical properties of materials are also of great significance in compression.

**II Relevant Program Outcomes (POs):**

PO1 - ***Basic knowledge:*** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems.

PO3 - ***Experiments and practice:*** Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems.

PO4 - ***Engineering tools:*** Apply relevant Mechanical technologies and tools with an understanding of the limitations.

PO7 - ***Ethics:*** Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Mechanical engineering.

PO8 - ***Individual and team work:*** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PO9 - ***Communication:*** Communicate effectively in oral and written form.

**III Competency and Skills:**

This practical is expected to develop the following skills for the industry identified competency: **"Estimate stresses in structural members and mechanical properties of materials."**

1. Selection of suitable material for the given loading.
2. Handling of instruments
3. Interpretation of result.
4. Setting up the instruments

**IV Relevant Course Outcome(s):**

- Estimate simple stresses in machine components.
- Perform test to evaluate mechanical properties according to Indian Standards

**V Practical Outcome**:

- Calculate compressive strength of Ductile such as Mild Steel (MS), Aluminium (Al), Brass (Br), Copper (Cu), using Compression testing machine as per IS 14858.

**VI Relevant Affective domain unrelated outcomes**:

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices

**VII Minimum Theoretical Background:**

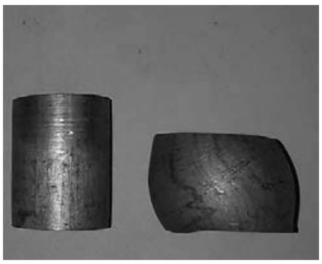
**1. Stress:** when a material is subjected to external loading, then the internal resistance per unit cross section, set up in the material to deformation is called as stress.

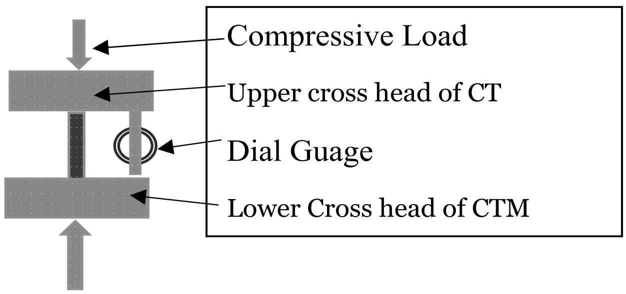
**2. Compressive Strength** of a material is maximum load carrying capacity per unit cross sectional area, in compression.

3. **Compressive strain ( $\epsilon$ ) =** Contraction in length / Original length.

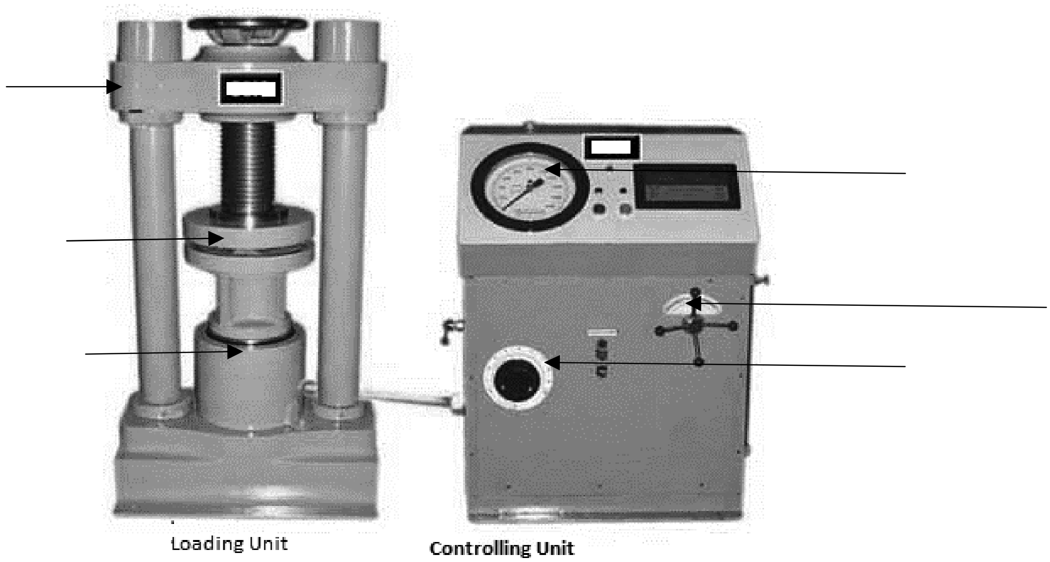
4. **Robert Hook's law :** Within elastic limit, stress is directly proportional to strain.

**VIII Block diagram / Setup:**






Specimen before and after the test




**Compression Testing Machine**

## IX Resources Required:

| S. No. | Name of Resource | Suggested Broad Specification | Quantity |
|---|---|---|---|
| 1 | Compression testing machine. | Digital display manual control compression testing; machine; Max. Capacity (KN): 2000 ; Measuring range: 4%-100% of FS | 1 No. |
| 2 | Ductile specimen of (MS) /Aluminium (Al) / Brass (Br) / Copper (Cu), | Length of specimen shall be equal to three times the lateral dimension | 1 No. |
| 3 | Dial gauge with suitable stand or any suitable arrangement for measuring contraction or movements of cross heads. | Compression dial gauge of least count 0.01mm and measuring range of 1mm-20mm.with magnetic stand. | 1 No. |
| 4 | Vernier caliper | Least count of 0.02 mm and measuring range of 0.02 mm to 150mm. | 1 No. |

## X Precautions to be Followed:

1. Avoid over accelerating of CTM and maintain proper rate of loading.
2. Place the sample exactly at the center of lower cross head.
3. The sample should be short column and have smooth cross section exactly perpendicular to the length.
4. At the time of operation keep safe distance from the machine or use caging.

**XI Procedure:**

1. Select the diameter as 16mm or 20mm from the available samples of AL/Cu/Br/MS
2. Keep the length of the sample as three times the lateral dimension. Record dimensions in the observations.
3. Place the sample on the central portion of lower cross head and fix the upper cross head on the sample.
4. Attach the dial gauge on the lower cross head. The movement of the cross head will be indicated by the dial gauge.
5. Apply the compressive load at the rate of 140Kg/sq.cm/min. till failure of the sample.
6. Record the load and dial gauge readings at suitable interval, in the observation table.
7. Observe the increase in the lateral dimension and decrease in the linear dimension of the sample
8. Determine the compressive strength as ratio of maximum compressive load to the cross sectional area of the sample.
9. Observe the bulging of the sample at failure in compression.
10. Switch off the machine.
11. Draw the graph of stress against strain.
12. Lebel the Parts of the Diagram

**XII Resources Used:**

| S. No. | Name of Resource | Broad Specifications | | Quantity | Remarks (If any) |
|---|---|---|---|---|---|
| | | Make | Details | | |
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**XIII Actual Procedure Followed:**

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**XIV Precautions Followed:**

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**XV Observations and Calculations:**

**Observations:** **1)** Material of the sample=
**2)** Diameter of sample =…………mm
3) Length of sample=………….mm
**4)** Least count of dial gauge for deformation =……mm
**5)** Least count of dial gauge for Load =………KN

| **Sr.No.** | **Compressive Load =P (Newton)** | **Compressive Stress=P/A ($N/mm^2$)** | **Dial gauge reading DGR** | **Contraction= DGR x Least count of dial gauge(mm)** | **Compressive strain= contraction /original length of sample** |
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**Sample Calculations:**
**(for reading No. )**

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**XVI Results:**

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**XVII Interpretation of Results:** (Giving meaning to the results)

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**XVIII Conclusions:** (Actions to be taken based on the interpretations)

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**XIX Practical Related Questions:**

***Note***: *Below given are few sample questions for reference. Teachers* *<u>must design</u>* *more such questions so as to ensure the achievement of identified CO.*

1. Calculate the Failure load of sample of same material of 30mm diameter.
2. Explain the formation of bulging of the specimen in compression in ductile materials.
3. Explain the reason behind keeping the length three times of lateral dimension.

[Space for Answers]

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## XX References / Suggestions for Further Reading:

1. Uniaxial Tension and Compression Testing of Materials by Nikita Khlystov and others

## XXI Assessment Scheme:

| | Performance Indicators | Weightage |
|---|---|---|
| | **Process Related (10 Marks)** | **(40%)** |
| 1 | Handling of the UTM and Dial gauge | 20% |
| 2 | Loading of the specimen | 10% |
| 3 | Taking readings using dial indicator | 10% |
| | **Product Related (15 Marks)** | **(60%)** |
| 4 | Determination of tensile stress, strain , strength | 20% |
| 5 | Interpretation of result | 20% |
| 6 | Conclusions | 10% |
| 7 | Practical related questions | 10% |
| | **Total (25 Marks)** | **100 %** |

***Names of Student Team Members***

1. ……………………..
2. ……………………….
3. …………………………
4. ………………………….

| **Marks Obtained** | | | **Dated signature of Teacher** |
|---|---|---|---|
| **Process Related(10)** | **Product Related(15)** | **Total (25)** | |
| | | | |

Scale

X-axis -

Y-axis -

# Practical No. 6: Compression test of brittle materials

**I Practical Significance:**

This compression test provides knowledge of failure pattern in brittle materials. It also provide information about yield and ultimate compressive strength which is further utilized in designing and manufacturing components with same material. Brittle materials do not show any significant increase in lateral dimension .The failure pattern is totally different than that of ductile material .The failure of brittle material in compression is on the plane of maximum shear, which is clearly indicted on failure plane at 45 degree angle.

**II Relevant Program Outcomes (POs):**

PO1 - ***Basic knowledge:*** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems.

PO3 - ***Experiments and practice:*** Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems.

PO4 - ***Engineering tools:*** Apply relevant Mechanical technologies and tools with an understanding of the limitations.

PO7 - ***Ethics:*** Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Mechanical engineering.

PO8 - ***Individual and team work:*** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PO9 - ***Communication:*** Communicate effectively in oral and written form.

**III Competency and Skills:**

This practical is expected to develop the following skills for the industry identified competency : **"Estimate stresses in structural members and mechanical properties of materials."**

1. Selection of suitable material for the given loading.
2. Handling of instruments
3. Interpretation of result.
4. Setting up the instruments

**IV Relevant Course Outcome(s):**

- Estimate simple stresses in machine components.
- Perform test to evaluate mechanical properties according to Indian Standards

**V Practical Outcome:**

- Calculate compressive strength of brittle material such as Cast Iron, using Compression testing machine as per IS 14858.

**VI Relevant Affective domain unrelated outcomes:**

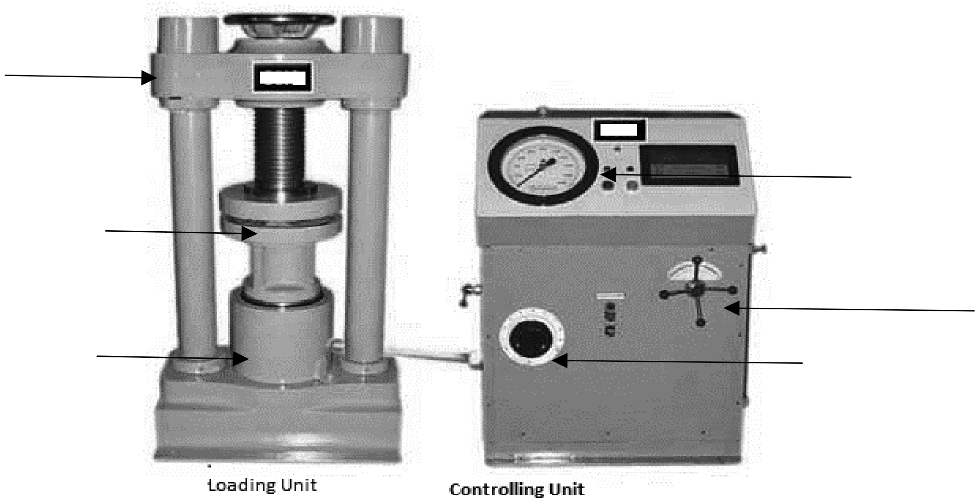
1. Follow safety practices.
2. Practice good housekeeping.
3. Practice energy conservation.
4. Demonstrate working as a leader/a team member.
5. Maintain tools and equipment.
6. Follow ethical Practices

**VII Minimum Theoretical Background:**

1. **Stress** : when a material is subjected to external loading, then the internal resistance per unit cross section, set up in the material to deformation is called as stress.
2. **Compressive Strength** of a material is maximum load carrying capacity per unit cross sectional area, in compression.
3. **Compressive strain ( ϵ ) =** Contraction in length / Original length.
4. **Robert Hook's law**: Within elastic limit, stress is directly proportional to strain.

**VIII Block diagram / Setup:**

**Shape of Specimen Before & After Test**




**Compression Testing Machine**

## IX Resources Required:

| S. No. | Name of Resource | Suggested Broad Specification | Quantity |
|---|---|---|---|
| 1 | Compression testing machine. | Digital display manual control compression testing; machine; Max. Capacity (KN): 2000 ; Measuring range: 4%-100% of FS | 1 No. |
| 2 | Cast Iron specimen | Length of specimen shall be equal to three times the lateral dimension | 1 No. |
| 3 | Dial gauge with suitable stand or any suitable arrangement for measuring contraction or movements of cross heads. | Compression dial gauge of least count 0.01mm and measuring range of 1mm-20mm.with magnetic stand. | 1 No. |
| 4 | Vernier caliper | Least count of 0.02 mm and measuring range of 0.02 mm to 150mm. | 1 No. |

## X Precautions to be Followed:

1. Avoid over accelerating of CTM and maintain proper rate of loading.
2. Place the sample exactly at the center of lower cross head.
3. The sample should be short column and have smooth cross section exactly perpendicular to the length.
4. At the time of operation keep safe distance from the machine or use caging.

