

**STATE BOARD OF TECHNICAL EDUCATION  
& TRAINING::AP, VIJAYAWADA**



**DIPLOMA IN MECHANICAL ENGINEERING**

**III SEMESTER**

**MATERIAL TESTING AND METALLOGRAPHY LAB (M-308)**

**MANUAL (AS PER C-20 CURRICULUM)**

## INTRODUCTION

### 1.0 INTRODUCTION

The Curriculum of Technical Education should invariably provide for knowledge, attitudes and skills required by the technicians /technologists in the country. In this context the laboratory courses form a vital portion in the entire curriculum of technician education. The laboratory courses shall therefore be so designed and delivered that they help the students acquire attitudes and motor skills that are essential to function effectively as technicians/technologists.

The planning, organization and implementation of lab courses need a detailed description of tasks to be performed by the students. Well thought out instructional objectives to a large extent give these descriptions. The analysis of tasks (by identifying the activities the students are expected to do) help prepare the objectives meticulously. In other words the objectives would be clearer, when the task analysis is done to spell out the sub tasks for each objective.

A survey of the practices currently followed in the technical/technician education shows an urgent need to plug in gaps in instructional procedures. The reasons for these gaps are ambiguity in the minds of the teachers regarding tasks to be performed, levels of competency to be achieved by the students and the weightage to be allocated for each task. This aids in scientific design of instructional plan (optimizing the resources, budgeting the time & content).

The task analysis, teaching points and the structured scheme of evaluation are very important in focusing the instruction on specific skill of desired outcome and in evaluating the same. The Instruction and evaluation in Laboratory courses are different from that of cognitive lessons in the sense that adequate importance and hence weightage needs to be given for all three domains of learning viz. cognitive, psychomotor and affective. Since both training and evaluation of traits of affective domain are practically difficult, a few traits (called values) most relevant and essential to occupations/professions after the Course may be identified for the purpose. It is imperative to integrate these values during instruction and evaluation and also overtly notify the same to the students.

A technician, in addition to performing a skill needs to prepare a report of testing that includes the description of procedure, details of measurements made, reasoning based inferences and so on.,. The current practice of record writing has failed to achieve this purpose as most of the time students end up with making copies of available material.

Therefore, for sensitizing the need for the changes in laboratory instruction, the present hand book has been prepared to meet the above requirements. As such the hand book comprises four parts that intend to :

- Present task analysis, teaching points which can be used for effective design of instruction
- provide a scheme of evaluation with rationally allocated weightage to each significant skill component
- offer a set of questions designed at different levels of competencies for assessment enabling the teacher to set the question paper with balanced levels of competencies
- present pre set worksheets that cultivate the habit of systematic recording of observations and writing the technical report.

- Provide all important data related to particular laboratory activity at one point in the form of annexure

## 1.1. STRUCTURE OF THE BOOK

The hand book is presented in four parts viz., Laboratory sheets, Worksheet, Experimental Methodology and Annexure. The description of each part is given in the following sections

### Part I. Laboratory Sheet

The information provided in this part is useful for the teacher for designing the instruction, planning & organization of the experiment and for scientific evaluation of the students. The major features of the Laboratory sheet are further explained below.

#### 1. Objective

It indicates the **Task** to be performed and completed by the student during the specified duration of time.

#### 2. Task Analysis

It is the process of identifying the component activities (sub tasks) to be carried out by the student in order to achieve the stipulated objective. As the task analysis aim at fitting the instructional objectives into various classes of behaviour, it would help the teacher to determine any particular type of behaviour the student has learnt / failed to perform.

The task analysis would help the teacher in identifying the specific activities to be performed by the students. This could also be used as some kind of check list to compare with activities planned for the laboratory. Further it would give clue to the teacher to make students think originally & act independently. It includes both psychomotor learning and the related cognitive information and hence the task analysis is presented as Knowledge and skill parts.

**A. Knowledge Part:** That includes the cognitive aspects of the task.

**B. Skill Part:** That includes Psychomotor & Affective aspects of the task.

#### 3. Teaching Points:

This includes the points based on the SKILL identified with suggested duration for each point and total duration which helps the teacher for the time and content budgeting during instruction.

#### 4. Need and Scope:

The purpose, application and scope of the task to be performed are normally included in this sub section.

#### 5. Planning and Organisation:

It lists actions to be taken to perform various activities and hence useful in planning the instruction and organizing the resources and equipment

## 6. Scheme of Valuation:

The information provided in this section helps the teacher to devise a tool for rational measurement assessment of the competencies accomplished by the student.

### Part II. Work Sheet

It is designed for the student, where in the student enters his personal data of identification, details of the experiment, stepwise procedure, observations made during experiment, a sample calculation, free hand typical graph, graph from experimental data and inference with discussion.

### Part III. Experimental Methodology

This section furnishes information with regard to standard procedure to conduct the experiment along with the description of equipment/apparatus and the basic theory/concept involved in the conduct of the experiment. Thus this section is very useful for both teacher and student as well to conduct the experiment systematically. Thus this section is presented in four sub section as described below:

➤ **Description**

It gives the detailed description of apparatus / tools / equipment / materials to be used for the task.

➤ **Theory / Concept**

It gives the concept of the task to be performed with formulae and units.

➤ **Procedure**

It provides the idea of step wise procedure to perform the task.

➤ **Observation and Calculation**

It includes sample observation, sample graph, sample calculation for reference

### Part IV. Annexure

All important and useful information that may help in accomplishment of tasks like conversion tables for units, technical & scientific data like material properties, standard trend or characteristic curves (graphs) etc are compiled and presented at one place in this section.

## 1.2. WHO IS TO USE AND HOW TO USE.

The hand book is so designed that it can be beneficially used by different sections of the technical education viz., the teacher, the student, the examiner and the administrator convenient to individual's requirements. A few uses of this hand book each stakeholder could make is outlined in the following sections.

## 1. Teacher

**A.** The **laboratory sheet** is designed keeping the teacher in mind for the teacher has key responsibility of imparting the skills to the student and hence the information given in the lab sheets may be useful for planning & organizing the experimental set up and designing an effective instruction. Thus the teacher may

**Plan and organize** as per *section 4*,

**Instruct** the students as per *section 2*,

**Demonstrate** each sub task as per *section 1.B*.and

**Evaluate** the students as per *section 5*, according to the level of competency.

**Values: The values** in a person are an important personality trait that needs to be nurtured in the learning environment. Further it is also a driving component in any individual to deliver the best and hence this component is also included in the evaluation. However only five key dimensions, that are important in the teaching-learning environment, are taken into consideration for nurturing and evaluation. A little information about these five dimensions is given below as a guideline for the teacher while assessing students.

**1. Co-operation:** It is the voluntary arrangement in which two or more students engage in a mutually beneficial exchange, instead of competition. Cooperation can happen where resources adequate for both students exist or are created by their interaction.

**2. Co-ordination:** It is the unification, integration, synchronization of the effect of group members so as provide unity of action in the pursuit of common goals. It is an integral element and required in each & every function and at each & every stage & therefore it cannot be separated.

**3. Communication;** Communication skill is the set of skills that enables a student to convey information so that it is received and understood.

**4. Sharing:** A part or portion belonging to, distributed to, contributed by, owed by a person or a group **Or** To participate in, use, enjoy or experience jointly or in turns.

**s5. Leadership:** Students with the following leadership qualities are almost always the ones that rise above the crowd.

1. Trustworthiness: This refers to integrity.

2. Inspiration: Guides, leads and inspiring others to want to participate in the process of moving towards the vision.

3. Self awareness: It is the individual awareness of him or her self – their abilities and the impact that they have on others.

4. Acceptance of responsibility: True leaders are accepting responsibility for all that comes their way and taking ownership and responsibilities for getting things back on track. Blaming, justifying and excuse making just is not in their responsibility.

**B.** The **Experimental methodology** is designed for both teacher and student. The teacher can refer the experimental methodology for the details of equipment/apparatus/ materials/tools, procedure to be followed, observations to be made, graphs to be drawn and calculations to be done for the task to be performed

## **2. Student**

The Worksheet is designed keeping in view the needs, deficiencies and the adolescent characteristics of the student for student.

The students submit the filled in work sheet given by the teacher on the day of experiment after referring to experimental methodology and listening to instructions of teacher. The design of the worksheet is made user friendly and the contents are so logically sequenced that the student finds it easy to understand and develop the skill of recording and report writing skill. It also helps the student to actively participate in skill learning. More importantly the student gets immediate meaningful feedback of his performance since the competency wise assessment is done and that too on the same day.

## **3. Examiner**

The examiner may find this hand book very useful as Laboratory sheets and Scheme of evaluation provides information with regard to various competencies (skills) the students is expected to acquire during the course of study and the relative weightages of each competency. This information helps him to design a well balance question paper/measurement tool for assessment.

## SIMPLE TENSION TEST

### OBJECTIVE:

To conduct a tensile test on a mild steel specimen to determine the following:

1. Elastic limit
2. Yield strength
3. Ultimate strength
4. Young's modulus
5. Percentage of elongation
6. Percentage of reduction in area.

**Equipment:** Universal Testing Machine / Tensile Testing Machine

**Instruments:** Vernier Calipers, Dial Indicator with Magnetic Stand / Extensometer

**Tools:** Dot Punch, Hammer

**Material:** Mild Steel rod



### TASK ANALYSIS:

#### A) KNOWLEDGE:

- 1) UTM
- 2) Vernier calipers
- 3) Extensometer/Dial Indicator
- 4) Load and deformation readings
- 5) Stress-strain curve
- 6) Young's modulus
- 7) Percentage of elongation
- 8) Percentage of reduction in area
- 9) Tensile strength
- 10) Yield strength

## B. SKILL:

Category of Skill	Sub Task
Handling of apparatus	A. Listing and collecting the instruments, tools and material required. B. Punching the gauge points on the specimen
Manipulation of apparatus	A. Operating the motor to move the movable crosshead to fix the specimen B. Fixing job between jaws of upper and movable crossheads C. Fixing extensometer / Dial Indicator
Precise Operations/Activities	A. Operating the control valves to apply the load on the specimen at the required rate D. Recording the load and elongations E. Calculating the stress and strains F. Drawing the graph between stress and strain G. Measuring the final gauge length and neck diameter H. Calculating the Young's modulus, Yield strength and Ultimate Strength from the graph I. Calculating the percentage of elongation and percentage of reduction in area

## TEACHING POINTS:

Sl. No	Teaching point	Time allocation (20 mins Suggestive)
1	Required equipment, instruments, tools and materials	2 min
2	Preparation of the specimen	2 min
3	Operation of the UTM	8 min
4	Note down the readings	2 min
5	Drawing the stress-strain curve	2 min
6	Sample calculations	4 min

## A) ROCEDURAL PRECAUTIONS:

- Fixing the job carefully
- The grips used in testing machine must be properly serrated so that there is no chance of slippage of specimen (The specimen should be gripped such that the two ends of the specimen are covered by the grip, approximately 3 mm away from its gage-length. It is important that the specimens are tightly gripped onto the specimen grips to prevent slipping, which will otherwise result in experimental errors.)
- Use the “Up” and “Down” buttons, which are located next to the “Return” button to adjust the position of the upper grip (Make sure that the specimen is vertically aligned, if not a torsional force, rather than axial force, will result).
- Specifications of the specimen must be according to the ASTM standards.
- Misalignment of the specimen should not be allowed during the test.
- Take measurements of the specimen accurately.
- Note down the readings carefully.
- Operate the hydraulic valves carefully.

**B) SAFETY PRECAUTIONS:**

- Observe the experiment at a safe distance (about 1.5 meters away), at an angle and take note of the failure mode when the specimen fails (Be sure to wear safety glasses. Do not come close to equipment when the tensile test is running).
- Wear shoe and apron.
- Don't wear loose cloths.

**NEED AND SCOPE:**

- It is the very important and fundamental test from which we can find very important mechanical properties of the material which are essential in the design of any machine member
- From this test we can decide the nature of the material
- You can get Poisson's Ration, which is important for use in finite element analysis

**SCHEME OF EVALUATION:**

Category of Skill	SUB TASK	WEIGHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)																
1. Handling of apparatus	A. Collecting the instruments, tools and material required. B. Punching the gauge points on the specimen	<table border="1"> <tr> <td>A</td> <td>B</td> <td>T</td> </tr> <tr> <td>2</td> <td>3</td> <td>5</td> </tr> </table>	A	B	T	2	3	5	05										
A	B	T																	
2	3	5																	
2. Manipulation of apparatus	A. Operating the motor to move the movable crosshead to fix the specimen B. Fixing job between jaws of upper and movable crossheads C. Fixing extensometer / Dial Indicator	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>T</td> </tr> <tr> <td>4</td> <td>5</td> <td>4</td> <td>2</td> <td>15</td> </tr> </table>	A	B	C	D	T	4	5	4	2	15	15						
A	B	C	D	T															
4	5	4	2	15															
3. Precise Operations/ Activities	A. Operating the control valves to apply the load on the specimen at the required rate B. Recording the load and elongations C. Calculating the stress and strains D. Drawing the graph between stress and strain E. Measuring the final gauge length and neck diameter F. Calculating the Young's modulus, Yield strength and Ultimate Strength from the graph G. Calculating the percentage of elongation and percentage of reduction in area	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>E</td> <td>F</td> <td>G</td> </tr> <tr> <td>4</td> <td>5</td> <td>3</td> <td>4</td> <td>2</td> <td>5</td> <td>2</td> </tr> </table> <table border="1"> <tr> <td>T</td> </tr> <tr> <td>25</td> </tr> </table>	A	B	C	D	E	F	G	4	5	3	4	2	5	2	T	25	25
A	B	C	D	E	F	G													
4	5	3	4	2	5	2													
T																			
25																			
4. Values	A) Cooperation B) Co-Ordination C) Communication D) Sharing E) Leadership	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>E</td> <td>T</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>5</td> </tr> </table>	A	B	C	D	E	T	1	1	1	1	1	5	5				
A	B	C	D	E	T														
1	1	1	1	1	5														

**ASSESSMENT QUESTIONS:**

- 1) Measure the diameter of the given cylindrical specimen with the Vernier Calliper and find the gauge length (LO)
- 2) Locate 5 gauge points on the given specimen of tension test (LO)
- 3) Fix the specimen in UTM to conduct the tension test(MO)
- 4) Measure the final gauge length and neck diameter with the Vernier calliper(LO)
- 5) Apply the load on the specimen so that the strain is approximately constant(HO)
- 6) Note down the load vs deformation readings (HO)
- 7) Calculate stress and strain values for the given loads, deformations and initial dimensions of the specimen.(HO)
- 8) Draw the stress strain diagram for the given values and find the Young's modulus and yield strength.(HO)
- 9) Find the percentage of elongation and percentage reduction in area and thereby decide the nature of the material.(HO)
- 10) Draw the stress strain diagrams for standard material like Mild Steel, Cast Iron, Aluminium and write the differences between them.(HO)

**VIVA-VOCE QUESTIONS:**

1. What is meant by ASTM standards?
2. What do you understand from load vs extension graph?
3. How stress and strain vary with rate of loading?
4. Why mild steel material is chosen for tension test?
5. What do you understand when rate of loading is increased?
6. Why breaking load is less than peak load (ultimate load)?
7. How do you indicate the proportional limit point on stress-strain curve obtained from tension test?
8. How do you understand Hooke's law from this tension test?