## XI Procedure:

1. Select the diameter as 16mm or 20mm from the available samples of Cast Iron.
2. Keep the length of the sample as three times the lateral dimension. Record dimensions in the observations.
3. Place the sample on the central portion of lower cross head and fix the upper cross head on the sample.
4. Attach the dial gauge on the lower cross head. The movement of the cross head will be indicated by the dial gauge.
5. Apply the compressive load at the rate of 140Kg/sq.cm/min. till failure of the sample.
6. Record the load and dial gauge readings at suitable interval, in the observation table.
7. Observe the increase in the lateral dimension (which is very small in brittle specimen) and decrease in the linear dimension of the sample.
8. Determine the compressive strength as ratio of maximum compressive load to the cross sectional area of the sample.
9. Observe the formation of cracking of the sample at failure in compression.
10. Switch off the machine.
11. Draw the graph of stress against strain.
12. Label parts of the figure.

## XII Resources Used:

| S. No. | Name of Resource | Broad Specifications | | Quantity | Remarks (If any) |
|---|---|---|---|---|---|
| | | Make | Details | | |
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## XIII Actual Procedure Followed:

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## XIV Precautions Followed:

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**XV Observations and Calculations:**

**Observations:** 1) Material of the sample=

2) Diameter of sample =…………mm

3) Length of sample=…………mm

4) Least count of dial gauge for deformation =……mm

5) Least count of dial gauge for Load =………KN

| S.N. | Compressive Load =P (Newton) | Compressive Stress=P/A ($N/mm^2$) | Dial gauge reading DGR | Contraction= DGR x Least count of dial gauge (mm) | Compressive strain= contraction /original length of sample |
|---|---|---|---|---|---|
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**Sample Calculations: (for reading No.)**

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**XVI Results:**

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**XVII Interpretation of Results:** (Giving meaning to the results)

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**XVIII Conclusions:** (Actions to be taken based on the interpretations)

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## XIX Practical Related Questions:

***Note:*** *Below given are few sample questions for reference. Teachers* *must design* *more such questions so as to ensure the achievement of identified CO.*

1. Calculate the failure load of sample of same material of 30mm diameter using analytical method.
2. Explain the formation of cutting plane at 45 degree on compression failure in brittle materials.
3. Which is stronger Cast Iron or Steel? Justify your answer.

[Space for Answers]

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**XX References / Suggestions for Further Reading:**

1. Uniaxial Tension and Compression Testing of Materials by Nikita Khlystov and others

**XXI Assessment Scheme:**

| Performance Indicators | | Weightage |
|---|---|---|
| **Process Related (10 Marks)** | | **(40%)** |
| 1 | Handling of the CTM and Dial gauge | 20% |
| 2 | Loading of the specimen | 10% |
| 3 | Taking readings using dial indicator | 10% |
| **Product Related (15 Marks)** | | **(60%)** |
| 4 | Determination of compressive stress, strain , strength | 20% |
| 5 | Interpretation of result | 20% |
| 6 | Conclusions | 10% |
| 7 | Practical related questions | 10% |
| | **Total (25 Marks)** | **100 %** |

***Names of Student Team Members***

1. ……………………..
2. ……………………….
3. …………………………
4. ………………………….

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related(10)** | **Product Related(15)** | **Total (25)** | |
| | | | |

# Annexure

## (BIS Standards and Requirements)

Requirements as per IS: 432-1982 (Part I)

| Requirements as per IS: 432 -1982 (Part I) | | | | | |
|---|---|---|---|---|---|
| Sr. No. | Type of steel | Bar diameter | Yield stress ($N/mm^2$) | Ultimate stress ($N/mm^2$) | Minimum elongation on gauge length |
| 1 | Mild steel Grade - I | ≤ 20 mm<br>>20 mm and ≤ 50 mm | 250<br>240 | 410<br>410 | 23 %<br>23 % |
| 2 | Mild steel Grade II | ≤ 20 mm<br>>20 mm and ≤ 50 mm | 225<br>215 | 370<br>370 | 23 %<br>23 % |

Scale

X-axis -

Y-axis -

# Practical No. 7: Shear Strength of various metals by single shear test

## I Practical Significance:

Shear force acting on a member is a force parallel to the surface. The resistance to such tangential force is called shear stress. Fasteners such as bolts and screws are subjected to single and double shear. Design of such components is based on the shear strength of the metal.

## II Relevant Program Outcomes (POs):

PO1 - ***Basic knowledge:*** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO3 - ***Experiments and practice:*** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

PO4 - ***Engineering tools****:* Apply relevant Mechanical technologies and tools with an understanding of the limitations.

PO7 - ***Ethics****:* Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Mechanical engineering.

PO8 - ***Individual and team work****:* Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PO9 - ***Communication****:* Communicate effectively in oral and written form.

PO10 - ***Life-long learning****:* Engage in independent and life-long learning activities in the context of technological changes also in the Mechanical engineering and allied industry.

## III Competency and Skills:

This practical is expected to develop the following skills for the industry identified competency: **'Estimate stresses in structural members and mechanical properties of materials.'**

1. Select and use the relevant measuring instrument for measuring diameter of the specimen.
2. Perform shear test to determine single shear strength.

## IV Relevant Course Outcome(s):

- Perform test to evaluate mechanical properties according to Indian Standards.
- Estimate simple stresses in machine components.

## V Practical Outcome:

- Determine shear strength of various metals such as MS, Al, Br and Cu, (Any two metals) by Single Shear test as per IS 5242

**VI Relevant Affective domain unrelated outcomes**:

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices

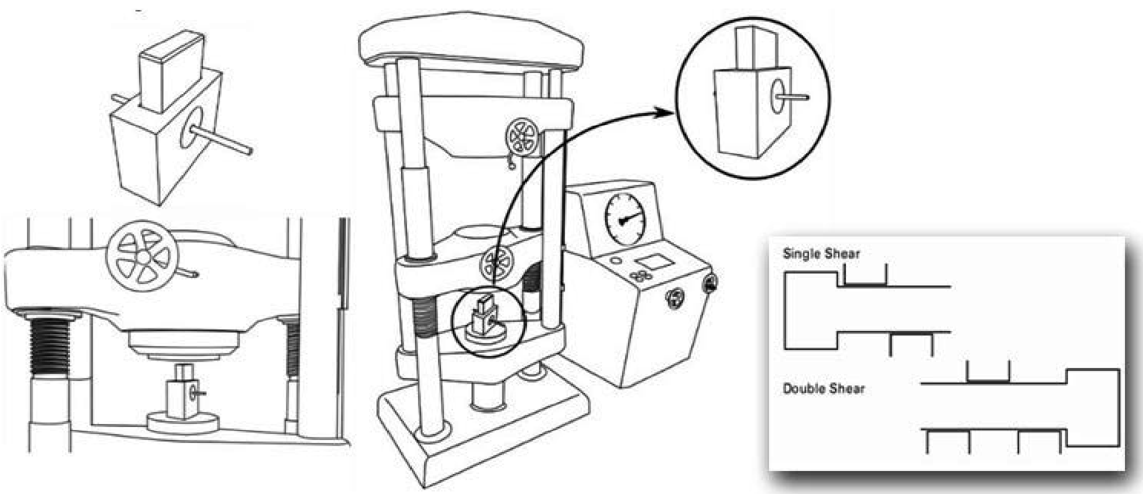
**VII Minimum Theoretical Background:**

An axial force is a force perpendicular to the surface of the member. Shear force is a force parallel to surface. Strength of a metal in shearing may be different than its tensile and compressive strength. Shear strength can be defined as the maximum shear stress that can be resisted by the material, before failure occurs. In single shear condition, the total shearing force is resisted by single cross-sectional area. The specimen breaks into 2 pieces.

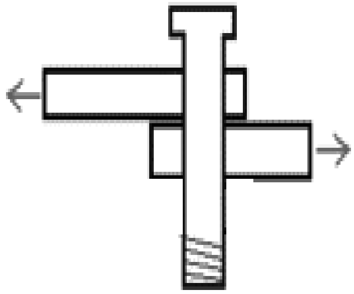
$$\text{Single shear strength} = \frac{\text{Load at failure (P) in N}}{\text{(tangential area of the bar in mm}^2\text{)}}$$

**VIII Shear Attachment**

**Shear Attachment**




**Single Shear Test on Metals**



**IX Resources Required:**

| S. No. | Name of Resource | Suggested Broad Specification | Quantity |
|---|---|---|---|
| 1 | Universal Testing Machine | Capacity - 100 tonnes.<br>Type: Mechanical type digital, electrically Operated. | 1 |
| 2 | Shear Attachment | Shear test attachment with sizes of bushes 5,6,8,10,12,16,20,24 mm | 1 |
| 3 | Vernier Caliper | Least count 0.02 mm and measuring range 0.02 to 20 mm | 1 |
| 4 | MS, Aluminium, brass and Copper specimen | Round bar of diameters 6 to 20 mm | Any 2 diameters of any two metals |

**X Precautions to be Followed:**

1. Avoid improper handling of instrument
2. Choose proper range on the UTM.
3. Ensure proper alignment of cutters in the shear attachment.

**XI Procedure**

1. Measure the diameter (d) of the given specimen.
2. The inner diameter of the hole in the shear stress attachment is slightly greater than that of the specimen.
3. Fit the specimen in the single shear device and place whole assembly in the UTM.
4. Apply the load till the specimen fails by single – shear.
5. Note down the load at which the specimen fails (P).
6. Calculate the maximum shear strength of the given specimen by using the formula.
7. Repeat the procedure for a specimen of the same metal with different diameter.
8. Repeat the procedure for specimen of different metal.
9. Compare the shear strengths of specimen of two different metals with same diameter.
10. Compare the shear strengths of specimen of same metal with different diameters.

**XII Resources Used:**

| S. No. | Name of Resource | Broad Specifications | | Qty. | Remarks (If any) |
|---|---|---|---|---|---|
| | | Make | Details | | |
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**XIII Actual Procedure Followed:**

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**XIV Precautions Followed:**

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**XV Observations and Calculations:**

| Sr. No. | Specimen (Metal) | Diameter of specimen (mm) | Tangential sectional Area ($mm^2$) | Load at Failue (kN) | Single Shear strength (MPa) |
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**XVI Results:**

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**XVII Interpretation of Results: (**Giving meaning to the results)

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**XVIII Conclusions:** (Actions to be taken based on the interpretations. )

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## XIX Practical Related Questions:

***Note:*** *Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.*

1. Calculate failure load for a square MS bar of size 30mm under single shear failure.
2. Calculate ratio of single shear load to double shear load for MS.
3. Draw sketch of failure of rivet subjected to single shear and double shear.

[Space for Answers]

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## XX References / Suggestions for Further Reading:


1. IS 5242: Method of test for determining shear strength of metals
2. https://www.youtube.com/watch?v=sLZeR7RMGFA
3. https://www.youtube.com/watch?v=jjw-PG0cfJU


## XXI Assessment Scheme:

| Performance Indicators | | Weightage |
|---|---|---|
| **Process Related (10 Marks)** | | **(40%)** |
| 1 | Handling of the measuring Instruments | 30% |
| 2 | Calculation of final readings | 10% |
| **Product Related (15 Marks)** | | **(60%)** |
| 3 | Interpretation of result | 20% |
| 4 | Conclusions | 20% |
| 5 | Practical related questions | 20% |
| | **Total (25 Marks)** | **100 %** |

***Names of Student Team Members***

1. ……………………..
2. ……………………….
3. ………………………
4. ………………………

| **Marks Obtained** | | | **Dated signature of Teacher** |
|---|---|---|---|
| **Process Related(10)** | **Product Related(15)** | **Total (25)** | |
| | | | |

Scale

X-axis -

Y-axis -

# Practical No. 8: Determine shear strength of various metals by double shear test

**I Practical Significance:**

Shear force acting on a member is a force parallel to the surface. The resistance to such tangential force is called shear stress. Fasteners such as bolts and screws are subjected to single and double shear. Design of such components is based on the shear strength of the metal.

**Single shear** comes at many places. **Single shear** means a cross section having unbalanced force on its either side and the cross section is ineffective to take that unbalanced force, then it fails in **single shear**. For **double shear** an unbalanced load is acting on both side of the cross section and whole section fails in **double shear**.

**II Relevant Program Outcomes (POs)**:

PO1 - ***Basic knowledge:*** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO3 - ***Experiments and practice:*** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

PO4- ***Engineering tools***: Apply relevant Mechanical technologies and tools with an understanding of the limitations.

PO7- ***Ethics***: Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Mechanical engineering.

PO8 - ***Individual and team work***: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PO9- ***Communication***: Communicate effectively in oral and written form.

PO10- ***Life-long learning***: Engage in independent and life-long learning activities in the context of technological changes also in the Mechanical engineering and allied industry.

**III Competency and Skills:**

- This practical is expected to develop the following skills for the industry identified competency : **'Estimate stresses in structural members and mechanical properties of materials.'**

1. Select relevant measuring instrument for measuring diameter of the specimen.
2. Use relevant measuring instrument for measuring diameter of the specimen.
3. Perform shear test to determine double shear strength.

**IV Relevant Course Outcome(s):**

- Estimate simple stresses in machine components.
- Perform test to evaluate mechanical properties according to Indian Standards.