## COMPRESSION TEST

**OBJECTIVE:** To conduct a compression test on concrete cube to find its compressive strength

**EQUIPMENT:** CTM/UTM,

**INSTRUMENTS:** Scale

**MATERIAL:** Concrete cube (specimen)



### TASK ANALYSIS

A)

#### B) KNOWLEDGE:

- 11) Types of axial loading
- 12) Compression Testing Machine (CTM)
- 13) Stating the specifications of the test specimen as per ASTM/IS standards

#### C) SKILL

Category of Skill	Sub Task
<b>Handling of apparatus</b>	C. Listing and collecting the components required. D. Measuring the dimensions of a given concrete cube.
<b>Manipulation of apparatus</b>	E. Connecting the power supply and placing the specimen. F. Operating the load valve and back oil valve. G. Observing the rate of loading
<b>Precise Operations Activities</b>	<ul style="list-style-type: none"> <li>• Checking of both the valves in closed position before start of the experiment.</li> </ul> H. Operating the load valve. I. Observing the readings and noting of the final reading. J. Calculating the compressive strength of the given specimen

#### D) TEACHING POINTS:

Sl. No	Teaching point	Time allocation (20 mins Suggestive)
1	Components of CTM	5 min
2	Working of CTM	4 min
3	Operation of load valve	3 min
4	Specimen details	2 min
5	Need and scope of the experiment	2 min
6	Safety Precautions	3 min
7	Sample Calculations	1 min

### 1. Procedural precautions :

- Observe the valve opening and closing carefully
- Check that both the valves are closed before start of the experiment.
- The specimen must be kept at the centre of cross-head so that a uniform compressive loading can be assured on the specimen.
- The loading is to be increased gradually.
- The size of the specimen is to be measured accurately.

### 2. SAFETY PRECAUTIONS :

- All **loose clothing** must be tucked in.
- Safety boots or enclosed shoes must be worn.
- Always wear an apron.

### E) NEED AND SCOPE:

The goal of a compression test is to determine the behavior or response of a material while it experiences a compressive load by measuring fundamental variables such as stress, strain and deformation.

Compression tests are performed on brittle materials as these materials fail in shear. It is seen that the shear develops along a diagonal plane which is maximum on a plane inclined at  $45^\circ$  from the direction of compression load. In compression loading, the fracture of the specimen takes place due to bulging action. The property of a material to bulge under compressive loading is called malleability. It is the ductility that is associated with tensile loading while it is malleability that is associated with compressive loading.

The maximum load capacity of the CTM used is 2000KN. Students for research can work to construct a CTM with increased load capacity.

### F) PLANNING AND ORGANISATION :

ACTION	ACTIVITY
Check for	<ol style="list-style-type: none"><li>1. The specimen must be kept at the centre of lower fixed jaw so that a uniform compressive loading can be assured on the specimen.</li><li>2. The loading is to be increased gradually.</li><li>3. The size of the specimen is to be measured accurately</li></ol>
For design and instruction	Read the teaching points carefully.

**G) SCHEME OF EVALUATION:**

Category of Skill	SUB TASK	WEIGHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)										
<b>1. Handling of apparatus</b>	A) Identifying the components required. B) Measuring the dimensions of a given concrete cube.	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>3</td> <td>2</td> <td>5</td> </tr> </tbody> </table>	A	B	T	3	2	5	5				
A	B	T											
3	2	5											
<b>2. Manipulation of apparatus</b>	A) Connecting the power supply B) Fixing the specimen C) Setting the load range depending on the size of the specimen	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>2</td> <td>8</td> <td>5</td> <td>15</td> </tr> </tbody> </table>	A	B	C	T	2	8	5	15	15		
A	B	C	T										
2	8	5	15										
<b>3. Precise Operations Activities</b>	A) Checking of both the valves in closed position before start of the experiment. B) Operating the load valve. C) Observing the readings and noting of the final reading. D) Calculating the compressive strength	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>5</td> <td>10</td> <td>5</td> <td>5</td> <td>25</td> </tr> </tbody> </table>	A	B	C	D	T	5	10	5	5	25	25
A	B	C	D	T									
5	10	5	5	25									
<b>4. Values</b>	F) Co Operation G) Co- Ordination H) Communication I) Sharing J) Leadership	<table border="1"> <tbody> <tr> <td>5</td> </tr> </tbody> </table>	5	5									
5													

**ASSESSMENT QUESTIONS** (Only suggestive):

1. What is the purpose of compression test? (Lower order )
2. How do you calculate compressive stress? (Lower order )
3. Why is compressive strength important? (Middle order )
4. What is the significance of ultimate compressive strength? (Middle order )
5. How is compression test different from tensile test? (Higher order )
6. Why is compressive test conducted on brittle materials? (Higher order )

### **VIVA – VOCE QUESTIONS:**

(Only suggestive. The teacher may add questions depending upon the context of examination)

1. Why is material testing necessary?
2. What is the main failure effect arising during the compression test?
3. Is steel stronger in compression or tension?
4. Why is concrete stronger in compression than in tension?
5. Which material is stronger in compression for bridges
6. What is factor of safety?
7. What is ultimate strength?
8. What are the different types of stresses?
9. What are the different types of strains?
10. What is working stress?
11. What is compressive stress and compressive strain?

## SHEAR TEST

### OBJECTIVE:

To conduct shear test to find the allowable shear strength of the given material

**Equipment:** Universal Testing machine (UTM), Shear Shackles / Shear Test Attachment

**Instruments:** Vernier Calipers

**Material:** Specimen, Bushes

### TASK ANALYSIS

#### 1. KNOWLEDGE:

- 1) UTM (Universal Testing machine)
- 2) Specimen
- 3) Shear attachments

#### 2. SKILL:

Category of Skill	Sub Task
Handling of apparatus	A. Listing and collecting the components required. B. Fixing the specimen in shear attachment
Manipulation of apparatus	A. Operating the motor to move the movable crosshead to fix the specimen B. Fixing job between movable and lower crossheads
Precise Operations Activities	A. Operating the control valves to apply the load on the specimen at the required rate B. Recording the maximum load C. Calculating the Maximum Shear Stress D. Calculating the Allowable Shear Strength

#### 3. TEACHING POINTS:

Sl. No	Teaching point	Time allocation (20 mins Suggestive)
1	Shear Strength	3 min
2	Working of UTM	8 min
3	Shear Attachment	3 min
4	Calculation of shear strength of the given specimen	2 min
5	Need and scope of the experiment	2 min
6	Precautions	2 min
	Total	20 min

### A) PROCEDURAL PRECAUTIONS:

- 1) The measuring range should not be changed at any stage during the test.
- 2) Inner diameter of the hole in the shear attachment should be slightly greater than that of the specimen.
- 3) Measure the diameter of the specimen accurately.
- 4) Care should be taken while applying the loads on the UTM.
- 5) After shearing specimen stops the machine.

### B) SAFETY PRECAUTIONS:

- 1) Wear apron
- 2) Beware of loose clothing while operating

### NEED AND SCOPE OF THE EXPERIMENT:

Place the shear test attachment on the lower table, this attachment consists of cutter. The specimen is inserted in the shear test attachment & lift the lower table so that the zero is adjusted, then apply the load such that the specimen breaks in two or three pieces. If the specimen breaks in two pieces, then it will be single shear & if it breaks in three pieces, then it will be in double shear.

### SCHEME OF EVALUATION:

Category of Skill	SUB TASK	WEIHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)								
1. Handling of apparatus	A) Identifying the components required. B) Identifying the specifications of the specimen	<table border="1"> <tr> <td>A</td> <td>B</td> <td>T</td> </tr> <tr> <td>3</td> <td>2</td> <td>5</td> </tr> </table>	A	B	T	3	2	5	5		
A	B	T									
3	2	5									
2. Manipulation of apparatus	A) Checking the power supply and working of UTM remote B) Checking start and stop buttons, Opening and closing valves. C) Checking the position of specimen in shear attachment	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>T</td> </tr> <tr> <td>3</td> <td>7</td> <td>10</td> <td>20</td> </tr> </table>	A	B	C	T	3	7	10	20	20
A	B	C	T								
3	7	10	20								
3. Precise Operations Activities	A) Measuring the diameter of the specimen and fixing the Specimen in the Shear attachment. B) Keeping the shear equipment on the fixed jaw of UTM and apply the load slowly at right angles to the axis of piece through the central block and noting of load at fracture.	<table border="1"> <tr> <td>A</td> <td>B</td> <td>T</td> </tr> <tr> <td>10</td> <td>10</td> <td>20</td> </tr> </table>	A	B	T	10	10	20	20		
A	B	T									
10	10	20									
4. Values	A) Co Operation B) Co- Ordination C) Communication D) Sharing E) Leadership	<table border="1"> <tr> <td></td> </tr> <tr> <td>5</td> </tr> </table>		5	5						
5											

**ASSESSMENT QUESTIONS:**

- 1) Fix the given specimen in shear shackles to conduct the double shear test.(MO)
- 2) Fix the specimen in shear attachment (MO)
- 3) Place the shear shackles in UTM to conduct shear test.(LO)
- 4) Apply the load on the specimen gradually(MO)
- 5) Find the allowable shear strength of the given specimen for a given factor of safety.(MO)

**VIVA QUESTIONS:**

1. What is twisting moment?
2. Does the shear failure in wood occur along the 45° shear plane?
3. What is bulging? Why does it occur?
4. What is yield strength?
5. How is deformation calculated?
6. What is single & double shear?
7. What is unit of shear strength?

## IMPACT TEST (IZOD and CHARPY)

**Objective:** To conduct Izod / Charpy Impact Test to find the impact strength of given material

**Equipment:** Universal Impact testing machine, Bench vice

**Instruments:** Vernier Calliper

**Tools:** Hacksaw, Triangular File and Bastard File

**Material:** Specimen

### TASK ANALYSIS

#### KNOWLEDGE:

- 1) Impact strength
- 2) Operating principle of Impact testing machine.
- 3) Components of impact Testing Machine
- 4) Preparation of the specimen
- 5) Fixing the specimen.
- 6) Calculating the impact strength
- 7) Precautions

#### SKILL:

##### a. IZOD IMPACT TEST-

Category of Skill	Sub Task
<b>Handling of apparatus</b>	A. Listing and collecting the instruments, tools and material required B. Preparing the specimen as per the standard dimensions C. Fixing the Izod striker D. Placing the pendulum at correct position
<b>Manipulation of apparatus</b>	A. Fixing the specimen correctly B. Adjusting the dial needle to the maximum value
<b>Precise Operations Activities</b>	A. Preparing the specimen with 45° notch. B. Recording the dial reading after releasing the pendulum without test specimen. C. Recording the dial reading after releasing the pendulum with test specimen. D. Recording the energy absorbed by the specimen E. Calculating the Impact Strength

**b. CHARPY IMPACT TEST-**

Category of Skill	Sub Task
<b>Handling of apparatus</b>	E. Listing and collecting the instruments, tools and material required F. Preparing the specimen as per the standard dimensions G. Fixing the Charpy striker H. Placing the pendulum at correct position
<b>Manipulation of apparatus</b>	C. Fixing the specimen correctly D. Adjusting the dial needle to the maximum value
<b>Precise Operations Activities</b>	F. Preparing the specimen with 45° notch. G. Recording the dial reading after releasing the pendulum without test specimen. H. Recording the dial reading after releasing the pendulum with test specimen. I. Recording the energy absorbed by the specimen J. Calculating the Impact Strength

**Teaching points (IZOD and CHARPY IMPACT TEST):**

Sl. No	Teaching point	Time allocation (20 mins Suggestive)
1	Working Principle of Impact Testing Machine	4 min
2	Function of different components of Impact Testing Machine	4 min
3	Preparation and fixing the Specimen	4 min
4	Differences between Izod and Charpy Tests	4 min
5	Need and scope of the experiment	2 min
6	Precautions	2 min

**A) PROCEDURAL PRECAUTIONS (IZOD and CHARPY IMPACT TEST):**

- 6) Note down the Readings without parallax error.
- 7) Measure the dimensions of the specimen carefully.
- 8) Apply brakes on the striking hammer only in the forward motion.

**B) SAFETY PRECAUTIONS(IZOD and CHARPY IMPACT TEST):**

- 1) Laboratory personnel should not stand in the direction of movement of striking hammer.
- 2) Beware of loose clothing while operating.

3) Fixing the specimen firmly.

### NEED AND SCOPE OF THE EXPERIMENT (IZOD and CHARPY IMPACT TEST):

Impact Test is used for determining the amount of forces that are absorbed by materials when it reaches the point of fracture. This amount of energy gives the analysis of the notch hardness of material.

- **In forging industry**, the test can be used to determine the malleability and ductility of a material that is being forged.
- **In the rubber industry**, this test is used for determining the shock absorbing ability of a type of rubber so that its proper application could be decided.
- **In plastic industry**, this test is used for analyzing the breaking strength of a sample when it is subjected to a high impact from a pendulum. This helps in ensuring that the material is best for an application where it is subjected to such impacts.

### SCHEME OF EVALUATION (IZOD and CHARPY IMPACT TEST):

Category of Skill	SUB TASK	WEIHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)										
<b>1.Handling of apparatus</b>	A. Identifying the components required. B. Using of allen key to fix striking hammer. C. Fixing striker to striking hammer	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>2</td> <td>1</td> <td>2</td> <td>5</td> </tr> </tbody> </table>	A	B	C	T	2	1	2	5	5		
A	B	C	T										
2	1	2	5										
<b>2.Manipulation of apparatus</b>	A. Fixing the one end of test specimen in jaws. B .Adjusting the striking hammer to test specimen and lock it. C. Adjusting the dial needle to extreme position.	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>4</td> <td>4</td> <td>7</td> <td>15</td> </tr> </tbody> </table>	A	B	C	T	4	4	7	15	15		
A	B	C	T										
4	4	7	15										
<b>3.Precise Operations Activities</b>	A. Preparing the specimen with Exact Dimensions B. Recording the dial reading after releasing the pendulum without test specimen. C. Recording the dial reading after releasing the pendulum with test specimen. D. Calculating the Impact Strength	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>10</td> <td>4</td> <td>4</td> <td>7</td> <td>25</td> </tr> </tbody> </table>	A	B	C	D	T	10	4	4	7	25	25
A	B	C	D	T									
10	4	4	7	25									
<b>4.Values</b>	F) Co Operation G) Co- Ordination H) Communication I) Sharing J) Leadership	<table border="1"> <tbody> <tr> <td>5</td> </tr> </tbody> </table>	5	5									
5													

### **ASSESSMENT QUESTIONS (IZOD and CHARPY IMPACT TEST):**

- 1) Draw the shape of the specimen for Charpy/Izod impact test(LO)
- 2) Prepare the specimen as per the standard dimensions (HO)
- 3) Fix the appropriate striker to conduct the Charpy/Izod impact test(MO)
- 4) Fix the pendulum at appropriate position to conduct the Charpy/Izod impact test(MO)
- 5) Fix/Place the specimen correctly to conduct the Charpy/Izod impact test(MO)
- 6) Adjust the position of the pointer on the scale (LO)
- 7) Break the specimen by releasing the pendulum and note down the energy(MO)
- 8) Calculate the impact strength of the given specimen and data(HO)

### **VIVA QUESTIONS**

1. Which type of material used in impact test?
2. What is angle of notch in the test specimen for impact test?
3. What is impact strength?
4. What is initial position of the striking hammer for izod test?
5. How specimen is positioned in IZOD IMPACT TEST?
6. How specimen is positioned in CHARPY IMPACT TEST?

## BRINELL HARDNESS TEST

**OBJECTIVE:** To conduct Hardness Test on Brinell Hardness Tester to determine the Brinell Hardness of

the given material

**Equipment:** Brinell hardness tester

**Instruments:** Brinell Microscope, Vernier Callipers

**Material:** Indentors, Specimen

### TASK ANALYSIS

#### A) KNOWLEDE:

- 1) Hardness
- 2) Brinell Hardness Tester
- 3) Brinell Microscope
- 4) Finding the Brinell hardness
- 5) Precautions

#### B) SKILL:

Category of Skill	Sub Task
Handling of apparatus	A. Identifying the ball indenter and dial indicator. B. Identifying the load knob (or load hand lever) and loads changer indicator.
Manipulation of apparatus	A. Unloading and loading of load hand lever. B. Operating the anvil. C. Measuring the diameter (d) of the indentation (impression).
Precise Operations Activities	A. Operating the anvil just makes contact with ball indenter. B. Unloading and loading of load on specimen with use of hand lever. C. Measuring the diameter d of the indentation (impression) made on the specimen using a micrometer microscope.