**V Practical Outcome:**

- Determine shear strength of various metals such as MS, Al, Br and Cu, (Any two metals) by Double Shear test as per IS 5242

**VI Relevant Affective domain unrelated outcomes:**

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices

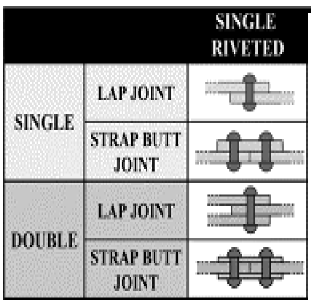
**VII Minimum Theoretical Background:**

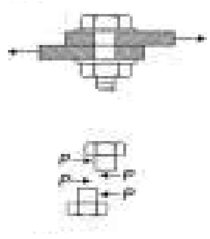
An axial force is a force perpendicular to the surface of the member. Shear force is a force parallel to surface. Strength of a metal in shearing may be different than its tensile and compressive strength. Shear strength can be defined as the maximum shear stress that can be resisted by the material, before failure occurs. In double shear condition, the total shearing force is resisted by two cross-sectional areas simultaneously. The specimen breaks into 3 pieces.

$$\text{Double shear strength} = \frac{\text{Load at failure (P) in N}}{(2 \times \text{tangential area of the bar in mm}^2)}$$

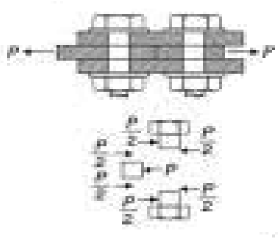
**VIII Experimental setup:**

**Shear Attachment**

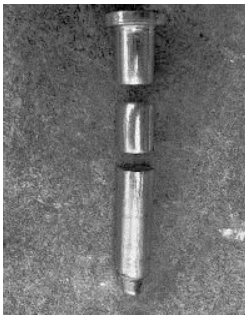


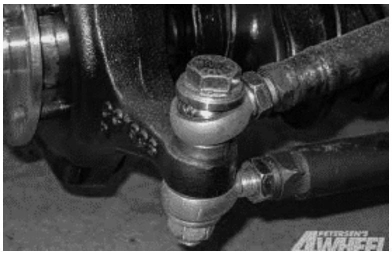



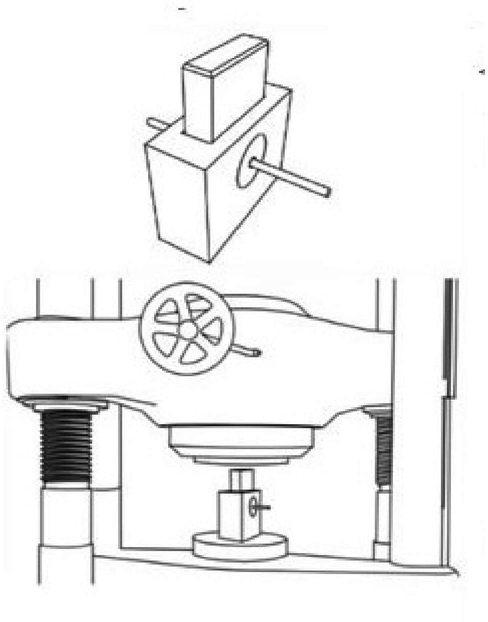
Lap Joint Bolt in Single Shear



Butt Joint Bolt in Double Shear







**Double Shear Test on Metals**

## IX Resources Required:

| S. No. | Name of Resource | Suggested Broad Specification | Quantity |
|---|---|---|---|
| 1 | Universal Testing Machine | Capacity - 100 tonnes.<br>Type: Mechanical type digital, electrically Operated. | 1 |
| 2 | Shear Attachment | Shear test attachment with sizes of bushes 5,6,8,10,12,16,20,24 mm | 1 |
| 3 | Vernier Caliper | Least count 0.02 mm and measuring range 0.02 to 20 mm | 1 |
| 4 | MS, Aluminium, brass and Copper specimen | Round bar of diameters 6 to 20 mm | Any 2 diameters of any two metal |

**X Precautions to be Followed:**

1. Avoid improper handling of instrument
2. Choose proper range on UTM.
3. Ensure proper alignment of cutters in the shear attachment.

**XI Procedure:**

1. Measure the diameter (d) of the given specimen.
2. The inner diameter of the hole in the shear stress attachment is slightly greater than that of the specimen.
3. Fit the specimen in the double shear device and place whole assembly in the UTM.
4. Apply the load till the specimen fails by double – shear.
5. Note down the load at which the specimen fails (P).
6. Calculate the maximum shear strength of the given specimen by using the formula.
7. Repeat the procedure for a specimen of the same metal with different diameter.
8. Repeat the procedure for specimen of different metal.
9. Compare the shear strengths of specimen of two different metals with same diameter.
10. Compare the shear strengths of specimen of same metal with diameters.

**XII Resources Used:**

| S. No. | Name of Resource | Broad Specifications | | Qty | Remarks (If any) |
|---|---|---|---|---|---|
| | | Make | Details | | |
| 1. | | | | | |
| 2. | | | | | |
| 3. | | | | | |

**XIII Actual Procedure Followed:**

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**XIV Precautions Followed:**

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## XV Observations and Calculations:

| Sr. No. | Specimen (Metal) | Diameter of specimen (mm) | Tangential section Area ($mm^2$) | Load at Failue (kN) | Double Shear strength (MPa) |
|---|---|---|---|---|---|
| | | | | | |
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## XVI Results:

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## XVII Interpretation of Results: (Giving meaning to the results)

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## XVIII Conclusions: (Actions to be taken based on the interpretations. )

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## XIX Practical Related Questions:

***Note:*** *Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.*

1. Calculate failure load for a square bar of size 30mm under double shear failure of the same materials that you have tested.
2. Calculate ratio of double shear load to single shear load for MS.

[Space for Answers]

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**XX References / Suggestions for Further Reading:**


1. IS 5242: Method of test for determining shear strength of metals
2. https://www.quora.com/in/What-is-the-difference-between-single-shear-and-double-shear


**XXI Assessment Scheme:**

| Performance Indicators | | Weightage |
|---|---|---|
| **Process Related (10 Marks)** | | **(40%)** |
| 1 | Handling of the measuring Instruments | 30% |
| 2 | Calculation of final readings | 10% |
| **Product Related (15 Marks)** | | **(60%)** |
| 3 | Interpretation of result | 20% |
| 4 | Conclusions | 20% |
| 5 | Practical related questions | 20% |
| | **Total (25 Marks)** | **100 %** |

***Names of Student Team Members***

1. ……………………..
2. ……………………….
3. ………………………
4. ……………………….

| **Marks Obtained** | | | **Dated signature of Teacher** |
|---|---|---|---|
| **Process Related(10)** | **Product Related(15)** | **Total (25)** | |
| | | | |

# Practical No. 9: Toughness of ductile and brittle materials by izod impact test

**I Practical Significance:**

Several engineering materials have to withstand impact or suddenly applied loads while in service. These loads are applied suddenly. The stress induced in these components is many times more than the stress produced by same load applied gradually. Therefore, impact tests are performed to asses shock absorbing capacity.

**II Relevant Program Outcomes (POs):**

PO1 - ***Basic knowledge:*** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO3 - ***Experiments and practice:*** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

**III Competency and Skills:**

- This practical is expected to develop the following skills for the industry identified competency : **'Estimate stresses in structural members and mechanical properties of materials.'**

1. Select and use the relevant measuring instrument for measuring dimensions of the specimen.
2. Perform Izod Impact test to evaluate toughness of Ductile and Brittle materials.

**IV Relevant Course Outcome(s):**

- Perform test to evaluate mechanical properties according to Indian Standards.

**V Practical Outcome:**

- Evaluate toughness of Ductile and Brittle materials such as MS, Al, Br , Cu, & CI by conducting Izod Impact test as per IS 1598.

**VI Relevant Affective domain unrelated outcomes:**

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices

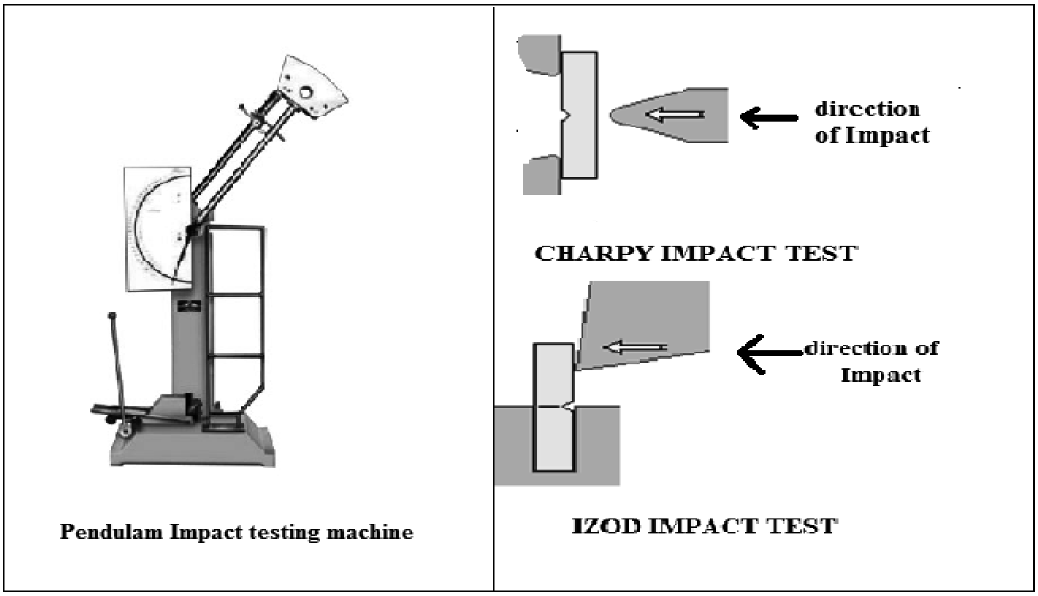
## VII Minimum Theoretical Background:

Loads applied suddenly with an impact on a member induce higher stresses in the member. Static tension tests where load is applied gradually, do not always reveal the susceptibility of a metal to brittle fracture under such impact loading. This important factor is determined by impact test. Impact test signifies toughness of material that is ability of material to absorb energy during impact. Toughness takes into account both the strength and ductility of the material.

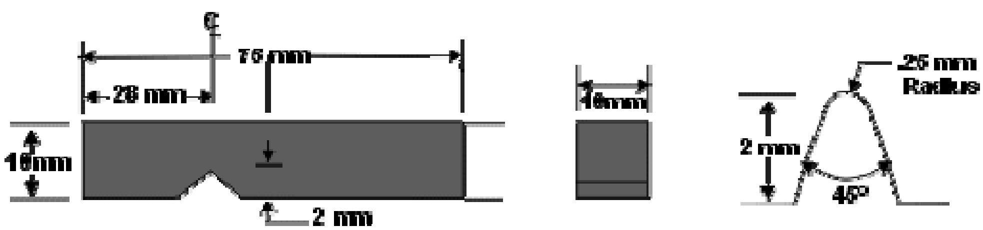
Two types of notch impact tests are commonly used - 1. Charpy test. 2. Izod test.
In Izod test, the specimen is placed as 'cantilever beam'. The specimens have V-shaped notch of 45°. The notch is located on tension side of specimen during impact loading.

Energy absorbed in Joules = Initial Energy in Joules - Final Energy in Joules

## VIII Experimental setup:



Pendulum Impact testing machine
CHARPY IMPACT TEST
IZOD IMPACT TEST




**IZOD IMPACT TEST SPECIMEN**

**IX Resources Required:**

| S. No. | Name of Resource | Suggested Broad Specification | Quantity |
|---|---|---|---|
| 1 | IZOD Impact Test Apparatus: | Pendulum drop angle: 90°-120°; Pendulum effective Wt: 20-25 kg; Striking velocity of pendulum: 3-4 m/sec; Pendulum impact energy: 168 j; Min scale graduation: 2 J; Distance of axis of pendulum rotation from center of specimen to specimen hit by pendulum : 815 mm | 1 |
| 2 | Izod test specimen of Mild Steel /Aluminium, Brass/ Copper and Cast Iron | Square bar of size 10 mm as per details shown in sketch, with proper notch. | 1 each |

**X Precautions to be Followed:**

1. Avoid improper handling of instrument
2. Lock the hammer in position before placing the specimen.
3. Ensure that the broken pieces of specimen do not hurt students.
4. Read the values from Izod scale only

**XI Procedure:**

1. Bring the striking hammer to its horizontal striking position such that the energy of the pendulum is 165 Joules and lock it at that position.
2. Bring indicator of dial of the machine to zero, or follow the instructions of the operating manual supplied with the machine.
3. Without placing any specimen, release the hammer.
4. Hammer will push the pointer to show initial energy reading on the scale. Record this initial reading.
5. Bring the striking hammer back to its striking position and lock it at that position.
6. Bring indicator of the machine to zero.
7. Place the metal specimen in impact testing machine's vice in such a way that the notch faces the hammer and is half inside and half above the top surface of the vice.
8. Release the hammer. It will fall due to gravity and break the specimen through its momentum, and will continue to swing.
9. Apply breaks to stop the swinging hammer.
10. Note down the final reading after impact.
11. Calculate energy absorbed by the specimen by using the given formula:
12. Repeat the procedure for specimens of different metals..
13. Compare energy absorption capacities of different metals.

**XII Resources Used:**

| S. No. | Name of Resource | Broad Specifications | | Qty | Remarks (If any) |
|---|---|---|---|---|---|
| | | Make | Details | | |
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**XIII Actual Procedure Followed:**

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**XIV Precautions Followed:**

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**XV Observations and Calculations:**

| Sr. No. | Specimen (Metal) | Initial Energy Reading (J) | Final Energy Reading (J) | Energy Absorbed by the specimen (J) | Mode of failure |
|---|---|---|---|---|---|
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**XVI Results:**

1. Izod impact value of specimen No.1…………………..
2. Izod impact value of specimen No.2…………………..
3. Izod impact value of specimen No.3…………………..

**XVII Interpretation of Results: (**Giving meaning to the results)

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**XVIII Conclusions:** (Actions to be taken based on the interpretations.)

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**XIX References / Suggestions for Further Reading:**

1. https://www.youtube.com/watch?v=l20kF6fhScA
2. IS : 1598- 1977 Indian standard Method for Izod Impact Test on Metallic Materials.

**XX Assessment Scheme:**

| Performance Indicators | | Weightage |
|---|---|---|
| **Process Related (10 Marks)** | | **(40%)** |
| 1 | Handling of the measuring Instruments | 30% |
| 2 | Calculation of final readings | 10% |
| **Product Related (15 Marks)** | | **(60%)** |
| 3 | Interpretation of result | 20% |
| 4 | Conclusions | 20% |
| 5 | Practical related questions | 20% |
| **Total (25 Marks)** | | **100 %** |

***Names of Student Team Members***

1. ……………………..
2. ……………………….
3. …………………………
4. ………………………….

| **Marks Obtained** | | | **Dated signature of Teacher** |
|---|---|---|---|
| **Process Related(10)** | **Product Related(15)** | **Total (25)** | |
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# Practical No. 10: Toughness of ductile and brittle materials by charpy impact test

**I Practical Significance:**

Several engineering materials have to withstand impact or suddenly applied loads while in service. These loads are applied suddenly. The stress induced in these components is many times more than the stress produced by same load applied gradually. Therefore, impact tests are performed to asses shock absorbing capacity.