#### C) TEACHING POINTS:

Sl. No	Teaching point	Time allocation (20 mins Suggestive)
1	Hardness and different hardness tests	03 min
2	Brinell Hardness Tester	10 min
3	Choosing the Load to be applied	02 min
4	Measuring Diameter of Indentation	05 min
5	Calculating Brinell Hardness	05 min

## D) NEED AND SCOPE OF EXPERIMENT

Many new products entering the market today are based on new materials and processes. These new materials are playing increasingly important roles-supporting innovations and boosting competitiveness in technology driven industries.

The manufacturing processes and quality requirements for products made using high-tech materials call for a comprehensive knowledge of process technology in addition to thorough knowledge of the material's properties. Among the various mechanical and optical tests used to determine the characteristics of a material and its suitability for a given application, hardness testing is one of the most critical. Hardness is defined as the mean pressure a material will support. Hardness testing is typically undertaken to assess resistance to plastic deformation, a value of tremendous importance to the determination of part quality in a wide range of industries and applications.

## E) SCHEME OF EVALUATION:

Category of Skill	SUB TASK	WEIHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)												
Handling of apparatus	A. Measuring the diameter of the indenter B. Fixing the indenter	<table border="1"> <tr> <td>A</td> <td>B</td> <td>T</td> </tr> <tr> <td>2</td> <td>3</td> <td>5</td> </tr> </table>	A	B	T	2	3	5	5						
A	B	T													
2	3	5													
Manipulation of apparatus	A) Calculating the load to be applied depending on material and indenter B) Rotating the elevating screw so that there will be perfect contact between the indenter and specimen C) Apply the load on the specimen	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>T</td> </tr> <tr> <td>5</td> <td>5</td> <td>5</td> <td>15</td> </tr> </table>	A	B	C	T	5	5	5	15	15				
A	B	C	T												
5	5	5	15												
Precise Operations Activities	A) Measuring the diameter of the indentation with Brinell Microscope B) Calculating the Brinell Hardness Number	<table border="1"> <tr> <td>A</td> <td>B</td> <td>T</td> </tr> <tr> <td>15</td> <td>10</td> <td>25</td> </tr> </table>	A	B	T	15	10	25	25						
A	B	T													
15	10	25													
Values	A) Co Operation B) Co- Ordination C) Communication D) Sharing E) Leadership	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>E</td> <td>T</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>5</td> </tr> </table>	A	B	C	D	E	T	1	1	1	1	1	5	5
A	B	C	D	E	T										
1	1	1	1	1	5										

## ASSESSMENT QUESTIONS:

- 1) Fix the ball indenter in the Brinell Hardness tester.(LO)
- 2) Apply the load on the specimen/load lever for a given material (MO)
- 3) Measure the diameter of the indentation using Brinell microscope (HO)
- 4) Find the Brinell hardness number for the given data (MO)

### **VIVA-VOCE QUESTIONS:**

1. What is Hardness?
2. What is the importance of Hardness?
3. Identify the materials, which are the harder materials, you come across?
4. What are the methods of measuring hardness?
5. Which ball size is recommended for Brinell's test?
6. What is the formula for finding the Brinell's Hardness number?
7. How to differentiate between Hardness and Strength?
8. What is the hardest material in the world?
9. Which material is used for cutting tools?
10. How to differentiate between Brinell's and Rockwell's testing?

## ROCKWELL HARDNESS TEST

**OBJECTIVE:** To conduct Hardness Test on Rockwell Hardness Tester to determine the Rockwell

Hardness of the given material

**Equipment:** Rockwell hardness tester

**Material:** Indentors, Standard Specimen and actual specimen

### TASK ANALYSIS

#### A) KNOWLEDE:

- 1) Hardness
- 2) Rockwell Hardness Tester
- 3) Finding the Rockwell hardness
- 4) Precautions

#### B) SKILL:

Category of Skill	Sub Task
Handling of apparatus	A. Selecting the correct set of scale, dial, indenter and load for the given material
Manipulation of apparatus	A. Fixing the indenter B. Selecting the corresponding load by rotating the load selector wheel C. Adjusting the position of specimen on the anvil so that the new indentation will be at least 5 mm away from the
Precise Operations Activities	A. Applying the minor load B. Applying and releasing the major load C. Recording the dial reading after releasing the load

#### C) TEACHING POINTS:

Sl. No	Teaching point	Time allocation (20 mins Suggestive)
1	Define the Hardness	02 min
2	Rockwell Hardness Tester	10 min
3	Selecting the correct set of scale, dial, indenter and load for the given material	03 min
	Applying minor and Major loads	05 min

## D) NEED AND SCOPE OF EXPERIMENT

Many new products entering the market today are based on new materials and processes. These new materials are playing increasingly important roles-supporting innovations and boosting competitiveness in technology driven industries.

The manufacturing processes and quality requirements for products made using high-tech materials call for a comprehensive knowledge of process technology in addition to thorough knowledge of the material's properties. Among the various mechanical and optical tests used to determine the characteristics of a material and its suitability for a given application, hardness testing is one of the most critical. Hardness is defined as the mean pressure a material will support. Hardness testing is typically undertaken to assess resistance to plastic deformation, a value of tremendous importance to the determination of part quality in a wide range of industries and applications.

## E) SCHEME OF EVALUATION:

Category of Skill	SUB TASK	WEIHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)												
Handling of apparatus	A. Selecting the correct set of scale, dial, indenter and load for the given material B. Identifying the load knob (or load hand lever) and loads changer indicator.	<table border="1"> <tr> <td>A</td> <td>B</td> <td>T</td> </tr> <tr> <td>2</td> <td>3</td> <td>5</td> </tr> </table>	A	B	T	2	3	5	6						
A	B	T													
2	3	5													
Manipulation of apparatus	A. Fixing the indenter B. Selecting the corresponding load by rotating the load selector wheel C. Adjusting the position of specimen on the anvil so that the new indentation will be at least 5 mm away from the	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>T</td> </tr> <tr> <td>5</td> <td>5</td> <td>5</td> <td>15</td> </tr> </table>	A	B	C	T	5	5	5	15	15				
A	B	C	T												
5	5	5	15												
Precise Operations Activities	A. Applying the minor load B. Applying and releasing the major load C. Testing the hardness tester with standard specimen D. Recording the dial reading after releasing the load on actual specimen	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>T</td> </tr> <tr> <td>5</td> <td>5</td> <td>10</td> <td>5</td> <td>25</td> </tr> </table>	A	B	C	D	T	5	5	10	5	25	25		
A	B	C	D	T											
5	5	10	5	25											
Values	A) Co Operation B) Co- Ordination C) Communication D) Sharing E) Leadership	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>E</td> <td>T</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>5</td> </tr> </table>	A	B	C	D	E	T	1	1	1	1	1	5	5
A	B	C	D	E	T										
1	1	1	1	1	5										

## ASSESSMENT QUESTIONS:

- 1) Fix the indenter in the Rockwell Hardness tester (LO)
- 2) Select the correct set of indenter, scale, dial and load for a given material (LO)
- 3) Apply the minor load on the specimen (HO)
- 4) Check whether the tester is working properly with the help of standard specimen (HO)
- 5) Find the Rockwell hardness by applying minor and major loads (HO)

### **VIVA QUESTIONS:**

1. What is Hardness?
2. What is the importance of Hardness?
3. Identify the materials, which are the harder materials, you come across
4. What are the methods of measuring hardness?
5. Which ball size is recommended for Rockwell's test?
6. How to find the Rockwell's Hardness number?
7. How to differentiate between Hardness and Strength?
8. What is the hardest material in the world?
9. Which material is used for cutting tools?
10. How to differentiate between Brinell's and Rockwell's testing?
11. How many scales on Hardness tester dial?
12. Which scale is used for higher hardness?
13. Which scale is suitable for 1/16" steel ball indenter?

## FLEXURAL TEST ON CANTILEVER BEAM

**OBJECTIVE:** To conduct flexural test on Cantilever beam to determine the Young's modulus of a given beam material

**Equipment:** Cantilever Beam Set-up

**Instruments:** Vernier Calipers, Scale, Dial Indicator with magnetic stand  
**Beam of different cross-Material:** Load Hangers, Weights

### TASK ANALYSIS

#### A) KNOWLEDGE:

- 1) Types of supports and beams
- 2) Purpose of Dial indicator
- 3) Flexural formula
- 4) Young's Modulus and stiffness

#### B) SKILL

Category of Skill	Sub Task
Handling of apparatus	A. Listing and collecting the instruments and material required B. Measuring the length, width and depth of the given beam. C. Placing the hangers and dial indicator at the appropriate locations
Manipulation of apparatus	A. Fixing the dial indicator and adjust the initial reading to zero B. Ensuring the contact between the beam and strainer of dial indicator
Precise Operations Activities	A. Recording the load and dial gauge readings B. Calculating moment of inertia for both beams. C. Drawing the graph for deflection vs load D. Calculating the Young's modulus and stiffness of the beam.

#### C) TEACHING POINTS:

Sl. No	Teaching point	Time allocation (20 mins Suggestive)
1	Different supports and beams	4 min
2	Location of hangers and dial indicator	2 min
3	Fixing the dial indicator	2 min
4	Applying the loads and recording the dial gauge readings	5 min
5	Draw the graph between load and deflection	3 min
6	Calculating the stiffness and Young's modulus	2 min
7	Need and scope of experiment	1 min
8	Precautions	1 min

**PRECAUTIONS:**

- Make sure that beam and load are placed in a proper position.
- The cross- section of the beam should be large.
- Note down the readings of the Vernier scale carefully.

**D) SCHEME OF EVALUATION:**

Category of Skill	SUB TASK	WEIGHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)												
<b>Handling of apparatus</b>	A) Listing and collecting the instruments and material required. B) Measuring the length, width and depth of the given beam C) Placing the hangers and dial indicator at the appropriate locations	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>2</td> <td>2</td> <td>1</td> <td>5</td> </tr> </tbody> </table>	A	B	C	T	2	2	1	5	5				
A	B	C	T												
2	2	1	5												
<b>Manipulation of apparatus</b>	A) Fixing the dial indicator and adjust the initial reading to zero B) Ensuring the contact between the beam and strainer of dial indicator	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>5</td> <td>5</td> <td>10</td> </tr> </tbody> </table>	A	B	T	5	5	10	10						
A	B	T													
5	5	10													
<b>Precise Operations Activities</b>	A) Recording the load and dial gauge readings B) Calculating moment of inertia for both beams. C) Drawing the graph for deflection vs load D) Calculating the Young's modulus and stiffness of the beam.	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>10</td> <td>02</td> <td>10</td> <td>08</td> <td>30</td> </tr> </tbody> </table>	A	B	C	D	T	10	02	10	08	30	30		
A	B	C	D	T											
10	02	10	08	30											
<b>Values</b>	A) Co Operation B) Co- Ordination C) Communication D) Sharing E) Leadership	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>E</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>5</td> </tr> </tbody> </table>	A	B	C	D	E	T	1	1	1	1	1	5	5
A	B	C	D	E	T										
1	1	1	1	1	5										

**ASSESSMENT QUESTIONS:**

- 1) Measure the cross sectional dimensions of the beam with the Vernier calliper (LO)
- 2) Measure the span length of CANTILEVER beam (LO)
- 3) Place the hangers (weight pans) and dial indicator at the appropriate positions (LO)
- 4) Fix the dial indicator properly (MO)
- 5) Note down the dial indicator readings while applying and removing the loads (MO)
- 6) Calculate the moment of inertia for the given cross sectional dimensions.(MO)
- 7) Calculate the deflections of the beam for the given dial indicator readings.(LO)
- 8) Find the stiffness of the given beam material for the given data (HO)
- 9) Find the Young's modulus of the given beam material for the given data (HO)

## VIVA QUESTIONS:

1. Which position of the beam carries maximum load based on rigidity?
2. Why is young's modulus higher in transverse direction?
3. What is the effect of neutral axis after the deflection?
4. Give any three applications of CANTILEVER beam?
5. Why is the deflection maximum at centre than the supports?
6. Where is the slope maximum and minimum?
7. What is the effect of moment of inertia on young's modulus?
8. Why is Young's modulus calculated on one axis of the beam?
9. Why is cross section of beam rectangular rather than circular?
10. What will the Maximum Deflection in a beam when its depth is doubled in Strength of Materials?

## FLEXURAL TEST ON SIMPLY SUPPORTED BEAM

**OBJECTIVE:** To conduct flexural test on simply supported beam to determine the Young's modulus of a given beam material

**Equipment:** Simply Supported Beam Set-up

**Instruments:** Vernier Calipers, Scale, Dial Indicator with magnetic stand Beam of different cross-

**Material:** Load Hangers, Weights

### TASK ANALYSIS

#### A) KNOWLEDGE:

- 1) Types of supports and beams
- 2) Purpose of Dial indicator
- 3) Flexural formula
- 4) Young's Modulus and stiffness

#### B) SKILL

Category of Skill	Sub Task
Handling of apparatus	A. Listing and collecting the instruments and material required B. Measuring the length, width and depth of the given beam. C. Placing the hangers and dial indicator at the appropriate locations
Manipulation of apparatus	A. Fixing the dial indicator and adjust the initial reading to zero B. Ensuring the contact between the beam and strainer of dial indicator
Precise Operations Activities	A. Recording the load and dial gauge readings B. Calculating moment of inertia for both beams. C. Drawing the graph for deflection vs load D. Calculating the Young's modulus and stiffness of the beam.

#### C) TEACHING POINTS:

Sl. No	Teaching point	Time allocation (20 mins Suggestive)
1	Different supports and beams	4 min
2	Location of hangers and dial indicator	2 min
3	Fixing the dial indicator	2 min
4	Applying the loads and recording the dial gauge readings	5 min
5	Draw the graph between load and deflection	3 min
6	Calculating the stiffness and Young's modulus	2 min
7	Need and scope of experiment	1 min
8	Precautions	1 min

**PRECAUTIONS:**

- Make sure that beam and load are placed in a proper position.
- The cross- section of the beam should be large.
- Note down the readings of the Vernier scale carefully.

**D) SCHEME OF EVALUATION:**

Category of Skill	SUB TASK	WEIHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)												
<b>Handling of apparatus</b>	A) Listing and collecting the instruments and material required. B) Measuring the length, width and depth of the given beam C) Placing the hangers and dial indicator at the appropriate locations	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>2</td> <td>2</td> <td>1</td> <td>5</td> </tr> </tbody> </table>	A	B	C	T	2	2	1	5	6				
A	B	C	T												
2	2	1	5												
<b>Manipulation of apparatus</b>	A) Fixing the dial indicator and adjust the initial reading to zero B) Ensuring the contact between the beam and strainer of dial indicator	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>5</td> <td>5</td> <td>10</td> </tr> </tbody> </table>	A	B	T	5	5	10	10						
A	B	T													
5	5	10													
<b>Precise Operations Activities</b>	A) Recording the load and dial gauge readings B) Calculating moment of inertia for both beams. C) Drawing the graph for deflection vs load D) Calculating the Young's modulus and stiffness of the beam.	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>10</td> <td>02</td> <td>10</td> <td>08</td> <td>30</td> </tr> </tbody> </table>	A	B	C	D	T	10	02	10	08	30	30		
A	B	C	D	T											
10	02	10	08	30											
<b>Values</b>	A) Co Operation B) Co- Ordination C) Communication D) Sharing E) Leadership	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>E</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>5</td> </tr> </tbody> </table>	A	B	C	D	E	T	1	1	1	1	1	5	5
A	B	C	D	E	T										
1	1	1	1	1	5										

**ASSESSMENT QUESTIONS:**

- 1) Measure the cross sectional dimensions of the beam with the Vernier calliper (LO)
- 2) Measure the span length of simply supported beam (LO)
- 3) Place the hangers (weight pans) and dial indicator at the appropriate positions (LO)
- 4) Fix the dial indicator properly (MO)
- 5) Note down the dial indicator readings while applying and removing the loads (MO)
- 6) Calculate the moment of inertia for the given cross sectional dimensions.(MO)
- 7) Calculate the deflections of the beam for the given dial indicator readings.(LO)
- 8) Find the stiffness of the given beam material for the given data (HO)
- 9) Find the Young's modulus of the given beam material for the given data (HO)

### **VIVA QUESTIONS:**

1. Which position of the beam carries maximum load based on rigidity?
2. Why is young's modulus higher in transverse direction?
3. What is the effect of neutral axis after the deflection?
4. Give any three applications of simply supported beam?
5. Why is the deflection maximum at centre than the supports?
6. Where is the slope maximum and minimum?
7. What is the effect of moment of inertia on young's modulus?
8. Why is Young's modulus calculated on one axis of the beam?
9. Why is cross section of beam rectangular rather than circular?
10. What will the Maximum Deflection in a beam when its depth is doubled in Strength of Materials?

## COMPRESSION TEST ON SPRING

**OBJECTIVE:** To conduct compression test on a given spring to determine the modulus of rigidity of the given spring material

**Equipment:** Spring Testing Machine / Spring Test Attachment / Spring Test Set-up

**Instruments:** Vernier Caliper, Dial Indicator

**Material:** Close coiled helical spring, Weights

### TASK ANALYSIS

#### 1. KNOWLEDGE:

- 1) Types and functions of springs
- 2) Working of Spring Testing Machine / Spring Test Attachment / Spring Test Set-up
- 3) Stiffness and rigidity modulus

#### 2. SKILL:

Category of Skill	Sub Task
Handling of apparatus	A. Identifying the components required. B. Checking load on the dial gauge C. Opening and closing of oil valve
Manipulation of apparatus	A. Closing the oil valve B. Setting of spring between the two jaws by the movement of jaws manually/hydraulically C. Check the working of load dial gauge
Precise Operations Activities	A. Recording dial gauge reading of load and Recording the deflection of the spring on vertical scale. B. Adjust the load manually/hydraulically and record the dial gauge reading and Recording the deflection of spring on the scale by increasing load

#### 3. TEACHING POINTS:

Sl. No	Teaching point	Time allocation (20 mins Suggestive)
1	Construction and working of Spring testing machine	6 min
2	Specifications of Spring(s) and vernier scale	3 min
3	Calculation of modulus of rigidity	6 min
4	Need and scope of the experiment	5 min

#### A) PROCEDURAL PRECAUTIONS:

- 1) Check the oil valve closing position.
- 2) Check the dial gauge reading without load.
- 3) Check the deflection reading on scale without load.
- 4) Care should be taken while applying the load on spring.

**B) SAFETY PRECAUTIONS:**

- 1) Wear apron
- 2) Beware of loose clothing while operating

**NEED AND SCOPE OF THE EXPERIMENT:**

The test on springs will give the value of modulus of rigidity of the spring. The deflection of the spring depends on load applied, radius of coil, number of turns of the coil, radius of spring wire and rigidity modulus of the spring

**SCHEME OF EVALUATION:**

Category of Skill	SUB TASK	WEIGHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)										
Handling of apparatus	A. Listing and collecting the instruments, and the material required B. Measuring the diameters of the spring and coil/wire C. Placing the spring in the spring testing machine D. Attaching the load hanger to the attachment	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>2</td> <td>5</td> <td>3</td> <td>2</td> <td>12</td> </tr> </tbody> </table>	A	B	C	D	T	2	5	3	2	12	12
A	B	C	D	T									
2	5	3	2	12									
Manipulation of apparatus	A. Closing the oil valve B. Setting of spring between the two jaws by the movement of jaws manually/hydraulically C. Check the working of load dial gauge <b>OR</b> Recording the dead weight reading Applying and removing the loads/weights gradually	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>2</td> <td>10</td> <td>8</td> <td>20</td> </tr> </tbody> </table>	A	B	C	T	2	10	8	20	20		
A	B	C	T										
2	10	8	20										
Precise Operations Activities	A. Recording dial gauge reading of load and Recording the deflection of the spring on vertical scale. B. Adjust the load manually/hydraulically and record the dial gauge reading and recording the deflection of spring on the scale by increasing load <b>OR</b> Recording the dial gauge or Vernier scale readings by adding and removing the loads on the hanger Draw the graph between load and deflection Find the stiffness and Rigidity Modulus of the spring material	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>10</td> <td>10</td> <td>20</td> </tr> </tbody> </table>	A	B	T	10	10	20	20				
A	B	T											
10	10	20											
Values	K) Co Operation L) Co- Ordination M) Communication N) Sharing O) Leadership	<table border="1"> <tbody> <tr> <td>5</td> </tr> </tbody> </table>	5	5									
5													

**ASSESSMENT QUESTIONS:**

- 1) Find the mean diameter of the given spring. (MO)
- 2) Count the number of turns of the given spring (LO)
- 3) Note down load vs deflection readings (HO)
- 4) Draw the graph between load and deflection (HO)
- 5) Find the stiffness of the spring from the given data (HO)
- 6) Find the rigidity modulus of the spring material from the given data (HO)

**VIVA QUESTIONS:**

1. What are the function of springs?
2. What is difference between closed coil helical spring and open coil helical spring?
3. What type of stress are involved in helical coil springs?
4. what type of spring is used to transmit small torque?
5. what are material used for manufacturing of springs?

## STUDY OF MICRO STRUCTURE OF METALS AND ALLOYS

**Objective:** To study the microstructure of the given metallographic specimen using the metallurgical microscope

**Equipment:** Monocular / Binocular Optical Metallurgical Microscope

**Material:** Optical Lenses, Metallographic Specimen

### TASK ANALYSIS

#### 1. KNOWLEDGE:

- 1) Microstructures
- 2) Handling of Microscope.
- 3) Investigation of microscopic structure.

#### 2. SKILL:

Category of Skill	Sub Task
Handling of apparatus	A. Listing and collecting the material required B. Assembling the parts of the given microscope C. Giving the electrical connections
Manipulation of apparatus	A. Selecting the correct combination of the eye and object lenses for getting required magnification
Precise Operations Activities	A. Adjusting the focal length B. Drawing the Microstructure C. Studying the microstructure and thereby identifying the different components and the name of the material.

#### 3. TEACHING POINTS:

Sl. No	Teaching point	Time allocation (20 mins Suggestive)
1	Microstructure	5 min
2	Metallurgical Microscope	6 min
3	Observation of structure through microscope	6 min
4	Need and scope of the experiment	3 min

#### A) PROCEDURAL PRECAUTIONS:

- 1) Check the Grinding be done on the emery in one direction.
- 2) Ensure mirror polished surface.
- 3) Etchant should be applied for a particular time and washed away.
- 4) Care should be taken the polished surface.
- 5) Handling the Microscope properly.

#### B) SAFETY PRECAUTIONS:

- 1) Wear apron.
- 2) Beware of loose clothing while operating.

## NEED AND SCOPE OF THE EXPERIMENT:

1. Study the characteristics and mechanical properties of a Metals and Alloys.
2. To predict the behavior of a component this is important while predicting the failure of the component at certain conditions.

## SCHEME OF EVALUATION:

Category of Skill	SUB TASK	WEIHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)								
Handling of apparatus	A. Listing and collecting the material required B. Assembling the parts of the given microscope C. Giving the electrical connections	<table border="1"><tr><td>A</td><td>B</td><td>C</td><td>T</td></tr><tr><td>3</td><td>5</td><td>1</td><td>9</td></tr></table>	A	B	C	T	3	5	1	9	9
A	B	C	T								
3	5	1	9								
Manipulation of apparatus	A) Selecting the correct combination of the eye and object lenses for getting required magnification	<table border="1"><tr><td>A</td><td>T</td></tr><tr><td>5</td><td>5</td></tr></table>	A	T	5	5	5				
A	T										
5	5										
Precise Operations Activities	A. Adjusting the focal length B. Drawing the Microstructure C. Studying the microstructure and thereby identifying the different components and the name of the material.	<table border="1"><tr><td>A</td><td>B</td><td>C</td><td>T</td></tr><tr><td>10</td><td>10</td><td>11</td><td>31</td></tr></table>	A	B	C	T	10	10	11	31	31
A	B	C	T								
10	10	11	31								
Values	A) Co Operation B) Co- Ordination C) Communication D) Sharing E) Leadership	<table border="1"><tr><td></td></tr><tr><td>5</td></tr></table>		5	5						
5											

## ASSESSMENT QUESTIONS:

### ASSEMENT QUESTIONS:

- 1) Identify the different parts of the given metallurgical microscope. (LO)
- 2) Calculate the magnification for the given set of object and eye lenses (pieces) (LO)
- 3) Assemble the parts of given microscope. (LO)
- 4) Adjust the focal length (MO)
- 5) Draw the microstructure of the given specimen. (HO)
- 6) Identify the different compositions of material for the given micro structure and name the material. (HO)
- 7) Functions of the different parts of micro scope (MO)

## VIVA - VOCE QUESTIONS:

1. What do you mean by alloy?
2. What is the composition of brass?
3. What is the composition of Gray cast iron?
4. Why grinding is performed before polishing?
5. Why the sequences of emery paper grades are used for finishing?
6. Why etchants are applied on specimen to find microstructure?
7. What are the etchants applied for gray cast iron and brass specimen?
8. Which type of microscope used to find microstructure?
9. What is meant by magnification of microscope?
10. What is the form of carbon in gray cast iron micro structure?

TENSION TEST

NAME OF THE STUDENT:	INSTITUTION:
PIN NUMBER:	DATE OF EXPERIMENT:
BRANCH:	EXPERIMENT NO:

- 1. Title of the experiment:**
- 2. Objective of the Experiment:**
- 3. Apparatus/Tools Required:**
- 4. Procedure:**

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.

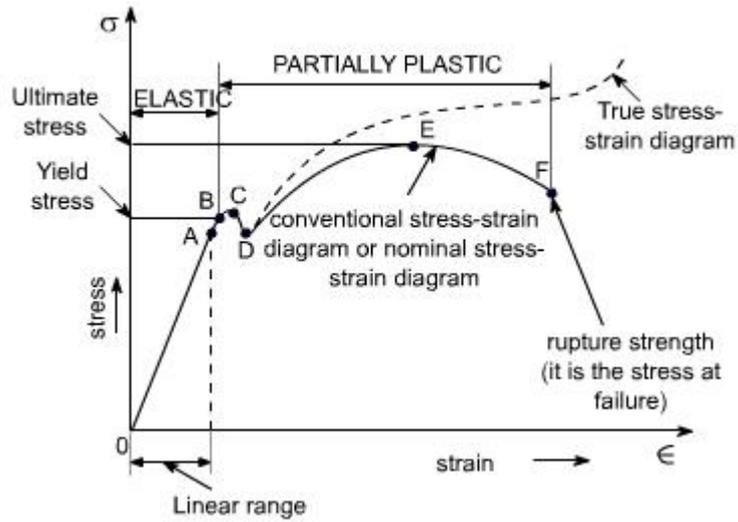
**5. Observations:**

- 1. Least count of vernier callipers: mm
- 2. Diameter of rod,D: mm
- 3. Initial Gauge length,L: mm
- 4. Load at yield point: N
- 5. Ultimate load: N
- 6. Breaking load: N
- 7. Final Gauge length, $\Delta L$ : mm
- 8. Diameter at fractured portion , $D_1$ : mm

**6. Table:**

S.NO	Load,P(KN)	Elongation, $\Delta l$ (mm)	Tensile Stress, $\sigma = P/A(KN/m^2)$	Stain, $e=\Delta L/L$	Young's modulus, $E= \sigma /e(KN/m^2)$

**7. GRAPHS:** Plot the graph between stress(y-axis) and strain(x-axis)



**8. Calculations :**

1. Original area of rod,  $A = \pi d^2/4 = \dots\dots\dots m^2$
2. Reduced area of rod,  $A_1 = \pi d_1^2/4 = \dots\dots\dots m^2$
3. Ultimate strength = ultimate load / original area =  $\dots\dots\dots N/m^2$
4. Yield strength = load at yield point / original area =  $\dots\dots\dots N/m^2$
5. Percentage of elongation =  $((L - \Delta L)/L) \times 100 = \dots\dots\dots$
6. Percentage area reduction =  $((A - A_1)/A) \times 100 = \dots\dots\dots$
7. Young's modulus,  $E = \dots\dots\dots$

**9. RESULTS AND DISCUSSIONS:**

1. % of elongation =  $\dots\dots\dots$
2. % of area reduction =  $\dots\dots\dots$
3. Youngs modulus =  $\dots\dots\dots$

**10. SCHEME OF EVALUATION:**

Category of Skill	SUB TASK	WEIHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)																
1. Handling of apparatus	A. Collecting the instruments, tools and material required. B. Punching the gauge points on the specimen	<table border="1"> <tr> <td>A</td> <td>B</td> <td>T</td> </tr> <tr> <td>2</td> <td>3</td> <td>5</td> </tr> </table>	A	B	T	2	3	5	05										
A	B	T																	
2	3	5																	
2. Manipulation of apparatus	A. Operating the motor to move the movable crosshead to fix the specimen B. Fixing job between jaws of upper and movable crossheads C. Fixing extensometer / Dial Indicator	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>T</td> </tr> <tr> <td>4</td> <td>5</td> <td>4</td> <td>2</td> <td>15</td> </tr> </table>	A	B	C	D	T	4	5	4	2	15	15						
A	B	C	D	T															
4	5	4	2	15															
3. Precise Operations/ Activities	A. Operating the control valves to apply the load on the specimen at the required rate B. Recording the load and elongations C. Calculating the stress and strains D. Drawing the graph between stress and strain E. Measuring the final gauge length and neck diameter F. Calculating the Young's modulus, Yield strength and Ultimate Strength from the graph G. Calculating the percentage of elongation and percentage of reduction in area	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>E</td> <td>F</td> <td>G</td> </tr> <tr> <td>4</td> <td>5</td> <td>3</td> <td>4</td> <td>2</td> <td>5</td> <td>2</td> </tr> </table> <table border="1"> <tr> <td>T</td> </tr> <tr> <td>25</td> </tr> </table>	A	B	C	D	E	F	G	4	5	3	4	2	5	2	T	25	25
A	B	C	D	E	F	G													
4	5	3	4	2	5	2													
T																			
25																			
4. Values	A) Cooperation B) Co-Ordination C) Communication D) Sharing E) Leadership	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>E</td> <td>T</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>5</td> </tr> </table>	A	B	C	D	E	T	1	1	1	1	1	5	5				
A	B	C	D	E	T														
1	1	1	1	1	5														



1.Ultimate Load : N

2. Dimensions of concrete cube: LXBXH

Length (L) = \_\_\_\_\_ mm

Breadth (B) = \_\_\_\_\_ mm

Height (H) = \_\_\_\_\_ mm

**6. CALCULATIONS:**

Compressive strength = \_\_\_\_\_

**7.SCHEME OF EVALUATION:**

Category of Skill	SUB TASK	WEIHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)										
<b>1. Handling of apparatus</b>	A) Identifying the components required. B) Measuring the dimensions of a given concrete cube.	<table border="1"> <tr> <td>A</td> <td>B</td> <td>T</td> </tr> <tr> <td>3</td> <td>2</td> <td>5</td> </tr> </table>	A	B	T	3	2	5	5				
A	B	T											
3	2	5											
<b>2. Manipulation of apparatus</b>	A) Connecting the power supply B) Fixing the specimen C) Setting the load range depending on the size of the specimen	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>T</td> </tr> <tr> <td>2</td> <td>8</td> <td>5</td> <td>15</td> </tr> </table>	A	B	C	T	2	8	5	15	15		
A	B	C	T										
2	8	5	15										
<b>3. Precise Operations Activities</b>	A) Checking of both the valves in closed position before start of the experiment. B) Operating the load valve. C) Observing the readings and noting of the max reading. D) Calculating the compressive strength	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>T</td> </tr> <tr> <td>5</td> <td>10</td> <td>5</td> <td>5</td> <td>25</td> </tr> </table>	A	B	C	D	T	5	10	5	5	25	25
A	B	C	D	T									
5	10	5	5	25									
<b>4. Values</b>	A) Co Operation B) Co- Ordination C) Communication D) Sharing E) Leadership	<table border="1"> <tr> <td>5</td> </tr> </table>	5	5									
5													