**II Relevant Program Outcomes (POs):**

PO1 - ***Basic knowledge:*** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO3 - ***Experiments and practice:*** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

**III Competency and Skills:**

- This practical is expected to develop the following skills for the industry identified competency : **'Estimate stresses in structural members and mechanical properties of materials.'**

1. Select and use the relevant measuring instrument for measuring dimensions of the specimen.
2. Perform Charpy Impact test to determine energy absorption capacity of Ductile and Brittle materials.

**IV Relevant Course Outcome(s):**

- Perform test to evaluate mechanical properties according to Indian Standards.

**V Practical Outcome**:

- Determine energy absorption capacity of Ductile and Brittle materials such as MS, Al, Br and Cu, by conducting Charpy Impact test as per IS 1598 and Evaluate toughness of Ductile and Brittle materials such as MS, Al, Br and Cu, & CI

**VI Relevant Affective domain unrelated outcomes:**

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices

**VII Minimum Theoretical Background:**

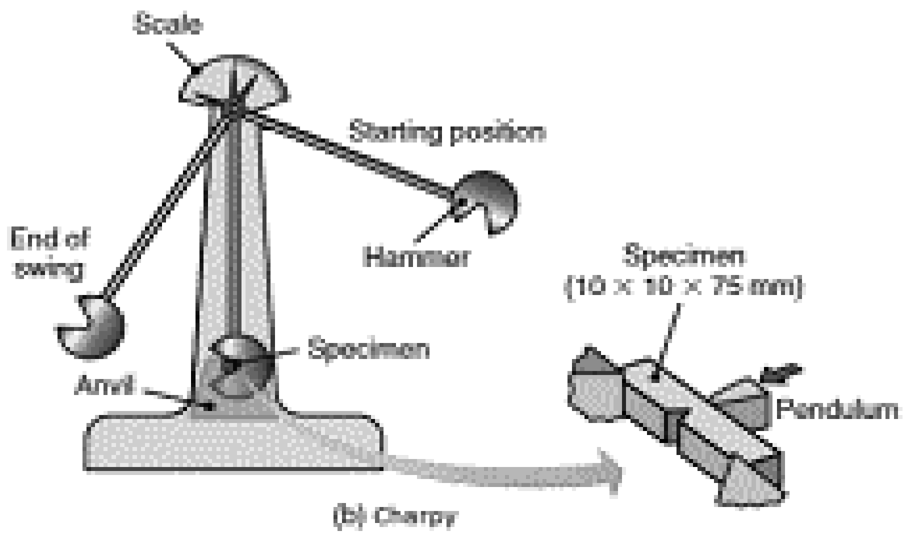
Loads applied suddenly with an impact on a member induce higher stresses in the member. Static tension tests where load is applied gradually, do not always reveal the susceptibility of a metal to brittle fracture under such impact loading. This important factor is determined by impact test. Impact test signifies toughness of material that is ability of material to absorb energy during impact. Toughness takes into account both the strength and ductility of the material.

Two types of notch impact tests are commonly used - 1. Charpy test. 2. Izod test.

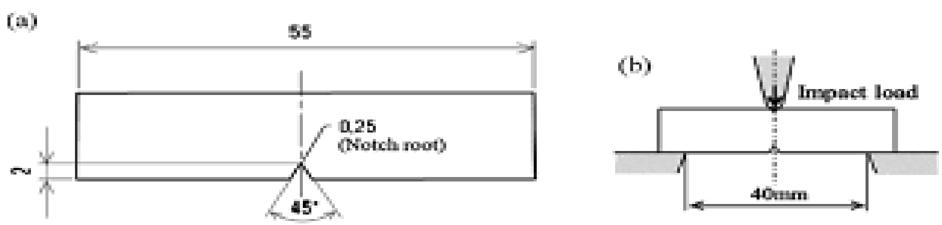
In Charpy test, the specimen is placed as ‘horizontal simply supported beam’. The specimens have V-shaped notch of 45° at the centre of the length. The notch is located on tension side of specimen during impact loading.

Energy absorbed in Joules = Initial Energy in Joules - Final Energy in Joules

**VIII Experimental setup:**




**CHARPY IMPACT TEST**




**CHARPY IMPACT TEST SPECIMEN**

## IX Resources Required:

| S. No. | Name of Resource | Suggested Broad Specification | Quantity |
|---|---|---|---|
| 1 | CHARPY Impact Test Apparatus: | Determine energy absorption capacity of Ductile and Brittle materials such as MS, Al, Br and Cu, by conducting Charpy Impact test as per IS 1757 | 1 |
| 2 | Charpy test specimen of Mild Steel, Aluminium, Brass and Copper | Square bar of size 10 mm as per details shown in sketch, with proper notch. | 1 each |

## X Precautions to be Followed:

1. Avoid improper handling of instrument
2. Lock the hammer in position before placing the specimen.
3. Ensure that the broken pieces of specimen do not hurt students.
4. Read the values from Charpy scale only

## XI Procedure:

1. Bring the striking hammer to its top most striking position so that the energy of the pendulum is 300 Joules and lock it at that position.
2. Bring indicator of the machine to zero, or follow the instructions of the operating manual supplied with the machine.
3. Without placing any specimen, release the hammer.
4. Hammer will push the pointer to show initial energy reading on the scale. Record this initial reading.
5. Bring the striking hammer back to its top most striking position and lock it at that position.
6. Bring indicator of the machine to zero.
7. Place the metal specimen in impact testing machine's vice in such a way that the notch is opposite to the hammer and is at the center of the span .
8. Release the hammer. It will fall due to gravity and break the specimen through its momentum, and will continue to swing.
9. Apply breaks to stop the swinging hammer.
10. Note down the final reading after impact.
11. Calculate energy absorbed by the specimen by using the given formula:
12. Repeat the procedure for specimens of different metals..
13. Compare energy absorption capacities of different metals.

**XII Resources Used:**

| S. No. | Name of Resource | Broad Specifications | | Qty | Remarks (If any) |
|---|---|---|---|---|---|
| | | Make | Details | | |
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**XIII Actual Procedure Followed:**

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**XIV Precautions Followed:**

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**XV Observations and Calculations:**

| Sr. No. | Specimen (Metal) | Initial Energy Reading (J) | Initial Energy Reading (J) | Energy Absorbed by the specimen (J) | Mode of failure |
|---|---|---|---|---|---|
| | | | | | |
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**XVI Results:**

1. Charpy impact value of specimen No.1…………………..
2. Charpy impact value of specimen No.2…………………..
3. Charpy impact value of specimen No.3…………………..

**XVII Interpretation of Results: (**Giving meaning to the results)

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**XVIII Conclusions:** (Actions to be taken based on the interpretations. )

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**XIX Practical Related Questions:**

***Note:*** *Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.*

1. List any two machine components which are subjected to impact loads.
2. State the strongest material and the weakest material out of the materials tested.
3. Define toughness of a material.

[Space for Answers]

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**XX References / Suggestions for Further Reading:**


1. IS : 1757 – 1988 : Indiann Standard Method for Charpy Impact Test on Metallic Materials.
2. https://www.youtube.com/watch?v=tpGhqQvftAo


**XXI Assessment Scheme:**

| Performance Indicators | | Weightage |
|---|---|---|
| **Process Related (10 Marks)** | | **(40%)** |
| 1 | Handling of the measuring Instruments | 30% |
| 2 | Calculation of final readings | 10% |
| **Product Related (15 Marks)** | | **(60%)** |
| 3 | Interpretation of result | 20% |
| 4 | Conclusions | 20% |
| 5 | Practical related questions | 20% |
| **Total (25 Marks)** | | **100 %** |

***Names of Student Team Members***

1. ……………………..
2. ……………………….
3. …………………………
4. …………………………

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| Process Related(10) | Product Related(15) | Total (25) | |
| | | | |

# Practical No. 11: SFD & BMD - Using open source simulation software.

## I Practical Significance:

Shear and bending moment diagrams are analytical tools used in conjunction with structural analysis, design shafts, design levers loaded safety valves, to help perform structural design by determining the values of shear force and bending moment . These diagrams can be used to easily determine the type, size, and material of a member in a structure so that a given set of loads can be supported without structural failure

While analyzing a structural element, we always concerned about finding the maximum values of forces and moments acting on it and the location where they act. SFD and BMD are very helpful to know how much stresses the member are expected to bear, thus one can select suitable material and section properties.

## II Relevant Program Outcomes (POs):

PO1 - ***Basic knowledge:*** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems.

PO 2. ***Discipline knowledge:*** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems

PO 8. ***Individual and team work:*** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PO 9. ***Communication:*** Communicate effectively in oral and written form.

PO 10. ***Life-long learning:*** Engage in independent and life-long learning activities in the context of technological changes also in the Mechanical engineering and allied industry.

## III Competency and Skills:

This practical is expected to develop the following skills for the industry identified competency : **"Estimate stresses in structural members and mechanical properties of materials."**

1. Selection of suitable software for given beam and loading conditions.
2. Handling software for given beam and loading conditions.
3. Interpretation of result on software and compare analytical method.
4. Correlating the values of maximum positive and negative BM and SF for designing a component of a machine.

## IV Relevant Course Outcome(s):

- Compute shear force and bending moment and corresponding shear and bending stresses in beams subjected to point and uniformly distributed load.

## V Practical Outcome:

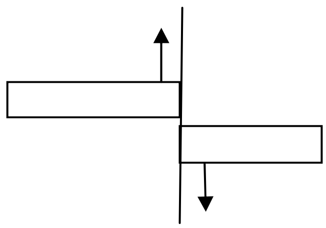
- Draw Shear force and Bending moment diagrams of given loading using open source SF/BM simulation software.

**VI Relevant Affective domain unrelated outcomes:**

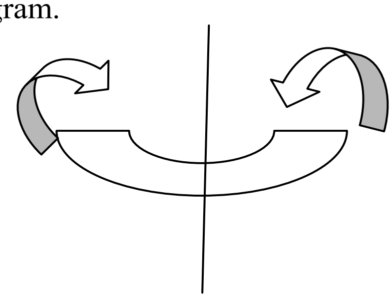
- Follow safety practices.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Follow ethical Practices.

**VII Minimum Theoretical Background:**

1. Shear force: The Shear Force at any cross-section of a horizontal beam is the algebraic sum of the vertical projection of all forces.
2. Loading intensity: The rate of change of SF with respect to distance is called as load intensity.
3. Point of contra-shear: It is the point in SFD where SFD changes its sign.
4. Bending moment: The bending moment at the cross-section of a beam may be defined as the algebraic sum of the moment due to all vertical forces acting on left or right of the section.
5. Point of contra-flexure: It is the point in BMD where BM changes its sign.
6. SFD: Graphical representation of the variation in the shear forces acting at the different cross sections of a given beam from left or right of the section considered . Salient values are written on the diagram.
7. BMD: Graphical representation of variation in the bending moments acting at different cross sections of a given beam from left or right of the section considered. Salient values are written on the diagram.

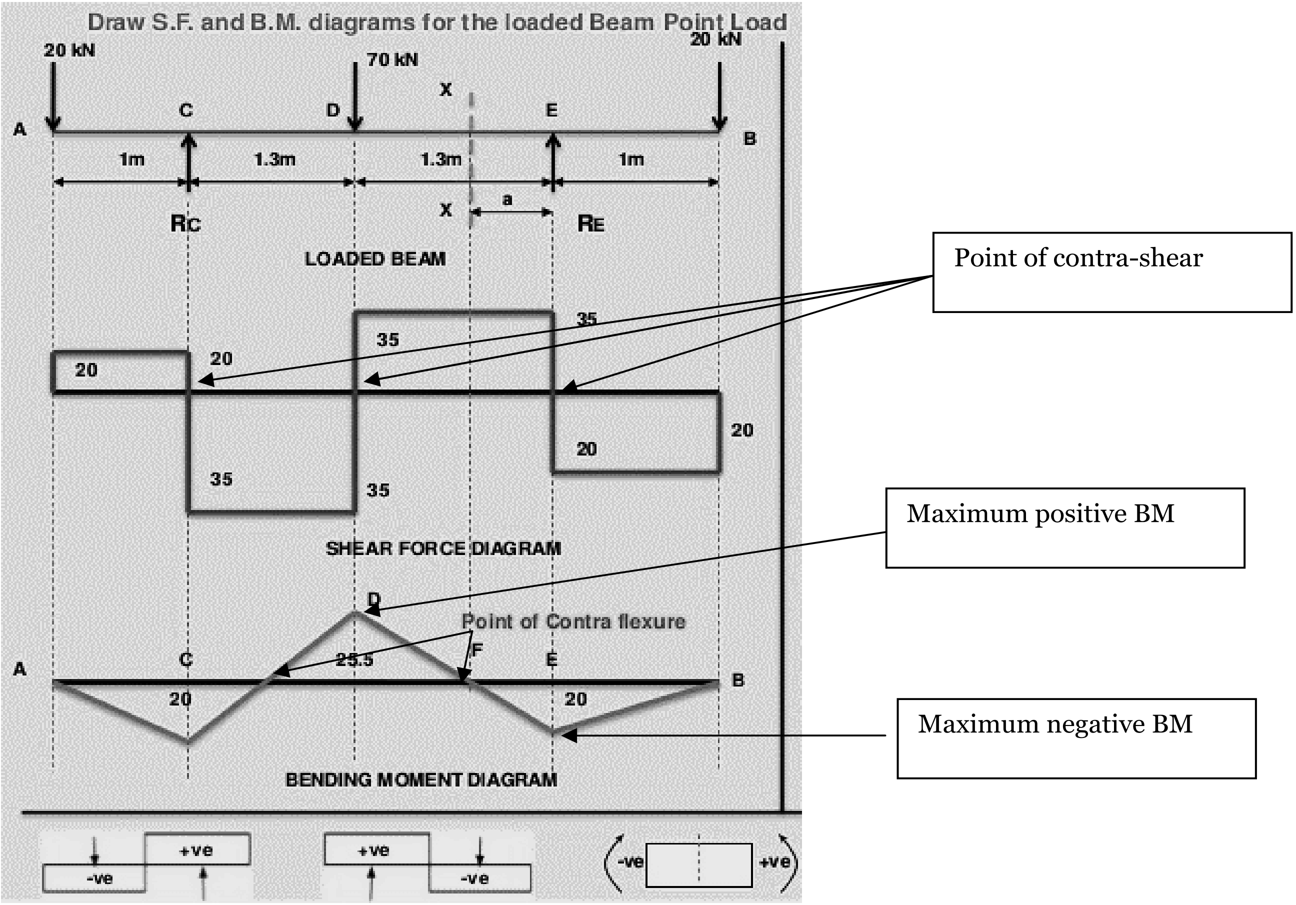


Positive Shear



Positive Bending Moment

## VIII Block diagram / Setup:




## IX Resources Required:

| S. No. | Name of Resource | Suggested Broad Specification | Quantity |
|---|---|---|---|
| 1 | Freeware/open source software for drawing SF and BM diagrams. | 1. **https://platform.skyciv.com/beam?preload_name=Busy%20Beam&preload_path=SkyCiv%20Beam%20Samples**<br>2. **https://in.mathworks.com/matlabcentral/fileexchange/51047-shear-force-bending-moment?s_tid=gn_loc_drop**<br>3. **http://nptel.ac.in/courses/112107146/23** | |

**X Precautions to be followed:**

Select proper freeware, which gives values of all important points on the SF & BM diagrams , from open sources to draw Shear force and Bending moment diagrams of given loading on a beam.

**XI Procedure**

1. Select any freeware software from the open source capable of drawing SFD &BMD
2. Add beam type with details of supports
3. Add loading on beam with span details
4. Add moment or UDL if any.
5. Enter on solve key on software.
6. Obtain SFD & BMDs on software
7. Take out the prints of the diagrams . Attach in the manual.
8. Compare the answers analytically for important points such as point of contra-shear and point of contra-flexure , maximum positive and negative BM, maximum positive and negative SF
9. Solve any four problems on simply supported, cantilever and overhanging beams with point loads and UDLs at different spans on software.

**XII Resources Used**

| S. No. | Name of Resource | Broad Specifications | | Quantity | Remarks (If any) |
|---|---|---|---|---|---|
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**XIII Actual Procedure Followed:**

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**XIV Precautions Followed:**

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**XV Observations and Calculations:**

**Sample Calculations:**

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**XVI Results:**

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**XVII Interpretation of Results (**Giving meaning to the results)

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**XVIII Conclusions** (Actions to be taken based on the interpretations.)

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**XIX Practical Related Questions:**

***Note:*** *Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.*

1. Does the beam section designed on Maximum shear force value criteria differ the section designed on maximum bending moment criteria? Justify your answer.
2. State the relation between increasing / decreasing values of SF for a particular part of a beam with the nature of BM curve between the same portions.
3. For the no load portion of a beam state the nature of SF graph and BM graph for the same portion. Justify your answer.

[Space for Answers]

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## XX References / Suggestions for Further Reading:

1. https://platform.skyciv.com/beam?preload_name=Busy%20Beam&preload_path=SkyCiv%20Beam%20Samples
2. https://in.mathworks.com/matlabcentral/fileexchange/51047-shear-force-bending-moment?s_tid=gn_loc_drop
3. http://nptel.ac.in/courses/112107146/23

## XXI Assessment Scheme:

| Performance Indicators | | Weightage |
|---|---|---|
| **Process Related (10 Marks)** | | **(40%)** |
| 1 | Selection of suitable software | 20% |
| 2 | Putting exact support conditions and loading in the Software | 10% |
| 3 | Locating all important values in SFD &BMD in the print of diagrams | 10% |
| **Product Related (15 Marks)** | | **(60%)** |
| 4 | Determination of PCF point and max+ve / max-ve SF & BM values. | 20% |
| 5 | Interpretation of result | 20% |
| 6 | Conclusions | 10% |
| 7 | Practical related questions | 10% |
| **Total (25 Marks)** | | **100 %** |

***Names of Student Team Members***

1. ……………………..
2. ……………………….
3. …………………………
4. …………………………..

| **Marks Obtained** | | | **Dated signature of Teacher** |
|---|---|---|---|
| **Process Related(10)** | **Product Related(15)** | **Total (25)** | |
| | | | |

# Practical No. 12 & 13: Flexural strength by conducting bending test

**I Practical Significance:**

The significance of a flexure test is to measure flexural strength and flexural modulus. Flexural strength is defined as the maximum stress at the outermost fiber on either the compression or tension side of the specimen. Flexural modulus is calculated from the slope of the stress vs. strain curve. These two values can be used to evaluate the sample materials ability to withstand flexure or bending forces.

Unlike a compression test or tensile test, a flexure test does not measure fundamental material properties. When a specimen is placed under flexural loading all three fundamental stresses are present: tensile, compressive and shear and so the flexural properties of a specimen are the result of the combined effect of all three stresses as well as the geometry of the specimen and the rate the load is applied.

**II Relevant Program Outcomes (POs):**

PO1 - ***Basic knowledge:*** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems.

PO3 - ***Experiments and practice:*** Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems.

PO4 - ***Engineering tools:*** Apply relevant Mechanical technologies and tools with an understanding of the limitations.

PO7 - ***Ethics:*** Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Mechanical engineering.

PO8 - ***Individual and team work:*** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PO 9. ***Communication:*** Communicate effectively in oral and written form.

PO 10. ***Life-long learning:*** Engage in independent and life-long learning activities in the context of technological changes also in the Mechanical engineering and allied industry.

**III Competency and Skills:**

This practical is expected to develop the following skills for the industry identified competency : **"Estimate stresses in structural members and mechanical properties of materials."**

1. Setting up the instruments
2. Ability to observe load, deflections and readings
3. Ability to observe nature of failure of timber specimen.
4. Handling of instruments
5. Interpretation of result.

**IV Relevant Course Outcome(s):**

- Compute Moment of Inertia of symmetric and asymmetric structural sections.
- Compute shear force and bending moment and corresponding shear and bending stresses in beams subjected to point and uniformly distributed loads
- Perform test to evaluate mechanical properties according to Indian Standards.

**V Practical Outcome:**

- Find flexural strength by conducting Bending Test on timber beam of Rectangular cross section with shorter side horizontally oriented as per IS 1708, IS 2408

**VI Relevant Affective domain unrelated outcomes:**

- Follow safety practices.
- Practice good housekeeping.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices

**VII Minimum Theoretical Background:**

The effect of transverse load on the timber beam is to cause deflection at any section of the beam. Bending moment and shear force are developed. Bending stress, shear stress can be easily calculated, when the beam is subjected to central point load. Various characteristics properties will be determined from the following equation.

**1.** Fiber stress at the limit of proportionality = $\mathbf{3WL / 2bd^2}$

Where W is load at elastic limit, L is span of timber specimen, b & d are breadth & depth of specimen

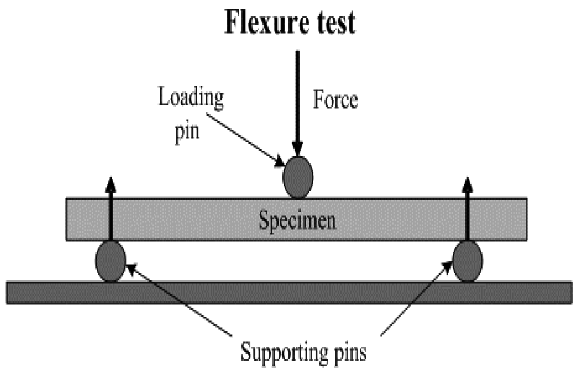
**2.** Modulus of rupture, (flexural Modulus)$\sigma_{b\ max} = (M/I).y$

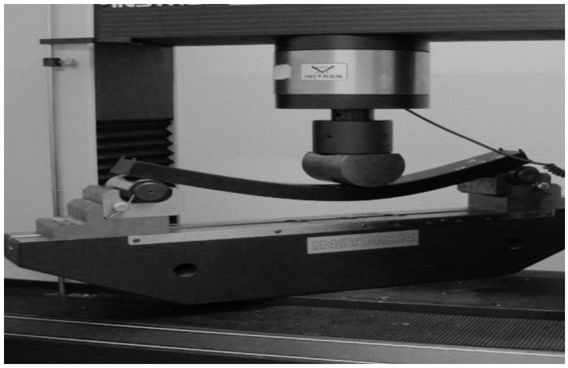
**Where, M = Maximum bending moment**

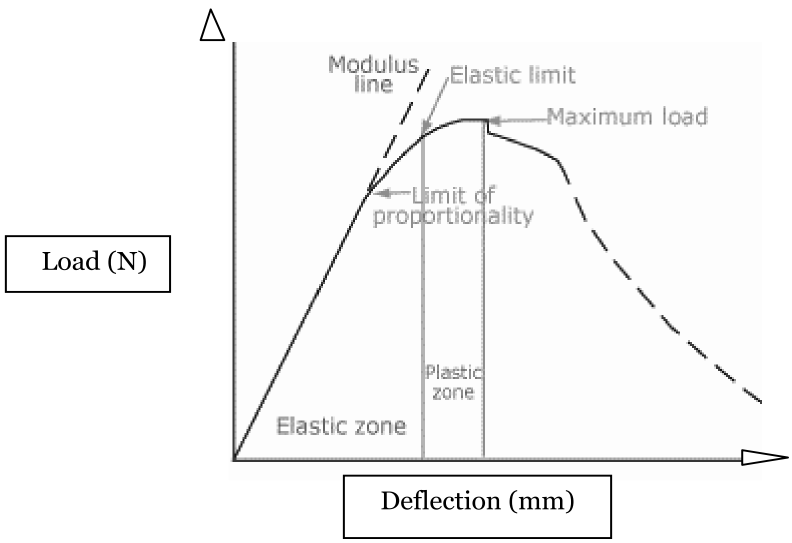
I = M. I. @ axis of bending

y = Distance of extreme fiber from Neutral Axis

## VIII Block diagram / Setup:






## IX Resources Required:

| Sr. No. | Name of Resource | Suggested Broad Specification | Quantity |
|---|---|---|---|
| 1 | Universal testing machine. | Capacity - 100 tonnes. Type: Mechanical type digital, electrically Operated. Accessories: Transverse test attachment with bending Punch, Service tools, Operation and maintenance manuals | 1 No. |
| 2 | Vernier caliper | Least count of 0.02 mm and measuring range of 0.02 mm to 150mm. | 1 No. |

| | | | |
|---|---|---|---|
| 3 | Test jig OR pin (assembly) | Holding supports of specimens (attached to the UTM) | Set |
| 4 | Test specimens | Required dimensions of rectangular c/s of timber specimen.<br>* 50 x 50 c/s, Length between supports is 400 mm. | **02 (for Part I & II)** |
| 5 | Loading block | Mandrel on UTM | 01 |
| 6 | scale | 100 cm or 50 cm long to measure length | 01 |

**X Precautions to be Followed:**

1. Avoid over accelerating or over loading of UTM and maintain proper rate of loading.
2. Place the sample exactly at the center of lower cross head of test jig or pins.
3. The specimens shall be free from any defect and shall not have a slope of grain more than 1 in 20 parallel to longitudinal edges.
4. At the time of operation keep safe distance from the machine or use caging.
5. The specimen shall be supported on the rig in such a way that it will be quite free to follow the bending action and will not be restrained by friction

**XI A) Procedure (Part I- when shorter side of cross section of timber specimen is kept horizontally)**

1. Measure the dimensions of specimen.
2. Fix the bending attachment to the appropriate cross head of UTM
3. The test specimen shall be so placed that shorter side of cross section of timber specimen is kept **horizontally** on a jig or pin and the load is applied through a loading block to the top surface and at the centre of timber specimen.
4. Select suitable loading rate and apply constantly.
5. Record the loads and deflections at suitable intervals.
6. Record the load at rupture and observe the nature of failure.
7. Plot a graph of load Vs deflection.

**XII Resources Used:**

| S. No. | Name of Resource | Broad Specifications | | Quantity | Remarks (If any) |
|---|---|---|---|---|---|
| | | Make | Details | | |
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**XIII Actual Procedure Followed:**

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**XIV Precautions Followed:**

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**XV A) Observations and Calculations: (Part I- when shorter side of cross section of timber specimen is kept horizontally)**

**Observations:**

1. Material of the sample=
2. Length of sample L =…………mm
3. Breadth or width of sample =………..mm
4. Depth or thickness of sample =………..mm
5. Moment of Inertia @ bending axis I= ---------- $mm^4$
6. Load at rupture W = ---------------- N

**Records of load and Deformations.(Part I- when shorter side of cross section of timber specimen is kept horizontally):**

| Sr. No. | Applied Load P (Newton) | Deflection(δ)(mm) |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |
| 9 | | |
| 10 | | |
| 11 | | |
| 12 | | |
| 13 | | |
| 14 | | |
| 15 | | |

**Sample Calculations :( for reading No…….)**

**1.** Bending equation, $M/I = \sigma_b/y$

**2.** Maximum bending moment M= WL / 4 = -------------- N-mm$^2$ …where W= load at rupture.

**3.** Moment of inertia I = ---------------- =

= ----------------mm$^4$

**4.** Distance of extreme fiber from Neutral Axis, y = --------mm

**5.** The modulus of **r**apture or maximum bending stress of given timber specimen

$\sigma_{br}$ = (M/I ) . y = ---------

= ------------------- N/mm$^2$

= ------------------- N/mm$^2$

**6.** Fiber stress at **e**lastic limit or limit of proportionality $\sigma_{be}$ = 3WL/ 2bd$^2$

Where W is load at elastic limit = ------------------- N/mm$^2$

= ------------------- N/mm$^2$

**XI B) Procedure (Part II- when shorter side of cross section of timber specimen is kept Vertically):**

1. Measure the dimensions of specimen.
2. Fix the bending attachment to the appropriate cross head of UTM
3. The test specimen shall be so placed that shorter side of cross section of timber specimen is kept **vertically** on a jig or pin and the load is applied through a loading block to the top surface and at the centre of timber specimen.
4. Select suitable loading rate and apply constantly.
5. Record the load and deflections at suitable intervals.
6. Record the load at rupture and observe the nature of failure.
7. Plot a graph of load Vs deflection.