## SHEAR TEST

NAME OF THE STUDENT:	INSTITUTION:
PIN NUMBER:	DATE OF EXPERIMENT:
BRANCH:	EXPERIMENT NO:

**1. TITLE OF EXPERIMENT:**

**2. OBJECTIVE OF THE EXPERIMENT:**

**3. EQUIPMENTS REQUIRED:**

**4. SHEAR ATTACHMENT :**



**5. PROCEDURE:**



S.NO	To be observed	What is observed	Answer choose one from
1	Position of load valve and release valve before the commencement of the experiment		Open/close
2	Position of the specimen with shear attachment		Proper/improper
3	Position of the specimen in between the jaws		Center/side
4	Position of the load valve after placing the specimen		Open/close
5	Position of the release valve after placing the specimen		Open/close
6	Position of load valve and release valve at the end of the experiment		Open/close

**9. SCHEME OF EVALUATION:**

Category of Skill	SUB TASK	WEIHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)												
1. Handling of apparatus	A) Listing and collecting the components required. B) Identifying the specifications of the specimen	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>3</td> <td>2</td> <td>5</td> </tr> </tbody> </table>	A	B	T	3	2	5	5						
A	B	T													
3	2	5													
2. Manipulation of apparatus	A) Checking the power supply and working of UTM B) Checking start and stop buttons, Opening and closing valves. C) Checking the position of specimen in shear attachment	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>T</th> </tr> </thead> <tbody> <tr> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>3</td> <td>7</td> <td>10</td> <td>20</td> </tr> </tbody> </table>	A	B	C	T					3	7	10	20	20
A	B	C	T												
3	7	10	20												
3. Precise Operations Activities	A) Measuring the diameter of the specimen and fixing the Specimen in the Shear attachment. B) Keeping the shear equipment on the fixed jaw of UTM and apply the load slowly at right angles to the axis of piece through the central block and noting of load at fracture.	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>10</td> <td>10</td> <td>20</td> </tr> </tbody> </table>	A	B	T	10	10	20	20						
A	B	T													
10	10	20													
4. Values	A) Co Operation B) Co- Ordination C) Communication D) Sharing E) Leadership	<table border="1"> <tbody> <tr> <td></td> </tr> <tr> <td>5</td> </tr> </tbody> </table>		5	5										
5															

## IMPACT TEST (IZOD and CHARPY)

NAME OF THE STUDENT:	INSTITUTION:
PIN NUMBER:	DATE OF EXPERIMENT:
BRANCH:	EXPERIMENT NO:

**Title of Experiment:**

**Objective of the experiment:**

**Equipment Required:**

**Diagram of the Izod Test Specimen:**

**Diagram of the Charpy Test Specimen:**

**Procedure**

**(a) Izod Impact Test:**


**(b) Charpy Impact Test:**


**Observations:**

**(a) Izod Impact Test:**

- a. Type of material used:
- b. Size of the specimen used:
- c. Type and position of V-notch:
- d. Depth of V-notch:
- e. Maximum capacity of pendulum:

S.No.	Materials	Scale reading without specimen( $E_1$ )	Scale reading after fracture( $E_2$ )	Impact resistance ( $E_1-E_2$ )
1				
2				
3				

**(b) Charpy Impact Test:**

- a. Type of material used:
- b. Size of the specimen used:
- c. Type and position of V-notch:
- d. Depth of V-notch:
- e. Maximum capacity of pendulum:

S.No.	Materials	Scale reading without specimen( $E_1$ )	Scale reading after fracture( $E_2$ )	Impact resistance ( $E_1-E_2$ )
1				
2				
3				

**Result:**

**Discussion on the result:**

**8. Deficiencies / malfunctioning of any apparatus:**

**9. Scheme of Evaluation:**

Category of Skill	SUB TASK	WEIHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)										
<b>1.Handling of apparatus</b>	A. Identifying the components required. B. Using of allen key to fix striking hammer. C. Fixing striker to striking hammer	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>2</td> <td>1</td> <td>2</td> <td>5</td> </tr> </tbody> </table>	A	B	C	T	2	1	2	5	5		
A	B	C	T										
2	1	2	5										
<b>2.Manipulation of apparatus</b>	A. Fixing the one end of test specimen in jaws. B. Adjusting the striking hammer to test specimen and lock it. C. Adjusting the dial needle to extreme position.	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>4</td> <td>4</td> <td>7</td> <td>15</td> </tr> </tbody> </table>	A	B	C	T	4	4	7	15	15		
A	B	C	T										
4	4	7	15										
<b>3.Precise Operations Activities</b>	A. Preparing the specimen with Exact Dimensions B. Recording the dial reading after releasing the pendulum without test specimen. C. Recording the dial reading after releasing the pendulum with test specimen. D. Calculating the Impact Strength	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>10</td> <td>4</td> <td>4</td> <td>7</td> <td>25</td> </tr> </tbody> </table>	A	B	C	D	T	10	4	4	7	25	25
A	B	C	D	T									
10	4	4	7	25									
<b>4.Values</b>	A) Co Operation B) Co- Ordination C) Communication D) Sharing E) Leadership	<table border="1"> <tbody> <tr> <td>5</td> </tr> </tbody> </table>	5	5									
5													

NAME OF THE STUDENT:	INSTITUTION:
PIN NUMBER:	DATE OF EXPERIMENT:
BRANCH:	EXPERIMENT NO:

**TITLE OF EXPERIMENT:**

**OBJECTIVE OF THE EXPERIMENT:**

**EQUIPMENTS REQUIRED:**

S.No	Name	Quantity

**PROCEDURE:**

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_
7. \_\_\_\_\_
8. \_\_\_\_\_
9. \_\_\_\_\_
10. \_\_\_\_\_
11. \_\_\_\_\_
12. \_\_\_\_\_

**OBSERVATIONS:**

**Table 1 Calculation of BHN**

S. No	material	Dia. of the indenter d (mm)	Dia. of ball indenter D (mm)	Applied Load (Kgf)	BHN

**RESULT:**

Hardness of the given material is \_\_\_\_\_ BHN

**DISCUSSION ON THE RESULT:**

---



---



---



---

**LIMITATIONS OF BRINELL'S HARDNESS EXPERIMENT:**

**SCHEME OF EVALUATION:**

Category of Skill	SUB TASK	WEIHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)												
1. Handling of apparatus	A. Measuring the diameter of the indentor B. Fixing the indentor	<table border="1"> <tr> <td>A</td> <td>B</td> <td>T</td> </tr> <tr> <td>2</td> <td>3</td> <td>5</td> </tr> </table>	A	B	T	2	3	5	7						
A	B	T													
2	3	5													
2. Manipulation of apparatus	A) Calculating the load to be applied depending on material and indentor B) Rotating the elevating screw so that there will be perfect contact between the indentor and specimen C) Apply the load on the specimen	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>T</td> </tr> <tr> <td>5</td> <td>5</td> <td>5</td> <td>15</td> </tr> </table>	A	B	C	T	5	5	5	15	15				
A	B	C	T												
5	5	5	15												
3. Precise Operations Activities	A) Measuring the diameter of the indentation with Brinell Microscope B) Calculating the Brinell Hardness Number	<table border="1"> <tr> <td>A</td> <td>B</td> <td>T</td> </tr> <tr> <td>15</td> <td>10</td> <td>25</td> </tr> </table>	A	B	T	15	10	25	25						
A	B	T													
15	10	25													
4. Values	A) Co Operation B) Co- Ordination C) Communication D) Sharing E) Leadership	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>E</td> <td>T</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>5</td> </tr> </table>	A	B	C	D	E	T	1	1	1	1	1	5	5
A	B	C	D	E	T										
1	1	1	1	1	5										

# ROCKWELL'S HARDNESS TEST

NAME OF THE STUDENT:	INSTITUTION:
PIN NUMBER:	DATE OF EXPERIMENT:
BRANCH:	EXPERIMENT NO:

**TITLE OF EXPERIMENT:**

**OBJECTIVE OF THE EXPERIMENT:**

**EQUIPMENTS REQUIRED:**

S.No	Name	Quantity

**PROCEDURE:**

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_
7. \_\_\_\_\_
8. \_\_\_\_\_
9. \_\_\_\_\_
10. \_\_\_\_\_
11. \_\_\_\_\_
12. \_\_\_\_\_

**OBSERVATIONS:**

**Table 1 Calculation of RHN**

S. No	Material	Rockwell scale	Weight	Indenter	RHN trials
1					
2					
3					

**RESULT:**

Hardness of the given material is \_\_\_\_\_ RHN

**DISCUSSION ON THE RESULT:**

**LIMITATIONS OF ROCKWELL'S HARDNESS EXPERIMENT:**

**SCHEME OF EVALUATION:**

Category of Skill	SUB TASK	WEIHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)												
1. Handling of apparatus	A. Selecting the correct set of scale, dial, indenter and load for the given material B. Identifying the load knob (or load hand lever) and loads changer indicator.	<table border="1"> <tr> <td>A</td> <td>B</td> <td>T</td> </tr> <tr> <td>2</td> <td>3</td> <td>5</td> </tr> </table>	A	B	T	2	3	5	8						
A	B	T													
2	3	5													
2. Manipulation of apparatus	A. Fixing the indenter B. Selecting the corresponding load by rotating the load selector wheel C. Adjusting the position of specimen on the anvil so that the new indentation will be at least 5 mm away from the	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>T</td> </tr> <tr> <td>5</td> <td>5</td> <td>5</td> <td>15</td> </tr> </table>	A	B	C	T	5	5	5	15	15				
A	B	C	T												
5	5	5	15												
3. Precise Operations Activities	A. Applying the minor load B. Applying and releasing the major load C. Testing the hardness tester with standard specimen D. Recording the dial reading after releasing the load on actual specimen	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>T</td> </tr> <tr> <td>5</td> <td>5</td> <td>10</td> <td>5</td> <td>25</td> </tr> </table>	A	B	C	D	T	5	5	10	5	25	25		
A	B	C	D	T											
5	5	10	5	25											
4. Values	A) Co Operation B) Co- Ordination C) Communication D) Sharing E) Leadership	<table border="1"> <tr> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>E</td> <td>T</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>5</td> </tr> </table>	A	B	C	D	E	T	1	1	1	1	1	5	5
A	B	C	D	E	T										
1	1	1	1	1	5										



Least count of dial gauge .....

Span of beam .....

Total Depth of the beam .....

Width of the beam .....

**For Depth of the beam:**

S.no	Main Scale reading	V.C.R	M.S.R+ (V.C.R × L.C)
1			
2			
3			
	Average		

**For Steel and wood: Load placed  $\left(\frac{L}{2}\right)$  mid span of the beam on a**

**longitudinal(Widthwise) direction:**

S.No	Load ,W (in kg )	Deflection reading in divisions		Deflection reading in "mm"		Young's modulus $E = \frac{WL^3}{48\delta I}, N/mm^2$	
		Mild Steel	Wood	Mild Steel	Wood	Mild Steel	Wood
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

For Steel and wood: Load placed  $\left(\frac{L}{2}\right)$  mid span of the beam on a longitudinal

(Depthwise) direction:

S.No	Load ,W (in kg )	Deflection reading in divisions		Deflection reading in "mm"		Young's modulus $E = \frac{WL^3}{48\delta I}, N/mm^2$	
		Mild Steel	Wood	Mild Steel	Wood	Mild Steel	Wood
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

For Steel and wood: load placed  $\frac{2L}{3}$  from right side support of the beam on longitudinal

(Widthwise) direction:

S.No	Load ,W (in kg )	Deflection reading in divisions		Deflection reading in "mm"		Young's modulus $E = \frac{WL^3}{48\delta I}, N/mm^2$	
		Mild Steel	Wood	Mild Steel	Wood	Mild Steel	Wood
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

For Steel and wood: load placed  $\frac{2L}{3}$  from right side support of the beam on lateral (Depth wise)) direction:



### 10. SCHEME OF EVALUATION:

Category of Skill	SUB TASK	WEIHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)												
<b>1. Handling of apparatus</b>	A) Listing and collecting the instruments and material required. B) Measuring the length, width and depth of the given beam C) Placing the hangers and dial indicator at the appropriate locations	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>2</td> <td>2</td> <td>1</td> <td>5</td> </tr> </tbody> </table>	A	B	C	T	2	2	1	5	7				
A	B	C	T												
2	2	1	5												
<b>2. Manipulation of apparatus</b>	A) Fixing the dial indicator and adjust the initial reading to zero B) Ensuring the contact between the beam and strainer of dial indicator	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>5</td> <td>5</td> <td>10</td> </tr> </tbody> </table>	A	B	T	5	5	10	10						
A	B	T													
5	5	10													
<b>3. Precise Operations Activities</b>	A) Recording the load and dial gauge readings B) Calculating moment of inertia for both beams. C) Drawing the graph for deflection vs load D) Calculating the Young's modulus and stiffness of the beam.	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>10</td> <td>02</td> <td>10</td> <td>08</td> <td>30</td> </tr> </tbody> </table>	A	B	C	D	T	10	02	10	08	30	30		
A	B	C	D	T											
10	02	10	08	30											
<b>4. Values</b>	A) Co Operation B) Co- Ordination C) Communication D) Sharing E) Leadership	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>E</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>5</td> </tr> </tbody> </table>	A	B	C	D	E	T	1	1	1	1	1	5	5
A	B	C	D	E	T										
1	1	1	1	1	5										

SPRING TEST

NAME OF THE STUDENT:	INSTITUTION:
PIN NUMBER:	DATE OF EXPERIMENT:
BRANCH:	EXPERIMENT NO:

**TITLE OF EXPERIMENT:**

**OBJECTIVE OF THE EXPERIMENT:**

**EQUIPMENT REQUIRED:**

**A) PROCEDURE (FOR TENSION TEST):**


**(B) PROCEDURE (FOR COMPRESSION TEST):**


**OBSERVATIONS TABLE (for TENSION TEST)**

S. No.	Load (W) In KN	Deflection $\delta$ (in mm)	Stiffness of Spring= $W/\delta$ (N/m)	Modulus of Rigidity 'N' (N/mm <sup>2</sup> )
1				
2				
3				
4				
5				
6				

**Model Calculations:**

Least count of vernier : mm  
 Mean dia of coil wire (d) : mm  
 Mean radius of Spring (R): mm  
 No. of coils (n) :

Deflection of Helical Spring ,  $\delta = \frac{64WR^3n}{Nd^4}$

Rigidity modulus of Spring , N=  $\frac{64WR^3n}{\delta d^4}$

**OBSERVATIONS TABLE (for COMPRESSION TEST)**

S. No.	Load (W) In KN	Deflection $\delta$ (in mm)	Stiffness of Spring= $W/\delta$ (N/m)	Modulus of Rigidity 'N' (N/mm <sup>2</sup> )
1				
2				
3				
4				
5				
6				

**Model Calculations:**

Least count of vernier : mm  
 Mean dia of coil wire (d): mm  
 Mean radius of Spring (R): mm  
 No. of coils (n) :

Deflection of Helical Spring ,  $\delta = \frac{64WR^3n}{Nd^4}$

Rigidity modulus of Spring , N=  $\frac{64WR^3n}{\delta d^4}$

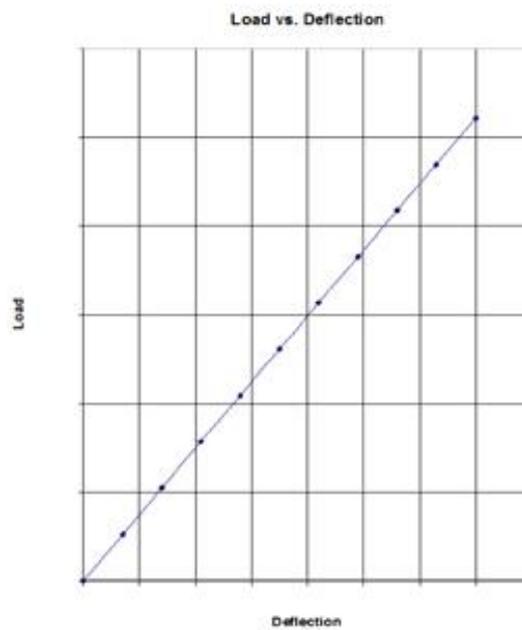
**RESULT:**

**DISCUSSION ON THE RESULT:**

**DEFICIENCIES / MALFUNCTIONING OF ANY APPARATUS:**

**GRAPHS:**

**1. LOAD  $V_s$  DEFLECTION**



**SCHEME OF EVALUATION:**

Category of Skill	SUB TASK	WEIHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)										
<b>1. Handling of apparatus</b>	A. Listing and collecting the instruments, and the material required B. Measuring the diameters of the spring and coil/wire C. Placing the spring in the spring testing machine D. Attaching the load hanger to the attachment	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>2</td> <td>5</td> <td>3</td> <td>2</td> <td>12</td> </tr> </tbody> </table>	A	B	C	D	T	2	5	3	2	12	12
A	B	C	D	T									
2	5	3	2	12									
<b>2. Manipulation of apparatus</b>	A. Closing the oil valve B. Setting of spring between the two jaws by the movement of jaws manually/hydraulically C. Check the working of load dial gauge OR Recording the dead weight reading Applying and removing the loads/weights gradually	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>2</td> <td>10</td> <td>8</td> <td>20</td> </tr> </tbody> </table>	A	B	C	T	2	10	8	20	20		
A	B	C	T										
2	10	8	20										
<b>3. Precise Operations Activities</b>	A. Recording dial gauge reading of load and Recording the deflection of the spring on vertical scale. B. Adjust the load manually/hydraulically and record the dial gauge reading and recording the deflection of spring on the scale by increasing load OR Recording the dial gauge or Vernier scale readings by adding and removing the loads on the hanger Draw the graph between load and deflection Find the stiffness and Rigidity Modulus of the spring material	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>10</td> <td>10</td> <td>20</td> </tr> </tbody> </table>	A	B	T	10	10	20	20				
A	B	T											
10	10	20											
<b>4. Values</b>	A) Co Operation B) Co- Ordination C) Communication D) Sharing E) Leadership	<table border="1"> <tbody> <tr> <td></td> </tr> <tr> <td>5</td> </tr> </tbody> </table>		5	5								
5													

## STUDY OF MICROSTRUCTURE

NAME OF THE STUDENT:	INSTITUTION:
PIN NUMBER:	DATE OF EXPERIMENT:
BRANCH:	EXPERIMENT NO:

- 1. TITLE OF EXPERIMENT:**
- 2. OBJECTIVE OF THE EXPERIMENT:**
- 3. EQUIPMENTS REQUIRED:**

S.no	Name	Quantity
1		-
2		
3		
4		
5		
6		
7		
8		

**4. Micro structures of****1. Gray cast iron****2. Brass****5. PROCEDURE:**

## 6. OBSERVATIONS:

S.NO	To be observed	What is observed
1	microstructure of given material	
2	Structural characteristics of materials	
3	What kind of structure it has	

## 7. SCHEME OF EVALUATION:

Category of Skill	SUB TASK	WEIHTAGE WITH COMPETENCY LEVEL INDIVIDUALLY	TOTAL (50)								
5. Handling of apparatus	D. Listing and collecting the material required 6. Assembling the parts of the given microscope 7. Giving the electrical connections	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>3</td> <td>5</td> <td>1</td> <td>9</td> </tr> </tbody> </table>	A	B	C	T	3	5	1	9	9
A	B	C	T								
3	5	1	9								
8. Manipulation of apparatus	B) Selecting the correct combination of the eye and object lenses for getting required magnification	<table border="1"> <thead> <tr> <th>A</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>5</td> <td>5</td> </tr> </tbody> </table>	A	T	5	5	5				
A	T										
5	5										
9. Precise Operations Activities	D. Adjusting the focal length E. Drawing the Microstructure F. Studying the microstructure and thereby identifying the different components and the name of the material. G.	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> <th>T</th> </tr> </thead> <tbody> <tr> <td>10</td> <td>10</td> <td>11</td> <td>31</td> </tr> </tbody> </table>	A	B	C	T	10	10	11	31	31
A	B	C	T								
10	10	11	31								
H. Values	F) Co Operation G) Co- Ordination H) Communication I) Sharing J) Leadership	<table border="1"> <tbody> <tr> <td>5</td> </tr> </tbody> </table>	5	5							
5											

# SIMPLE TENSION TEST

Equipment: Universal Testing Machine / Tensile Testing Machine

Instruments: Vernier Calipers, Dial Indicator with Magnetic Stand / Extensometer

Tools: Dot Punch, Hammer

Material: Mild Steel rod

## DESCRIPTION OF THE EQUIPMENT:



Capacity of the UTM:

Range of the loads available:

Type of control:

A universal testing machine consists of two main parts:

1. Loading Unit
2. Control Unit

The arrangement of the test specimen and the exertion of the load is held in the **loading unit**.

The variations in the application of the load and the corresponding test result are obtained from the **control unit**.

In the figure, the right unit with table and crosshead form the loading unit. The left unit with a load indicator arrangement is the control unit.

## 1. LOADING UNIT:

The loading unit of a UTM consists of the following components:

- a. Load Frame
- b. Upper crosshead and Movable crosshead
- c. Elongation Scale

### a. Load Frame

The load frame of a universal testing machine can be made either by single support or by double support. The load Frame consists of upper crosshead, lower crosshead and movable or middle cross head used to fix the specimen depending on the test to be conducted.

### *b. Upper Crosshead and Movable Crosshead*

The upper crosshead is used to clamp one end of the test specimen. The Movable crosshead in the load frame is the movable crosshead whose screws can be loosened for height adjustment and tightened. Both the crossheads have a tapered slot at the centre. This slot has a pair of racked jaws that is intended to grip and hold the tensile test specimen. The upper and lower crossheads are connected by two cylindrical columns.

### *c. Elongation Scale*

The relative movement of the lower and upper table is measured by an elongation scale which is provided along with the loading unit.

## 2. CONTROL UNIT

The main components of the control unit in a universal testing machine are :

- a. Hydraulic Power Unit
- b. Load Measuring Unit
- c. Control Devices

### a. Hydraulic Power Unit

This unit consists of an oil pump that provides non-pulsating oil flow into the main cylinder of the load unit. This flow helps in the smooth application of load on the specimen. The oil pump in a hydraulic power unit is run by an electric motor and sump.

### b. Load Measuring Unit

This unit has a pendulum dynamometer unit that has a small cylinder with a piston which moves with the non-pulsating oil flow. The pendulum is connected to the piston by pivot lever.

The pivot lever deflects based on the load applied to the specimen. This deflection is converted to the load pointer and displays as the load on the dial.

The range of load application can be adjusted by means of a knob in the load measuring unit (0-100 kN; 0-250 kN; 0-500 kN and 0-1000 kN). The accuracy of measuring unit controls the overall accuracy of the machine.

### c. Control Devices

The control devices can be electric or hydraulic. Electric control devices make use of switches to move the crossheads and switch on/off the unit. A hydraulic control device consists of two valves, Right Control Valve and Left Control Valve or Release Valve. A right control valve is used to apply load on the specimen. The left control valve is used to release the load application as shown in figure.

### THEORY:

It is the fundamental and very important test to be conducted to know the various mechanical properties of the metals like, Yield Strength, Ultimate Strength, Young's Modulus and ductility.

The test involves straining a test piece by tensile force, generally to fracture, for the purpose of determining one or more of the mechanical properties mentioned above.

The test is carried out at ambient temperature between 10°C and 35 °C, unless otherwise specified. Tests carried out under controlled conditions shall be made at a temperature of 23 °C ± 5°C.

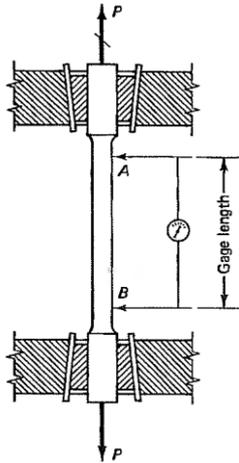
**Gauge Length:** Length of the cylindrical or prismatic portion of the test piece on which elongation shall be measured.

**Original Gauge Length ( $L_0$ ):** Gauge length before application of force. It is equal to 5d

**Final Gauge Length ( $L_f$ ):** Gauge length after rupture of the test piece

Each end of the original gauge length shall be marked by means of fine marks or scribed lines, but not by notches which could result in premature fracture.

For proportional test pieces, the calculated value of the original gauge length may be rounded off to the nearest multiple of 5 mm, provided that the difference between the calculated and marked gauge length is less than 10 % of  $L_0$ . The original gauge length shall be marked to an accuracy of ± 1 %.

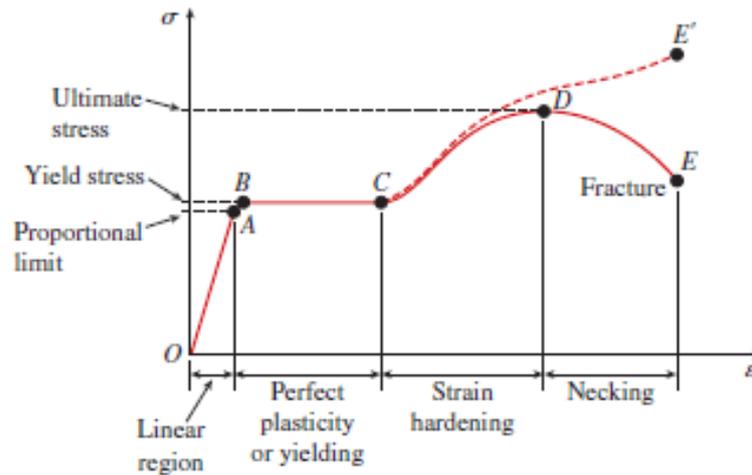


The axial stress  $\sigma$  in a test specimen is calculated by dividing the axial load  $P$  by the cross-sectional area  $A$ . When the initial area of the specimen is used in the calculation, the stress is called the **nominal stress** (other names are *conventional stress* and *engineering stress*). A more exact value of the axial stress, called the **true stress**, can be calculated by using the actual area of the bar at the cross section where failure occurs. Since the actual area in a tension test is always less than the initial area, the true stress is larger than the nominal stress.

The average axial strain  $\epsilon$  in the test specimen is found by dividing the measured elongation  $\delta$  between the gage marks by the gage length  $L$ . If the initial gage length is used in the calculation, then the **nominal strain** is obtained. Since the distance between the gage marks increases as the tensile load is applied, we can calculate the **true strain** (or *natural strain*) at any value of the load by using the actual distance between the gage marks. In tension, true strain is always smaller than nominal strain. However, for most engineering purposes, nominal stress and nominal strain are adequate.

After performing a tension or compression test and determining the stress and strain at various magnitudes of the load, we can plot a diagram of stress versus strain. Such a **stress-strain diagram** is a characteristic of the particular material being tested and conveys important information about the mechanical properties and type of behavior.

Structural steel is one of the most widely used metals and is found in buildings, bridges, cranes, ships, towers, vehicles, and many other types of construction. A stress-strain diagram for a typical structural steel in tension is shown in Fig. Strains are plotted on the horizontal axis and stresses on the vertical axis. (In order to display all of the important features of this material, the strain axis in Fig. is not drawn to scale.)



The diagram begins with a straight line from the origin  $O$  to point  $A$ , which means that the relationship between stress and strain in this initial region is not only *linear* but also *proportional*. Beyond point  $A$ , the proportionality between stress and strain no longer exists; hence the stress at  $A$  is called the **proportional limit**. For low-carbon steels, this limit is in the range 210 to 350 MPa, but high-strength steels (with higher carbon content plus other alloys) can have proportional limits of more than 550 MPa.

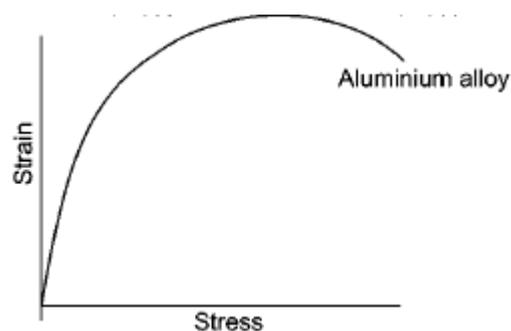
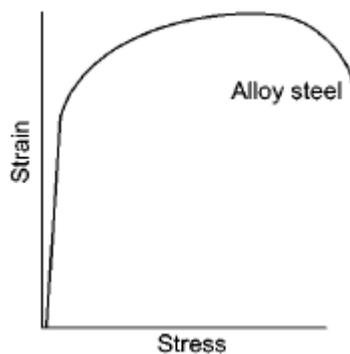
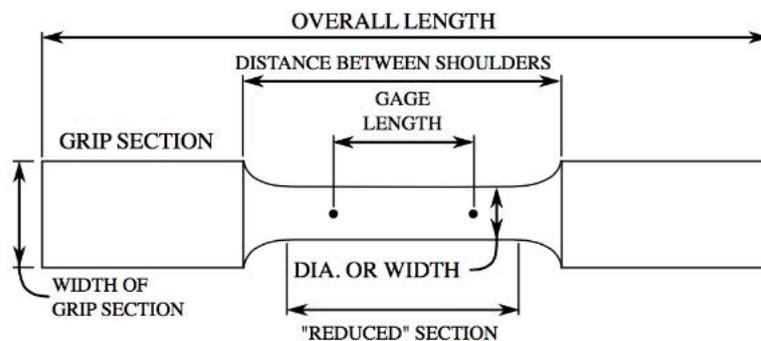
The slope of the straight line from  $O$  to  $A$  is called the **modulus of elasticity**. Because the slope has units of stress divided by strain, modulus of elasticity has the same units as stress.

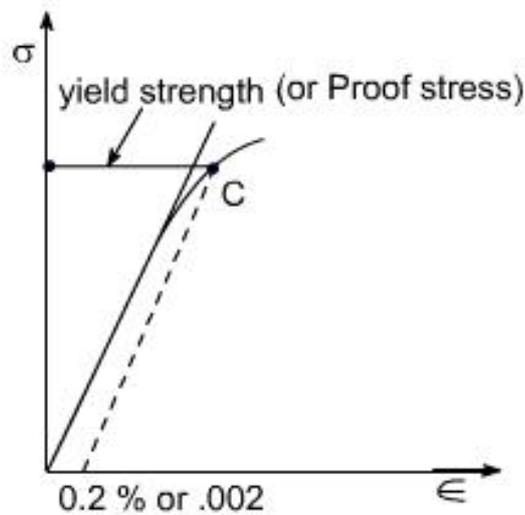
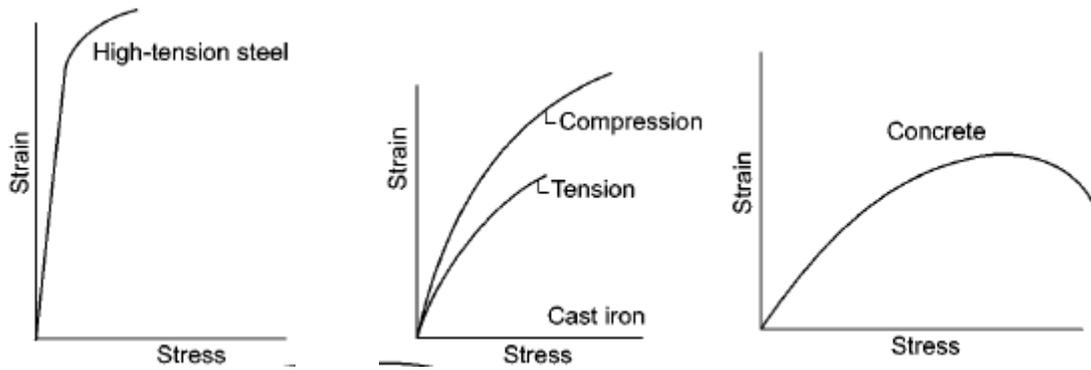
With an increase in stress beyond the proportional limit, the strain begins to increase more rapidly for each increment in stress. Consequently, the stress-strain curve has a smaller and smaller slope, until, at point  $B$ , the curve becomes horizontal (see Fig.). Beginning at this point, considerable elongation of the test specimen occurs with no noticeable increase in the tensile force (from  $B$  to  $C$ ). This phenomenon is known as **yielding** of the material, and point  $B$  is called the **yield point**. The corresponding stress is known as the **yield stress** of the steel. In the region from  $B$  to  $C$  (see Fig.), the material becomes **perfectly plastic**, which means that it deforms without an increase in the applied load. The elongation of a mild-steel specimen in the perfectly plastic region is typically 10 to 15 times the elongation that occurs in the linear region (between the onset of loading and the proportional limit). The presence of very large strains in the plastic region (and beyond) is the reason for not plotting this diagram to scale.