**XII B) Resources Used:**

| S. No. | Name of Resource | Broad Specifications | | Quantity | Remarks (If any) |
|---|---|---|---|---|---|
| | | Make | Details | | |
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**XIII B) Actual Procedure Followed:**

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**XIV B) Precautions Followed:**

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**XV B) Observations and Calculations (Part II- when shorter side of cross section of timber specimen is kept Vertically):**

**Observations:**

1. Material of the sample =
2. Length of sample L =…………mm
3. Breadth or width of sample =…………mm
4. Depth or thickness of sample =…………mm
5. Moment of Inertia @ bending axis I= ---------- $mm^4$
6. **Load at rupture** W = ---------------- N

**B) Recording of load and Deformations. (Part II- when shorter side of cross section of timber specimen is kept Vertically)**

| Sr.No. | Applied Load P (Newton) | Deflection (δ) (mm) |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |
| 9 | | |
| 10 | | |
| 11 | | |
| 12 | | |
| 13 | | |
| 14 | | |
| 15 | | |

**Sample Calculations: (for reading No…….)**

1. Bending equation , M/I = $\sigma_b$ **/y**
2. Maximum bending moment M= WL / 4 = -------------- N-mm$^2$ …where W= load at rupture
3. Moment of inertia I = -----------------=
   = ----------------mm$^4$
4. Distance of extreme fiber from NA, y = --------mm
5. The modulus of **r**apture or maximum bending stress of given timber specimen

   $\sigma_{br}$ = (M/I ) . y = ---------
   = ------------------- N/mm$^2$
   = ------------------- N/mm$^2$

6. Fiber stress at **e**lastic limit or limit of proportionality $\sigma_{be}$ = 3WL/ 2db$^2$
   Where W is load at elastic limit = -------------------
   N/mm$^2$
   = ------------------- N/mm$^2$

**XVI Results:**

1. Modulus of rupture $\sigma_{br}$ = --------N/mm$^2$ ..for Part I (specimen kept horizontally)
2. Modulus of rupture $\sigma_{br}$ = --------N/mm$^2$ ..for Part II (specimen kept Vertically)
3. Fiber stress at **e**lastic limit or limit of proportionality $\sigma_{be}$ =--------N/mm$^2$ ..for Part I (specimen kept horizontally)
4. Fiber stress at **e**lastic limit or limit of proportionality $\sigma_{be}$ =--------N/mm$^2$ ..for Part II (specimen kept Vertically)

**XVII Interpretation of Results: (**Giving meaning to the results)

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**XVIII Conclusions: (**Actions to be taken based on the interpretations.)

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**XIX Practical Related Questions:**

*Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.*

1. Calculate the maximum bending stress of 250 mm wide 450 mm depth of same timber specimen if it is simply supported and carrying 10 kN central point load using flexural formula.
2. Explain and sketch the nature of bending and shear stress diagrams at extreme fiber at top and bottom for simply supported beam section.

3. Explain and sketch the nature of bending and shear stress diagrams at extreme fiber at top and bottom for cantilever beam section.
4. Explain the reason of crack formation at center of beam section at maximum load.

[Space for Answers]

## XX References / Suggestions for Further Reading:


1. IS 1708-1 to 18 (1986): Methods of testing of small clear specimens of timber [CED 9: Timber and Timber Stores]
2. https://www.scribd.com/doc/242342954/flexural-test-lab-report
3. https://www.testresources.net/applications/test-types/flexural-test/


## XXI Assessment Scheme:

| Performance Indicators | | Weightage |
|---|---|---|
| **Process Related (10 Marks)** | | **(40%)** |
| 1 | Handling of the UTM and attachment for flexure test | 20% |
| 2 | Loading of the specimen | 10% |
| 3 | Taking readings by observations | 10% |
| **Product Related (15 Marks)** | | **(60%)** |
| 4 | Determination of flexural strength & Fiber stress | 20% |
| 5 | Interpretation of result | 20% |
| 6 | Conclusions | 10% |
| 7 | Practical related questions | 10% |
| **Total (25 Marks)** | | **100 %** |

***Names of Student Team Members***

1. ……………………..
2. ……………………….
3. ………………………
4. ………………………

| **Marks Obtained** | | | **Dated signature of Teacher** |
|---|---|---|---|
| **Process Related(10)** | **Product Related(15)** | **Total (25)** | |
| | | | |

# Practical No. 14 & 15: Torsion test on mild steel

**I Practical Significance:**

Materials commonly used in the manufacturing industry, such as metal fasteners and beams are often subjected to torsion, hence determination of their strength under twisting is necessary. Without torsion test, materials would not be properly vetted before being launched for commercial use.

In torsion test the measurable values include the modulus of elasticity in shear, yield shear strength, ductility, ultimate shear strength, and modulus of rupture in shear. These values are similar but not the same as those measured by a tensile test and are important in manufacturing as they may be used to simulate the service conditions, check the product's quality and design, and ensure that it was manufactured correctly.

The three common forms that torsion testing include **failure, proof** and **operational tests**. **A torsion test for failure requires that the test sample be twisted until it breaks** and is designed to measure the strength of the sample. **A proof test is designed to observe the material under a specified torque over a set period of time**. **Finally, operational testing measures the material's performance under the expected service conditions of its application**. All of these forms of tests may be performed with either torsion only or a combination of torsion and axial (tension or compression) loading depending upon the characteristics to be measured.

**II Relevant Program Outcomes (POs):**

PO1 - ***Basic knowledge:*** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems.

PO3 - ***Experiments and practice:*** Plan to perform experiments and practices to use the Results to solve broad-based mechanical engineering problems.

PO4- ***Engineering tools:*** Apply relevant Mechanical technologies and tools with an understanding of the limitations.

PO7- ***Ethics:*** Apply ethical principles for commitment to professional ethics, Responsibilities and norms of the practice also in the field of Mechanical engineering.

PO8- ***Individual and team work:*** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PO9- ***Communication:*** Communicate effectively in oral and written form.

PO10- ***Life-long learning:*** Engage in independent and life-long learning activities in the context of technological changes also in the Mechanical engineering and allied industry.

**III Competency and Skills:**

This practical is expected to develop the following skills for the industry identified competency: **"Estimate stresses in structural members and mechanical properties of materials."**

1. Selection of suitable material for the given loading.
2. Handling of instruments
3. Interpretation of result.
4. Setting up the instruments

**IV Relevant Course Outcome(s):**

- Estimate stresses in shafts under twisting moments.

**V Practical Outcome:**

- Determine modulus of rigidity by conducting Torsion Test on MS (Part II) as per IS 1717

**VI Relevant Affective domain unrelated outcomes:**

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices

**VII Minimum Theoretical Background:**

The value of modulus of rigidity can be found out through observations made during the experiment and by using the torsion equation

$T/ G.\theta = J/ L$ OR $G = T.L / J. \theta$

Where, T = Torque applied,

J = Polar moment of inertia,

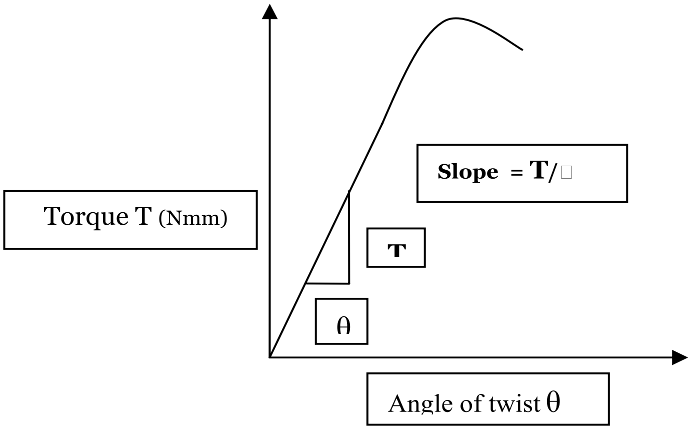
G = Modulus of rigidity,

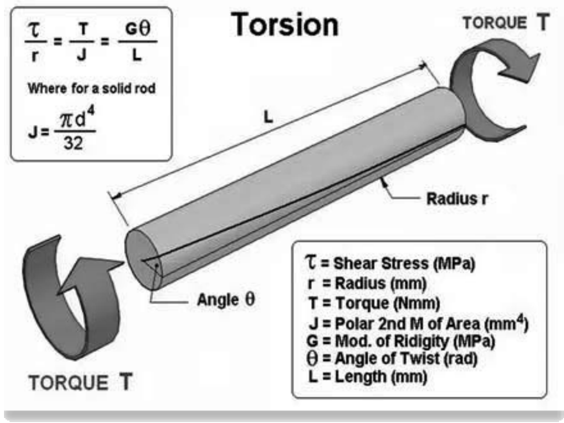
$\theta$ = Angle of twist (radians), and L = Gauge length

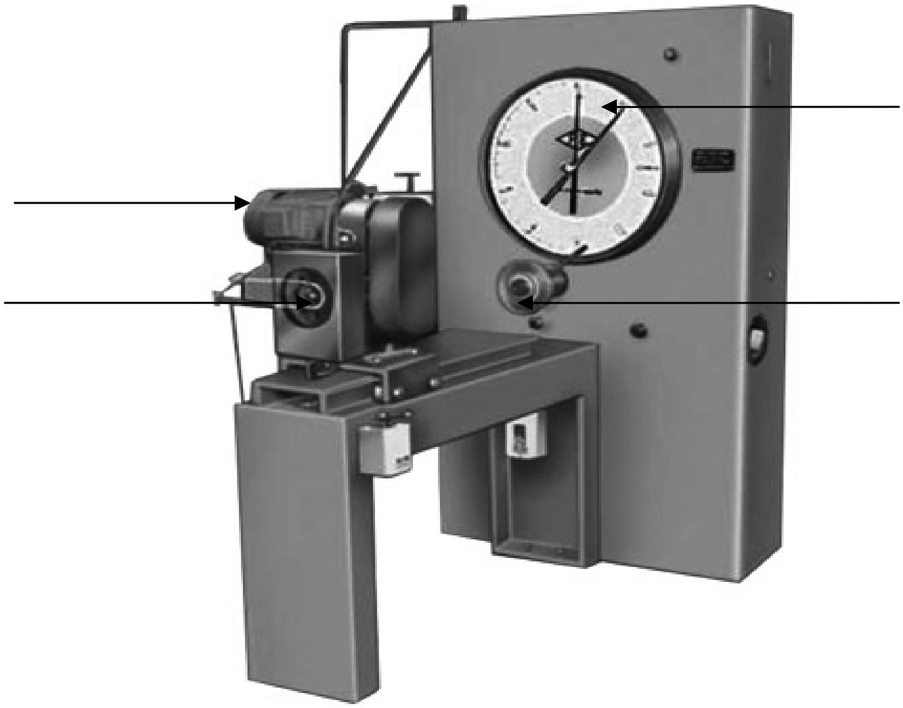
The value of maximum shear stress at elastic limit can be found out through observations made during the experiment and by using the torsional equation

$(\tau_{max}) =$ **T.r/J…..**where, r is radius of shaft in mm and
T is torque at elastic limit

## VIII Block diagram / Setup:



Torsion Testing Machine

## IX Resources Required:

| S. No. | Name of Resource | Suggested Broad Specification | Quantity |
|---|---|---|---|
| 1 | Torsion testing machine. | 1. Fixed with auto torque selector to regulate torque ranges Contains geared motor to apply torque to specimen through gearbox Attached with autographic recorder for relation between torque and angle of twist Accuracy + 1 % of the true torque Suitable For: Torsion and Twist test on diverse metal rods and flats Torque Measurement by pendulum dynamometer system<br>2. One of the grips shall be capable of being rotated around the axis of the test piece while the other shall not be subject to any angular deflection, except for such deflection as may be necessary to measure the torque.<br>3.The distance between the grips shall be capable of adjustment for different test piece lengths.<br>4.Testing machine, constructed so that a change of length between the grips, caused by contraction of the test piece during testing, is not prevented and that an appropriate tensile stress may be applied to the test piece. | 1 No. |
| 2 | Vernier caliper | Least count of 0.02 mm and measuring range of 0.02 mm to 150mm. | 1 No. |
| 3 | Specimen | Having minimum dimensions as per manuals of machine available | 1 No. |

## X Precautions to be Followed:

1. Avoid over acceleration of machine and maintain proper rate of loading.
2. Place the sample exactly at the required location only and fix properly.
3. At the time of operation keep safe distance from the machine or use caging.
4. Specimens of Grips having a minimum hardness of 55 HRC and straight faces must be used.
5. The grips shall be placed in the testing machine in such a way that during testing they remain on the same axis of specimen and do not apply any bending force to the test piece.
6. In general, the test is carried out at a temperature between 10 °C and 35 °C. Tests carried out under controlled conditions, where required, shall be made at a temperature of (23 ± 5) °C.

## XI Procedure:

1. Select the driving dogs to suit the size of the specimen and clamp it in the machine by means of a sliding spindle.
2. Measure the length and diameter at about three places and take the average value.
3. Mark a line over the surface of specimen along its length, to observe the number of turns (Nt).
4. Choose appropriate range by capacity change lever
5. Set the maximum load pointer to zero.
6. Set the protector to zero for convenience and clamp it by means of knurled screw.
7. Carry out straining by rotating one of the end with the help of hand wheel or electric motor in either direction.
8. Load the machine in suitable increments, record the readings of torque and angle of twist **(T & θ)**
9. Then load out to elastic limit so that the straight line graph can be obtained.
10. When the elastic limit is crossed, continue to test the sample for the destruction with increasing values of strain. Record the values of T & θ for each strain increment up to fracture. Compare the failure patterns with Annex A and comment on fracture plane ( smooth / Stepped/ Brittle/ Entirely cracked Or Irregular)
11. If the number of turns, *N*t, meets the requirements of the relevant standard, the test piece shall be considered as having passed the test, irrespective of the position of failure. If the number of turns, *N*t, reached, does not meet the requirements of the relevant standard and the failure is within 2 *d* distance from the grips, the test shall be considered invalid and shall be repeated. Where d is the diameter of the rod.
12. Plot a torque verses twist (T Vs θ) graph.
13. Read off co-ordinates of a convenient point from the straight line portion of the torque- twist ( T Vs θ ) graph and calculate the value of the modulus of rigidity (G) by using torsional equation.
14. Label the different parts of Torsion testing machine as shown in the figure.

## XII Resources Used:

| S. No. | Name of Resource | Broad Specifications | | Quantity | Remarks (If any) |
|---|---|---|---|---|---|
| | | Make | Details | | |
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## XIII Actual Procedure Followed:

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## XIV Precautions Followed:

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## XV Observations and Calculations:

**Observations:** 1) Material of the sample =

2) Diameter of sample,

$d_1$=………..mm, $d_2$=………..mm, $d_3$=………..mm

Average diameter d =

3) Length of sample L =………….mm

4) Least count of dial gauge of torque =………..N-mm

5) Least count on circular disc of Angle of twist θ

=………Degrees

**Observation Table :**

| S.N. | Torque (T) (N-mm) | Angle of twist (θ) | |
|---|---|---|---|
| | | θ In Degrees | θ In Radians = (π/180)* θ In Degrees |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | | | |
| 10 | | | |
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| 14 | | | |
| 15 | | | |

Number of turns at failure =Nt = …………

**Sample Calculations: (for reading No. )**

1. Polar moment of inertia (J) = $\pi/32 \cdot d^4$

=

= -----------$mm^4$

2. From torsional formula $T / J = G.\theta / L$ OR $G = T.L / J. \theta$

G = (Slope of the graph T Vs θ ) x L/J

= -----------------$N/mm^2$

3. Maximum Shear stress ($\tau_{max}$) = **T.r / J…..**where, r is radius of shaft in mm and T is torque at elastic limit

($\tau_{max}$) =

**XVI Results:**

1. Modulus of rigidity of mild steel is G = ---------
2. Maximum shear stress of mild steel is $\tau_{max}$ = ---------
3. Numbers of turns at failure Nt = …………
4. Failure plane is ( Smooth / Stepped/ Brittle/ Entirely cracked Or Irregular)

**XVII Interpretation of Results: (**Giving meaning to the results)

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**XVIII Conclusions: (**Actions to be taken based on the interpretations.)

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**XIX Practical Related Questions:**

***Note:*** *Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.*

1. Calculate the Modulus of rigidity of sample of same material of 120 mm diameter and **1 m** length.
2. Explain the relation between torque and angle of twist under elastic limit and beyond at failure in ductile materials.
3. Sketch the shear stress distribution diagram for solid and hollow circular shafts.

[Space for Answers]

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## XX References / Suggestions for Further Reading:


1. IS 1717 (2012): Metallic Materials - Wire - Simple Torsion Test [MTD 3: Mechanical Testing of Metals]
2. http://www.green-mechanic.com/2016/09/torsional-testing-of-materials.htm


## XXI Assessment Scheme:

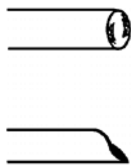
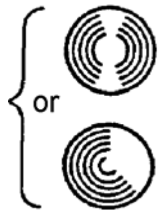
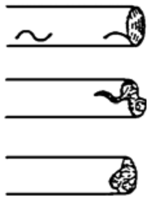
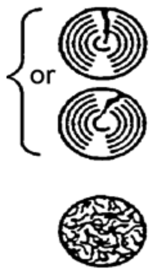
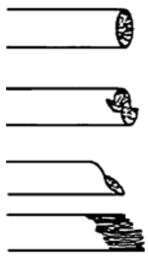
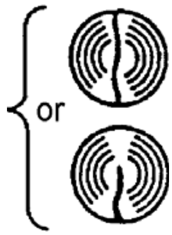
| Performance Indicators | | Weightage |
|---|---|---|
| **Process Related (10 Marks)** | | **(40%)** |
| 1 | Handling of the TTM and Dial gauge | 20% |
| 2 | Loading of the specimen | 10% |
| 3 | Taking readings using dial indicator | 10% |
| **Product Related (15 Marks)** | | **(60%)** |
| 4 | Determination of polar MI and modulus of rigidity | 20% |
| 5 | Interpretation of result | 20% |
| 6 | Conclusions | 10% |
| 7 | Practical related questions | 10% |
| **Total (25 Marks)** | | **100 %** |

***Names of Student Team Members***

1. ……………………..
2. ……………………….
3. …………………………
4. ………………………..

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related(10)** | **Product Related(15)** | **Total (25)** | |
| | | | |

## Annexure A:
### Evaluation of fractures occurring during simple torsion test

| Type of fracture | Type No. | Aspect | Description and characteristics | Fracture plane |
|---|---|---|---|---|
| | Product | | | |
| Normal torsion fracture | 1 A<br>B |  | Smooth: fracture plane perpendicular to wire axis (or slightly oblique). No cracks in fracture plane.<br>Brittle: fracture plane at an angle of 45° to wire axis. No cracks in fracture plane. |  |
| Fracture with local cracks Regular fracture (material defects) | 2 A<br>B<br>C |  | Smooth: fracture plan perpendicular to wire axis and partially cracked.<br>Stepped: a part of the fracture plane is still smooth: partially cracked.<br>Irregular fracture plane: no cracks in fracture plane. |  |
| Fracture with spiral cracks over the whole length (or large part of it) Crack formation already occurs after a low number (3 to 5) of torsions and is best visible at that moment | 3 A<br>B<br>C |  | Smooth: fracture plane perpendicular to wire axis and partially or entirely cracked.<br>Stepped: a part of the fracture plane is still smooth and partially or entirely cracked.<br>Brittle: fracture plane at an angle of 45° and partially or entirely cracked or<br>Irregular fracture plane and partially or entirely cracked |  |

# Practical No. 16: Determination of direct stress, bending stress and resistance stress for a given practical approach.

## I Practical Significance:

In strength of material you need to understand how object reacts to various forces. The behaviour of the material to axial loading /pure bending / direct stress& combined bending is different.

It is difficult to measure combined defect of direct and bending by experimental set up. Hence we have incorporated analytical approach to direct stress, bending stress and resultant stresses of mechanical elements.

Objective of this practical is to become familiar with the components like C-Clamp, hook, offset Links, Hacksaw frame etc. and analyse the effect of direct and Eccentric load and their stress distribution pattern.

## II Relevant Program Outcomes (POs):

PO1 - ***Basic knowledge:*** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO3 - ***Experiments and practice:*** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

PO4 - ***Engineering tools****:* Apply relevant Mechanical technologies and tools with an understanding of the limitations

PO7- ***Ethics:*** Apply ethical principal for commitment to professional ethics, responsibilities and norms of the practice also in the field of mechanical Engineering.

PO8 - ***Individual and team work****:* Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PO9 - ***Communication****:* Communicate effectively in oral and written form.

PO10 - ***Life-long learning****:* Engage in independent and life-long learning activities in the context of technological changes also in the Mechanical engineering and allied industry.

## III Competency and Skills:

- This practical is expected to develop the following skills for the industry identified competency : **'Estimate stresses in Mechanical elements and mechanical properties of materials.'**

1. Calculate the stresses for different eccentrically loaded cross section.
2. Design Sections for members carrying direct compressive/ tensile force and bending stresses
3. Analyze the effect of direct and eccentric load and their stress distribution pattern on C-Clamp, hook, offset Links, Hacksaw frame etc.

## IV Relevant Course Outcome(s):

- Perform test to evaluate mechanical properties according to Indian Standards.
- Compute Moment of Inertia of symmetric and asymmetric structural sections.
- Estimate stresses in short member subjected to eccentric loading.
- Compute Middle third rule for no tension conditions.

## V Practical Outcome:

- Calculate stress distribution in column and mechanical element by determining maximum and minimum resultant stress.

## VI Relevant Affective domain related outcomes:

- Follow safety practices.
- Practice good housekeeping.
- Demonstrate working as a leader/a team member.
- Practice Energy Conservation.

## VII Minimum Theoretical Background:

1. Axial Load: When load is acting along the longitudinal axis of column. It produce direct stress in column.
2. Eccentric load: A load whose line of action does not coincide with the axis of column. It produce direct and bending stress in column.
3. Eccentricity: The horizontal distance between the longitudinal axis of column and line of action of load.
4. When short column is subjected to axial compressive /Tensile force only direct stress ($\sigma_0$) is produce in the column.

   Direct Stress = $\sigma_0 = P/A$

5. **Eccentric Load produces both direct stress ($\sigma_0$) and bending stress ($\sigma_b$) in column.**

   Direct Stress = $\sigma_0 = P/A$
   Bending Stress = $\sigma_b = M/Z = M*y/I$ Where $Z = I/y$

6. **Stress Distribution Diagram :**

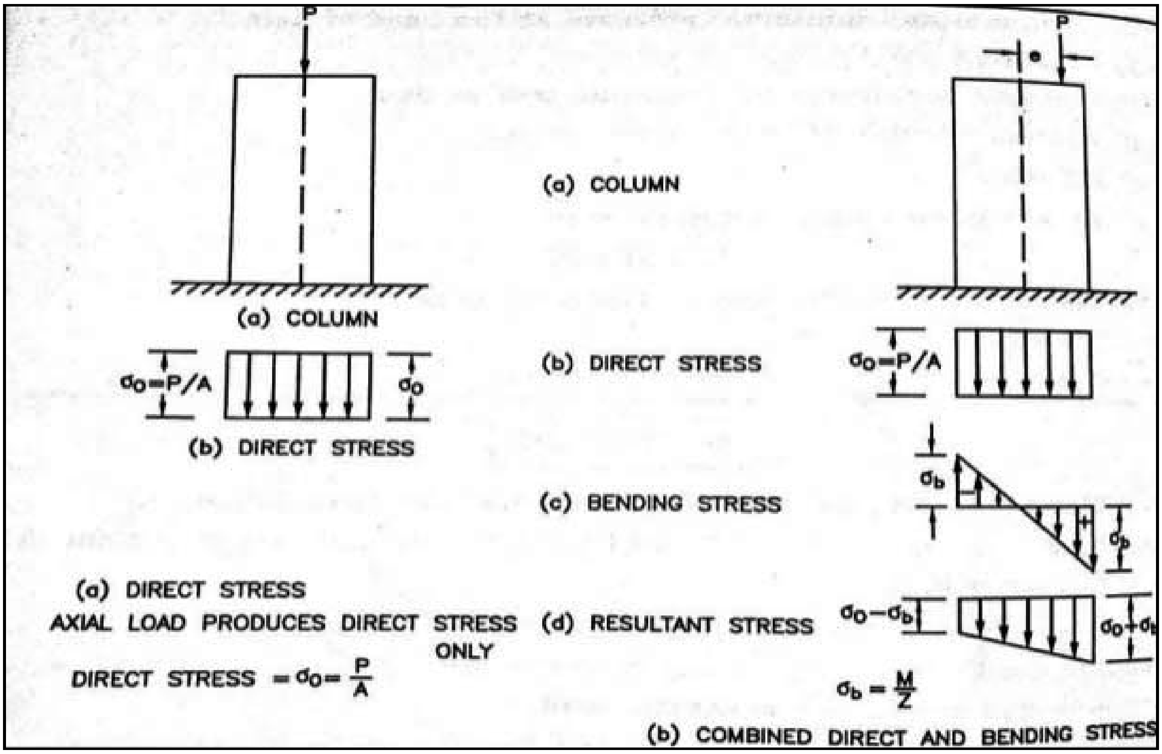



**Figure No. 1**

**VIII Steps for Solving Problems**:

1. Calculate area (A)
2. Calculate distance from N. A. (y)
3. Calculate Moment of inertia (I)
4. Calculate moment due to eccentric load $M = P \times e$
5. Calculate direct stress $\sigma_0 = P/\mathbf{A}$
6. Calculate bending stress $\sigma_b = M/Z = M*y/I$ Where $Z = I/y$
7. Calculate resultant stress

$$\sigma_{rmax} = \sigma_0 + \sigma_b$$

$$\sigma_{rmin} = \sigma_0 - \sigma_b$$

Note:
If the load is compressive load and magnitude of resultant stress is positive then the nature of stress is compressive, and if magnitude of resultant stress is negative then the nature of stress is tensile. If the load is tensile load and magnitude of resultant stress is positive then the nature of stress is tensile, and if magnitude of resultant stress is negative then the nature of stress is compressive.

## IX Analytical Based problems

1. Figure shows the frame of screw clamp carrying load of 10 KN. The cross section of frame is rectangular having width 60mm and thickness 20mm. Determine, the resultant stress for the frame material and draw stress distribution diagram.

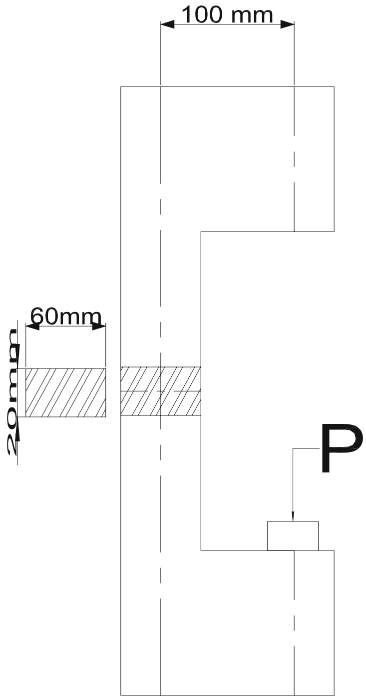



**Figure No. 2**

2. Figure shows M.S. offset link subjected to a pull of 60 KN . The cross section of link is rectangular having b=120 mm and t = 40 mm. Determine, the resultant stress for the frame material and draw stress distribution diagram.