After undergoing the large strains that occur during yielding in the region  $BC$ , the steel begins to **strain harden**. During strain hardening, the material undergoes changes in its crystalline structure, resulting in increased resistance of the material to further deformation. Elongation of the test specimen in this region requires an increase in the tensile load, and therefore the stress-strain diagram has a positive slope from  $C$  to  $D$ . The load eventually reaches its maximum value, and the corresponding stress (at point  $D$ ) is called the **ultimate stress**. Further stretching of the bar is actually accompanied by a reduction in the load, and fracture finally occurs at a point such as  $E$  in Fig.

The yield stress and ultimate stress of a material are also called the **yield strength** and **ultimate strength**, respectively. **Strength** is a general term that refers to the capacity of a structure to resist loads. For instance, the yield strength of a beam is the magnitude of the load required to cause yielding in the beam, and the ultimate strength of a truss is the maximum load it can support, that is, the failure load. However, when conducting a tension test of a particular material, we define load-carrying capacity by the stresses in the specimen rather than by the total loads acting on the specimen. As a result, the strength of a material is usually stated as a stress.

When a test specimen is stretched, **lateral contraction** occurs, as previously mentioned. The resulting decrease in cross-sectional area is too small to have a noticeable effect on the calculated values of the stresses up to about point C in Fig., but beyond that point the reduction in area begins to alter the shape of the curve. In the vicinity of the ultimate stress, the reduction in area of the bar becomes clearly visible and a pronounced **necking** of the bar occurs. If the actual cross-sectional area at the narrow part of the neck is used to calculate the stress, the **true stress-strain curve** (the dashed line  $CE'$  in Fig.) is obtained. The total load the bar can carry does indeed diminish after the ultimate stress is reached (as shown by curve  $DE$ ), but this reduction is due to the decrease in area of the bar and not to a loss in strength of the material itself. In reality, the material withstands an increase in true stress up to failure (point  $E'$ ). Because most structures are expected to function at stresses below the proportional limit, the **conventional stress-strain curve**  $OABCDE$ , which is based upon the original cross-sectional area of the specimen and is easy to determine, provides satisfactory information for use in engineering design.





**PROCEDURE:**

1. Determine the diameter of given steel rod using the vernier calipers at three places along the length of the specimen and calculate the average diameter of the rod.
2. Calculate the gauge length and mark the gauge points along the length of the specimen with the dot punch and hammer
3. Fix the specimen in between the upper and middle cross heads
4. Apply the load and note down the loads for every one mm elongation of the specimen
5. Continue the test till it breaks.
6. By switching off the machine remove the two parts of the broken specimen. By putting the two parts together find the final gauge length by measuring the distance between the gauge points on either side of the broken plane. Also measure the diameter at the neck of the specimen.

**Observations:**

**Initial Diameter of the specimen:**

S.No.	Main Scale Reading (MSR)(mm)	Vernier Coincidence (V C)	Vernier Reading (VR)= V C X L C (Least Count)	Total Reading = MSR + VR (mm)
01				
02				
03				

Initial Diameter of the rod ( $d_1$ ) =

Initial Gauge length ( $l_1$ ) = 5 X  $d_1$

Initial Cross - sectional area of the specimen  $A_1 = \frac{\pi}{4}(d_1)^2 =$

Final length of the specimen after elongation ( $l_2$ ) =

Neck diameter of the rod ( $d_2$ ) =

Final cross-sectional area of the specimen  $A_2 = \frac{\pi}{4}(d_2)^2 =$

Load at yield point =

Ultimate load =

Breaking point load =

S. No	Load in N (P)	Elongation in mm ( $\delta l$ )	Tensile Stress in MPa	Strain ( $\delta l / L$ )
1				
2				
3				
4				
5				

**Calculations:**

$$\text{Yield Stress} = \frac{\text{load at yield point}}{\text{original cross - sectional area}}$$

$$\text{Ultimate Stress} = \frac{\text{ultimate load}}{\text{original cross - sectional area}}$$

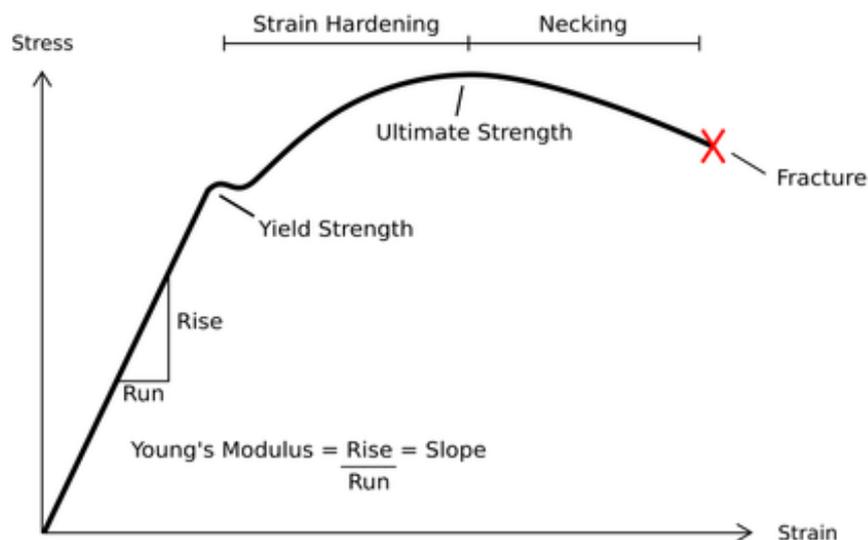
$$\text{Breaking Stress} = \frac{\text{breaking load}}{\text{original cross - sectional area}}$$

Young's Modulus of the material = Slope of the stress-strain diagram below the proportionality limit

$$\text{Percentage of elongation in length} = \frac{\text{final length} - \text{initial length}}{\text{initial length}} \times 100$$

$$\text{Percentage of reduction in area} = \frac{\text{Initial cross - sectional area} - \text{final cross - sectional area}}{\text{Initial cross - sectional area}} \times 100$$

**Graphs:** Draw the graph between stress and strain.



**Result:** By conducting the tension test on the given specimen the following mechanical properties of the material are determined

Young's Modulus =  
Yield Stress =  
Ultimate Stress =  
Breaking Stress =  
Percentage of Elongation in length =  
Percentage of reduction in Area =

## COMPRESSION TEST

### DESCRIPTION:

**COMPRESSION TESTING MACHINE:** Compression testing **equipment** is widely used in industry and lab works. Compression test machine is electrically operated with dual display load gauge-2000 KN x 1 KN/Division.

Capacity – 2000 KN (200 Tonnes)

Main features: High precision and resolution, user friendly software, performance of many types of tests, real time monitoring of test data.

**COMPONENTS OF COMPRESSION TESTING MACHINE:** The following main components are

- a. Loading unit
- b. Control panel
- c. Hydraulic system
- d. Load measuring and indicating system for Electronic machine

- a. **Loading unit:** It consists of base at its center, hydraulic cylinder, piston and two screws. Across head is mounted on the screws and is driven by a motor for rapid adjustment of test height. A table is mounted on the piston.
- b. **Control panel:** It consists of hydraulic system with power pack, load measuring and indicating system and electrical system
- c. **Hydraulic system:** It consists of hydraulic power pack with directly driven radial plunger pump power of consists of oil filter, oil strainer, air breather, drain plug, oil level indicator etc. A pressure compensated flow control valve is provided for controlling the oil flow to cylinder by achieving desired piston speed.
- d. **Load measuring and indicating system for Electronic machine:** The oil pressure in the main cylinder is transferred to an electronic pressure transducer which gives proportional electronic signal. Displacement measurement is carried out by a rotary encoder mounted on the base. The linear motion of piston is converted into rotary motion and the encoder undergoes angular displacement. This gives proportional electronic signal for deflection.



**THEORY:**

The goal of a compression test is to determine the behavior or response of a material while it experiences a compressive load by measuring fundamental variables such as stress, strain and deformation.

**PROCEDURE:**

1. Note the identification marks, size and weight of the concrete cube (specimen).
2. Start the machine after ensuring sufficient lubrication.
3. Place the specimen centrally on the lower fixed jaw.
4. Lower the upper movable jaw by means of hand operated lever until it touches the top of the cube.
5. Apply the load gradually by operating the load valve.
6. Observe the load and deflection readings.
7. Note the final reading (ultimate point) when the rate of loading displays a negative value.

**OBSERVATIONS:**

1. Load = N
2. Dimensions of concrete cube: LXBXH  
Length (L) = mm  
Breadth (B) = mm  
Height (H) = mm

**CALCULATIONS:**

Surface area= length X breadth = \_\_\_\_\_

Compressive strength = \_\_\_\_\_

S.No.	Sample size (mm <sup>3</sup> )	Breaking Load(KN)	Surface area	Compression strength(KN/mm <sup>2</sup> )

**RESULT:**

Ultimate compressive strength = \_\_\_\_\_

**OBSERVATION AND RECORDING:**

<b>S.NO</b>	<b>To be observed</b>	<b>What is observed</b>	<b>Answer choose one from</b>
1	Position of load valve and oil release valve before commencement of experiment		OPEN/CLOSED
2	Position of load valve and oil release valve after commencement of experiment		OPEN/CLOSED
3	Position of specimen in the jaws		Centre/ Side
4	Rate of loading before reaching ultimate point		POSITIVE/NEGATIVE
5	Rate of loading after reaching ultimate point		POSITIVE/NEGATIVE
6	Position of load valve and oil release valve at the end of the experiment		OPEN/CLOSED

## SHEAR TEST

Equipment: UTM, Shear Shackles / Shear test attachment

Instruments: Vernier Calipers

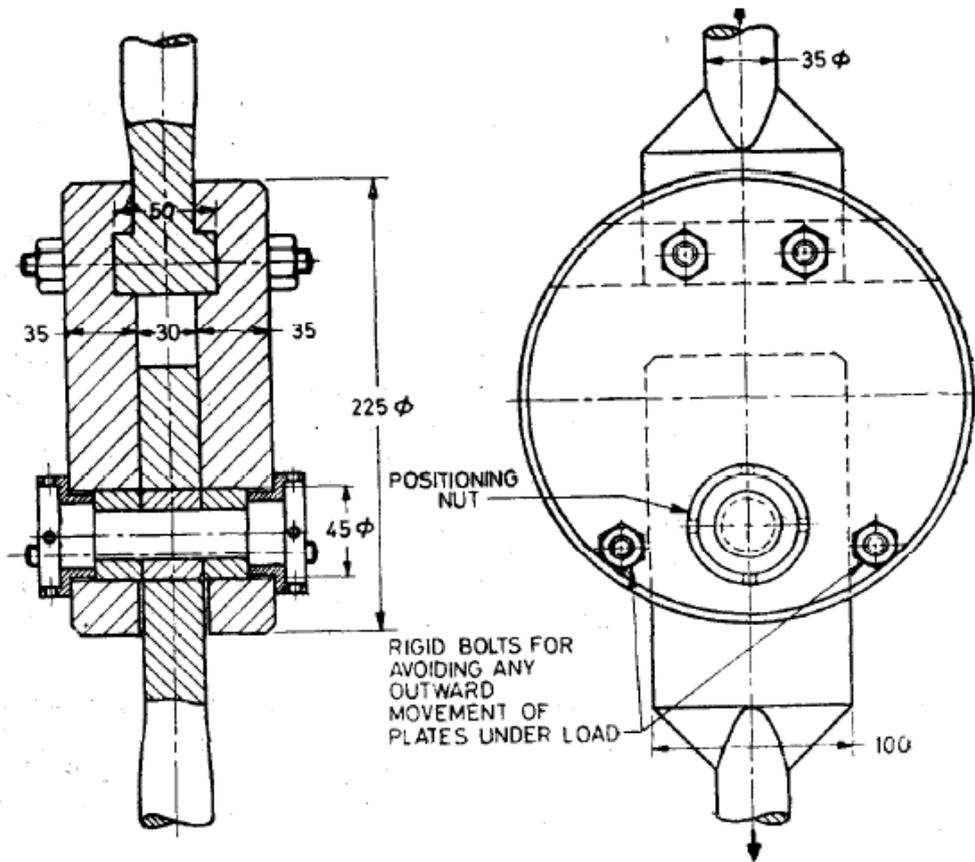
Material: Mild Steel Cylindrical Rod

### DESCRIPTION:

For conducting shear tests, a suitable steel shackle based upon fork-end and eye-plate principle may be used. The specimen is inserted as a connecting pin in the bush housing between the shackles, the fork plates of the shackle held rigidly together by bolts for avoiding any bending tendency of the specimen under high loads and tested in double shear. The nuts shown on either side of the forked shackle are used only for positioning and tightly holding the bushings in between. (Alternatively, the nuts may be dispensed with if the outer diameter of eye-plate bushing is slightly different from the diameter of the fork-end bushings.) The shearing edges of the shackle/bushings should have a hardness of not less than 530 HV. Suitable hardened steel bushes may also be used for different sizes of materials to be tested. Figures 1 and 2 show the test rigs suitable for conducting shear test with tensile and compressive loads, respectively.

The specimen is placed in the test rig, assembled as in Fig. 1 or Fig. 2, and loaded at a uniform rate until complete failure occurs. The maximum load to fracture the specimen is determined by direct reading on the testing machine, and the shear strength is obtained from maximum load in accordance with the formula given. The speed of testing or the rate of separation of the cross-heads, at any moment during the test, shall not be greater than 10 mm/min.

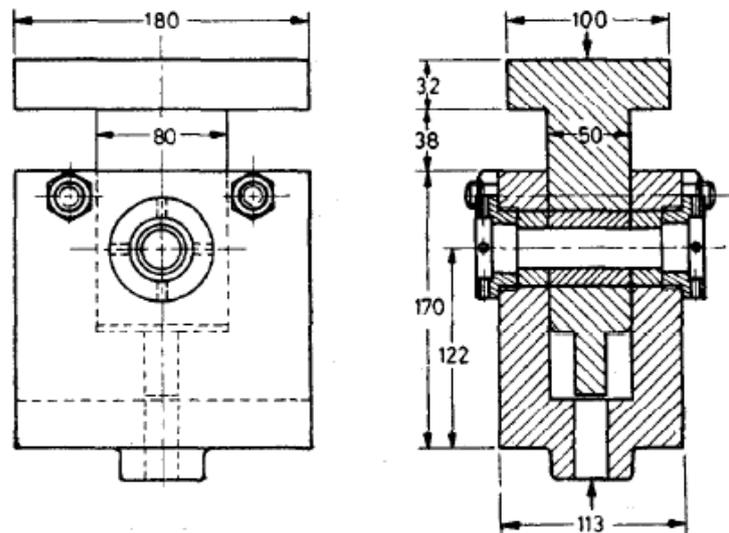




NOTE — The test-piece size shall be within  
 $+0$   
 $-0.05$  mm of the bore of the bush.