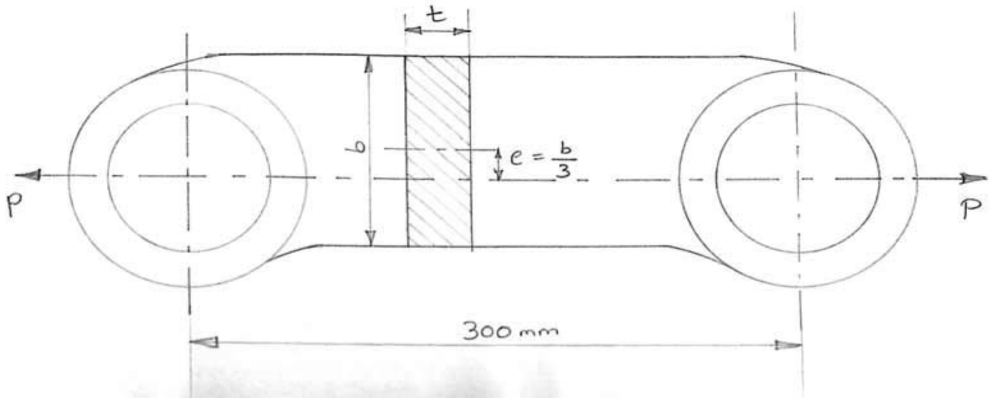



**Figure No. 3**

3. A Mild steel tube 60mm external diometer and 10mm thick is bent in the form of hook. What maximum load P the hook can lift, if the stress on cross section X-X should not exceed 100 N/$mm^2$ in tension and 20 N/$mm^2$ in compression.

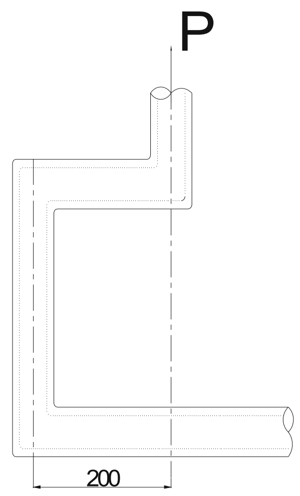



**Figure No. 4**

4. Determine the stress at A&B as shown in figure and draw stress distribution diagram.

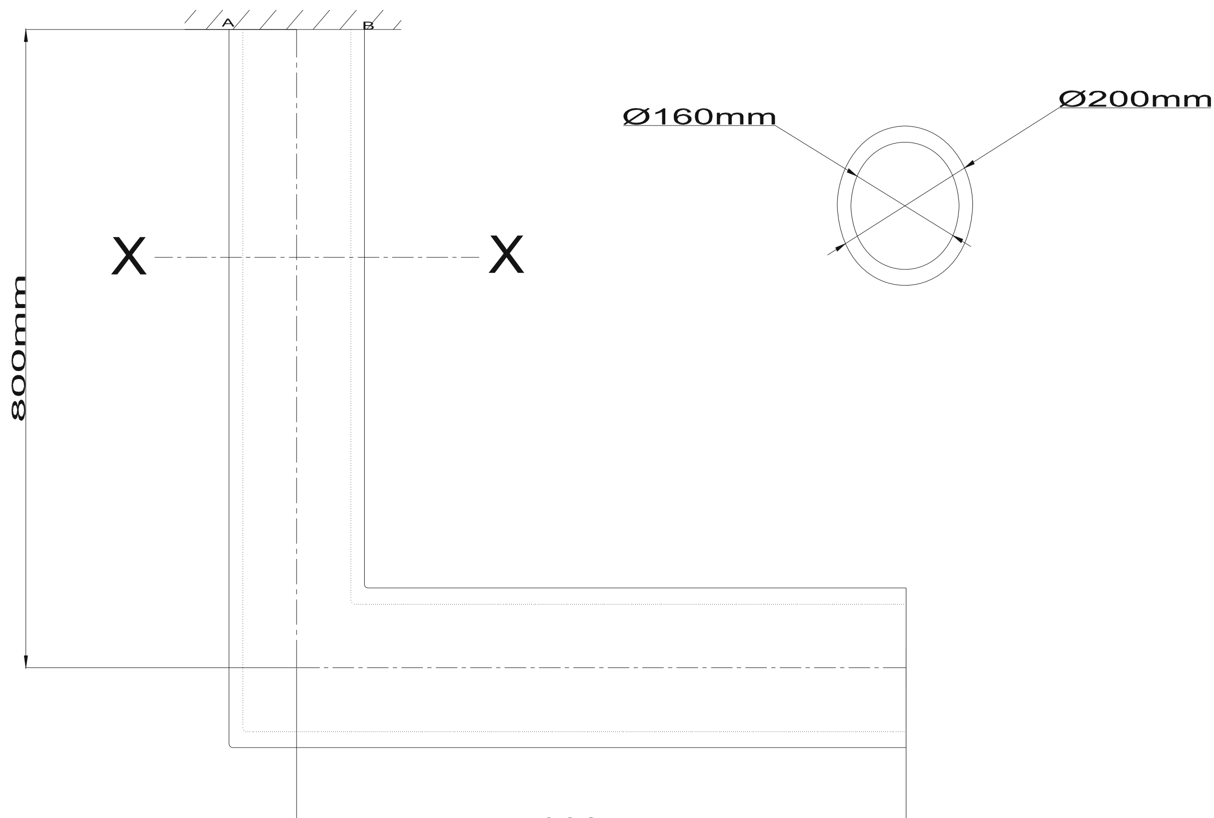



**Figure No. 5**

## X Practical related questions :

1. Define direct stress, bending stress and resultant stress
2. Define no tension condition.
3. Calculate eccentricity and draw core of section for circular cross section having diameter (d) for no tension condition.
4. Draw core of section for hollow circular section for no tension condition having external diameter (D) and internal diameter (d).
5. Draw kernel of section for rectangular section having breadth 2000mm and depth 1000mm.

[Space for Answers]

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## XI Assessment Scheme:

| Performance Indicators | | Weightage |
|---|---|---|
| **Process Related (10 Marks)** | | **(40%)** |
| 1 | Handling of the measuring Instruments | 30% |
| 2 | Calculation of final readings | 10% |
| **Product Related (15 Marks)** | | **(60%)** |
| 3 | Interpretation of result | 20% |
| 4 | Conclusions | 20% |
| 5 | Practical related questions | 20% |
| | **Total (25 Marks)** | **100 %** |

***Names of Student Team Members***

1. ……………………..
2. ……………………….
3. …………………………
4. …………………………

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related(10)** | **Product Related(15)** | **Total (25)** | |
| | | | |

# List Of Laboratory Manuals Developed by MSBTE

**First Semester:**

| | | |
|---|---|---|
| 1 | Fundamentals of ICT | 22001 |
| 2 | English | 22101 |
| 3 | English Work Book | 22101 |
| 4 | Basic Science (Chemistry) | 22102 |
| 5 | Basic Science (Physics) | 22102 |

**Second Semester:**

| | | |
|---|---|---|
| 1 | Bussiness Communication Using Computers | 22009 |
| 2 | Computer Peripherals & Hardware Maintenace | 22013 |
| 3 | Web Page Design with HTML | 22014 |
| 4 | Applied Science (Chemistry) | 22202 |
| 5 | Applied Science (Physics) | 22202 |
| 6 | Applied Machines | 22203 |
| 7 | Basic Surveying | 22205 |
| 8 | Applied Science (Chemistry) | 22211 |
| 9 | Applied Science (Physics) | 22211 |
| 10 | Fundamental of Electrical Engineering | 22212 |
| 11 | Elements of Electronics | 22213 |
| 12 | Elements of Electrical Engineering | 22215 |
| 13 | Basic Electronics | 22216 |
| 14 | 'C' programming Language | 22218 |
| 15 | Basic Electronics | 22225 |
| 16 | Programming in "C" | 22226 |
| 17 | Fundamentals of Chemical Engineering | 22231 |

**Third Semester:**

| | | |
|---|---|---|
| 1 | Applied Multimedia Techniques | 22024 |
| 2 | Advanced Serveying | 22301 |
| 3 | Highway Engineering | 22302 |
| 4 | Mechanics of Structures | 22303 |
| 5 | Building Construction | 22304 |
| 6 | Concrete Technology | 22305 |
| 7 | Strength Of Materials | 22306 |
| 8 | Automobile Engines | 22308 |
| 9 | Automobile Transmission System | 22309 |
| 10 | Mechanical Operations | 22313 |
| 11 | Technology Of Inorganic Chemicals | 22314 |
| 12 | Object Oriented Programming Using C++ | 22316 |
| 13 | Data Structure Using 'C' | 22317 |
| 14 | Computer Graphics | 22318 |
| 15 | Database Management System | 22319 |
| 16 | Digital Techniques | 22320 |
| 17 | Principles Of Database | 22321 |
| 18 | Digital Techniques & Microprocessor | 22323 |
| 19 | Electrical Circuits | 22324 |
| 20 | Electrical & Electronic Measurment | 22325 |
| 21 | Fundamental Of Power Electronics | 22326 |
| 22 | Electrical Materials & Wiring Practice | 22328 |
| 23 | Applied Electronics | 22329 |
| 24 | Electrical Circuits & Networks | 22330 |
| 25 | Electronic Measurments & Instrumentation | 22333 |
| 26 | Principles Of Electronics Communication | 22334 |
| 27 | Thermal Engineering | 22337 |
| 28 | Engineering Matrology | 22342 |
| 29 | Mechanical Engineering Materials | 22343 |
| 30 | Theory Of Machines | 22344 |

**Fourth Semester:**

| | | |
|---|---|---|
| 1 | Hydraulics | 22401 |
| 2 | Geo Technical Engineering | 22404 |
| 3 | Chemical Process Instrumentation & Control | 22407 |
| 4 | Fluid Flow Operation | 22409 |
| 5 | Technology Of Organic Chemicals | 22410 |
| 6 | Java Programming | 22412 |
| 7 | GUI Application Development Using VB.net | 22034 |
| 8 | Microprocessor | 22415 |
| 9 | Database Managment | 22416 |
| 10 | Electric Motors And Transformers | 22418 |
| 11 | Industrial Measurements | 22420 |
| 12 | Digital Electronics And Microcontroller Applications | 22421 |
| 13 | Linear Integrated Circuits | 22423 |
| 14 | Microcontroller & Applications | 22426 |
| 15 | Basic Power Electronics | 22427 |
| 16 | Digital Communication Systems | 22428 |
| 17 | Mechanical Engineering Measurments | 22443 |
| 18 | Fluid Mechanics and Machinery | 22445 |
| 19 | Fundamentals Of Mechatronics | 22048 |

**Fifth Semester:**

| | | |
|---|---|---|
| 1 | Design of Steel and RCC Structures | 22502 |
| 2 | Public Health Engineering | 22504 |
| 3 | Heat Transfer Operation | 22510 |
| 4 | Environmental Technology | 22511 |
| 5 | Operating Systems | 22516 |
| 6 | Advanced Java Programming | 22517 |
| 7 | Software Testing | 22518 |
| 8 | Control Systems and PLC's | 22531 |
| 9 | Embedded Systems | 22532 |
| 10 | Mobile and Wireless Communication | 22533 |
| 11 | Industrial Machines | 22523 |
| 12 | Switchgear and Protection | 22524 |
| 13 | Energy Conservation and Audit | 22525 |
| 14 | Power Engineering and Refrigeration | 22562 |
| 15 | Solid Modeling and Additive Manufacturing | 22053 |
| 16 | Guidelines & Assessment Manual for Micro Projects & Industrial Training | 22057 |

**Sixth Semester:**

| | | |
|---|---|---|
| 1 | Solid Modeling | 17063 |
| 2 | Highway Engineering | 17602 |
| 3 | Contracts & Accounts | 17603 |
| 4 | Design of R.C.C. Structures | 17604 |
| 5 | Industrial Fluid Power | 17608 |
| 6 | Design of Machine Elements | 17610 |
| 7 | Automotive Electrical and Electronic Systems | 17617 |
| 8 | Vehicle Systems Maintenance | 17618 |
| 9 | Software Testing | 17624 |
| 10 | Advanced Java Programming | 17625 |
| 11 | Mobile Computing | 17632 |
| 12 | System Programing | 17634 |
| 13 | Testing & Maintenance of Electrical Equipments | 17637 |
| 14 | Power Electronics | 17638 |
| 15 | Illumination Engineering | 17639 |
| 16 | Power System Operation & Control | 17643 |
| 17 | Environmental Technology | 17646 |
| 18 | Mass Transfer Operation | 17648 |
| 19 | Advanced Communication System | 17656 |
| 20 | Mobile Communication | 17657 |
| 21 | Embedded System | 17658 |
| 22 | Process Control System | 17663 |
| 23 | Industrial Automation | 17664 |
| 24 | Industrial Drives | 17667 |
| 25 | Video Engineering | 17668 |
| 26 | Optical Fiber & Mobile Communication | 17669 |
| 27 | Therapeutic Equipment | 17671 |
| 28 | Intensive Care Equipment | 17672 |
| 29 | Medical Imaging Equipment | 17673 |

## Pharmacy Lab Manual

**First Year:**

| | | |
|---|---|---|
| 1 | Pharmaceutics - I | 0805 |
| 2 | Pharmaceutical Chemistry - I | 0806 |
| 3 | Pharmacognosy | 0807 |
| 4 | Biochemistry and Clinical Pathology | 0808 |
| 5 | Human Anatomy and Physiology | 0809 |

**Second Year:**

| | | |
|---|---|---|
| 1 | Pharmaceutics - II | 0811 |
| 2 | Pharmaceutical Chemistry - II | 0812 |
| 3 | Pharmacology & Toxicology | 0813 |
| 4 | Hospital and Clinical Pharmacy | 0816 |

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