All dimensions in millimetres.

FIG. 1 TEST RIG FOR CONDUCTING SHEAR TEST UNDER A TENSILE LOAD



All dimensions in millimetres.

FIG. 2 TEST RIG FOR CONDUCTING SHEAR TEST UNDER A COMPRESSIVE LOAD

**THEORY:**

Ductile materials generally fail due to shear stress. That is why it is very much required to find the shear strength of the materials. Shear strength is determined by inserting a cylindrical specimen through round holes in three hardened steel blocks, the centre of which is pulled (or pushed ) between the other two so as to shear the specimen on two planes. The test consists of subjecting a suitable length of cylindrical specimen to double shear loading using a suitable test rig in a testing machine under a compressive load or tensile pull and recording the maximum load  $F$  to fracture. The maximum load divided by the combined cross-sectional area of the two planes is the shear strength, which shall be calculated from the following formula:

$$\tau = \frac{F}{2 \times \frac{\pi d^2}{4}} = \frac{2F}{\pi d^2}$$

where  $d$  is the actual diameter of the specimen.

Specimen for this test shall consist of short lengths of wire, rod, rivets or pins having diameters within 0.05 mm of the holes in the testing rig. The minimum length of the specimen should be twice the diameter, the maximum length is not specified, as it has no particular effect on the result of the test.

Shear test specimen shall normally be of full cross section for cylindrical metallic products up to and including 25 mm in diameter, except that sizes in between two bush sizes shall be turned down to the next smaller bush size.

In the case of cylindrical products over 25 mm in diameter, the sample may be turned down to a specimen of 25 mm diameter for testing.

**PROCEDURE:**

01. Measure the diameter of the given specimen with vernier caliper
02. Select the correct set of dies/bushes to assemble the shear attachment
03. Insert the specimen in to the dies/bushes so that it projects equally on either side
04. Place the entire assembly with the specimen on the lower cross head of the UTM
05. Bring the middle cross head slowly to touch the top surface of the attachment
06. Apply the load gradually until the specimen breaks
07. Note down the ultimate load
08. Find the allowable shear strength of the given material by using the appropriate factor of safety

**Observations:**

**Diameter of the specimen:**

S.No.	Main Scale Reading (MSR)(mm)	Vernier Coincidence (V C)	Vernier Reading (VR)= V C X L C (Least Count)	Total Reading = MSR + VR (mm)
01				
02				
03				

**Formula:**

$$\text{Ultimate Shear Strength} = \text{Ultimate Load} / \text{Cross – sectional Area}$$

$$\text{Allowable Shear Strength} = \text{Ultimate Shear Strength} / \text{Factor of Safety}$$

**RESULT:**      **The ultimate and allowable shear strengths of the given material are**

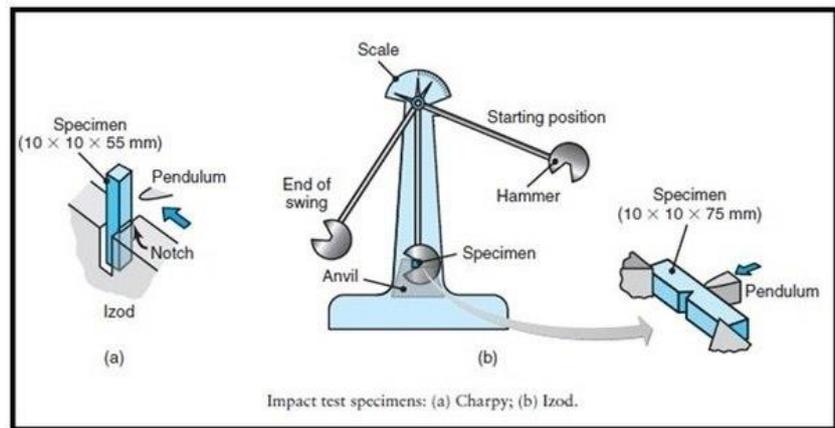
## IMPACT TEST

Equipment: Universal Impact Testing Machine, Bench Vice

Instruments: Vernier Calipers

Tools: Hack Saw, Triangular File, Bastard File

### DESCRIPTION:



Impact testing machine used for this experiment contains a heavy swing pendulum. This pendulum has the maximum capability of impacting energy of 300J. A scale is provided in the machine and an indicator will move on this scale when pendulum is allowed to swing from its horizontal static position to impact the V-notched specimen. There is an anvil at the bottom of the machine where V-notched specimen is supported as a beam in horizontal position.

### THEORY:

The stresses developed in a body vary with the type of loading. The loads applied can be gradual, sudden, Impact or shock type. The strength of the material decreases in the same order with the type of load, as described above.

The failure takes place suddenly in the case of Impact loading and hence the Impact strength is very important property of a material where the bodies are subjected to impact loads. (Example: Forging Machine, Load on the Connecting rod of an I.C. Engine).

The Impact strength of a material can be obtained by conducting by any of the following tests.

- |                        |                       |
|------------------------|-----------------------|
| 1. Izod Impact Test    | 2. Charpy Impact Test |
| 3. Fermont Impact Test | 3. Amlser Impact Test |

Of the above, the first and second are most commonly employed. These machines are standardized in all respects, including the specimens to be used in them.

The Principle employed in all impact-testing procedures is that, every material absorbs a certain amount of energy before it breaks. The quantity of energy thus absorbed is a characteristic of the physical nature of the material. If it is brittle, it breaks more readily, i.e. absorbs a lesser quantity of energy, and if tough, it needs more energy in order to fracture. The methods of testing are also very similar. A swinging hammer is made to strike the specimen held firmly in a vice. The hammer breaks the specimen on account of its potential energy. The height of rise of the hammer on the other side indicates the residual energy of the hammer. The energy actually absorbed by the specimen in order to fracture, is given by the difference between initial and final energies of the hammer.

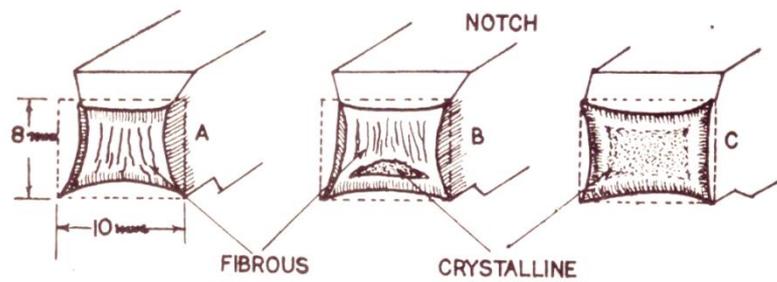
The tests are classified on the basis of the following:

- i). Type of impact used i.e. the way of the impact of the hammer acts to break the material viz., the tension, torsion etc.
- ii). The way in which the specimen is mounted i.e. as a simply supported beam or as a Cantilever.
- iii). The type of the specimen used-whether it is a notched specimen or an unnotched specimen.
- iv). The impact load whether applied only once or repeated many times to affect the failure of the specimen.

Both the Charpy and Izod impact testing are popular methods of determining impact strength, or toughness, of a material. In other words, these tests measure the total amount of energy that a material is able to absorb. This energy absorption is directly related to the ductility/brittleness of the material. Brittle materials, such as ceramics or glass, tend to have lower absorption rates than ductile materials like mild steel, copper or aluminum.

Understanding a material's energy absorption properties is critical, as it predicts how much plastic deformation the material will be able to withstand before catastrophic failure.

	CHARPY IMPACT TEST	IZOD IMPACT TEST
MATERIALS TESTED	METALS ONLY	METALS & PLASTICS
TYPES OF NOTCHES	V & U – NOTCHES	V – NOTCH ONLY
POSITION OF THE SPECIMEN	HORIZONTALLY, NOTCH FACING AWAY FROM THE PENDULUM (AS SIMPLY SUPPORTED BEAM)	VERTICALLY, NOTCH FACING TOWARDS THE PENDULUM (AS CANTILEVER BEAM)
STRIKING POINT	MIDDLE OF THE SPECIMEN	UPPER TOP OF THE SPECIMEN
COMMON SPECIMEN DIMENSIONS	55 X 10 X 10 mm	64 X 12.7 X 3.2 mm FOR PLASTIC 127 X 11.43 mm & 75 X 10 X 10 mm ROUND BAR FOR METAL



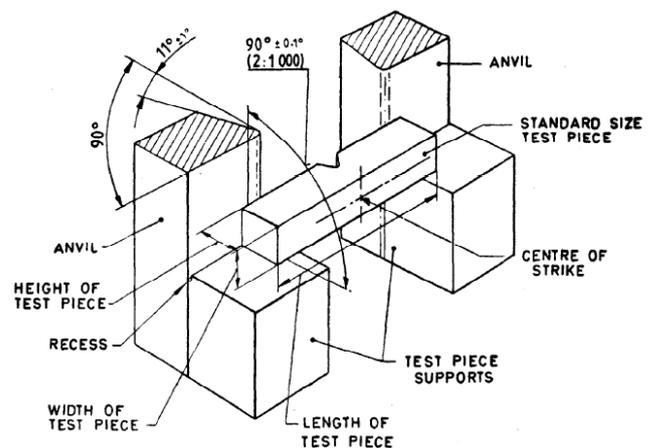
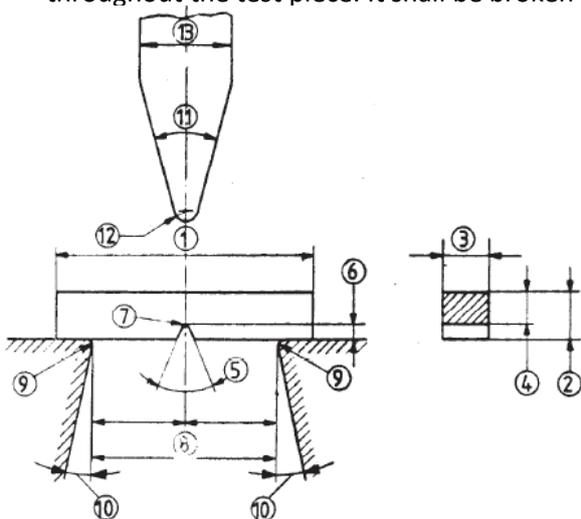
- A. COMPLETELY FIBROUS
- B. CRYSTALLINE PLUS FIBROUS.
- C. COMPLETELY CRYSTAL LINE.

## CHARPY IMPACT TEST

### Technical Specifications:

Maximum Impact energy	: 300 J	Angle of drop	: 140°
Effective weight of pendulum	: 21.3 Kg	Minimum scale Gradation	: 2J
Striking Velocity	: 5.308 m/s		

- The Charpy impact test was developed by S.B. Russell and Georges Charpy at the turn of the 20th century.
- The standard test piece shall be 55 mm long and of square section with 10 mm each side. In the centre of the length there shall be a V-notch of 45° included angle, 2 mm deep, with 0.25 mm root radius.
- If the standard test piece cannot be obtained from the material, one of the subsidiary test pieces having a width of 7.5 or 5 mm (see Table ) shall be used, the notch being cut in one of the narrower faces.
- The test pieces shall be machined all over.
- The plane of symmetry of the notch shall be perpendicular to the longitudinal axis of the test piece.
- Preparation shall be carried out in such a way that any alteration of the test piece, for example, due to heating or cold working is minimized. The notch shall be carefully prepared so that no grooves appear at the base of the notch,
- The test piece may be marked on any face not in contact with supports or anvils and at a position well away from the notch in order to avoid the effects of work hardening induced by stamping.
- The test piece shall lie squarely against the supports, with the plane of symmetry of the notch within 0.5 mm of the plane midway between them. It shall be struck by the striker in the plane of symmetry of the notch and on the side opposite the notch.
- If the temperature of testing is not specified in the product standard, it shall be  $23 \pm 5^\circ\text{C}$ .
- If the temperature of testing is specified in the product standard, it shall be adhered to within  $\pm 2^\circ\text{C}$
- For tests at temperature other than the ambient. The test piece shall be immersed in the heating/cooling medium for sufficient time to ensure that the required temperature is reached throughout the test piece. It shall be broken within 5 s from the time of removal from the medium

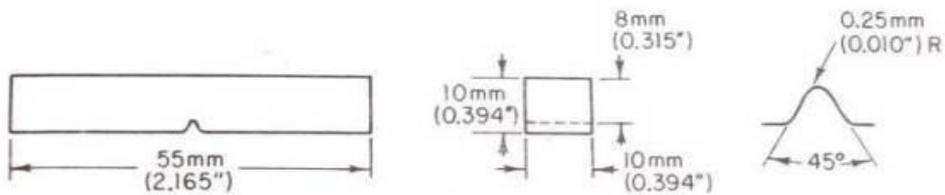


**PROCEDURE:**

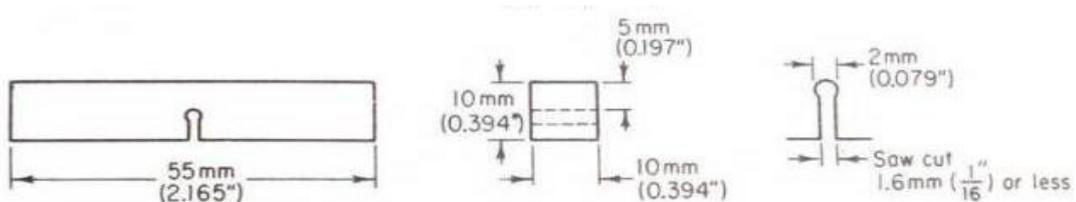
1. Fix up the Charpy block and the Charpy striker in their respective positions.
2. Place the Charpy test specimen on the supports.
3. Align the center of specimen notch w.r.t. center of support by means of Charpy testing gauge.
4. Touch the striker to the test specimen and adjust the indicating pointer to 300J.
5. Adjust the pointer carrier in such a way that it just touches the implicating pointer. Lift the hand pendulum by hand till it gets latched in position.
6. For releasing .the pendulum operate lever successively.
7. Allow the pendulum to swing freely and break the specimen.
8. After rupture, brake the pendulum by slowly operating the brake lever.
9. Read the absorbed energy directly on the dial as indicated by the indicating pointer.

**PRECAUTIONS:**

- Specimen should be fixed with notch centering the striking edge.
- No one should stand near the machine in the striking edge swinging direction.
- Notch should be made with 45° and 2 mm ± 0.01 mm depth accurately.



**V notched Charpy type specimen**



**Key-hole notched Charpy type specimen**

**OBSERVATIONS:**

Length of the Specimen (L) =  
 Breadth of the specimen (b) =  
 Depth of the Specimen (d) =  
 Depth of the Notch (dn) =

**CALCULATIONS:**

Area of Cross-Section at Notch =  
 Energy absorbed by Specimen (in J ) =  
 Impact Strength (in J/mm<sup>2</sup>) =

**RESULT:** The impact strength of the given specimen is found to be \_\_\_\_\_

## IZOD IMPACT TEST

### Technical Specifications:

Maximum Impact energy	: 170J	Angle of drop	: 90°
Effective weight of pendulum	: 21.3 Kg	Minimum scale Gradation	: 2J
Striking Velocity	: 3.994 m/s		

The Izod impact test was named for English engineer Edwin Gilbert Izod, who first described the test method in 1903.

The test apparatus and specimen design are very similar to Charpy impact, with some notable differences, including the orientation of the specimen, which is clamped into the apparatus vertically with the notch facing toward the pendulum. The pendulum then impacts the sample at a specified area above the notch.

One of the main differences from Charpy impact is that Izod impact testing can be performed on either plastic or metallic specimens. Plastic samples are typically a 64 x 12.7 x 3.2 mm bar with a machined V-shaped notch.

The test piece shall be of either square or round section.

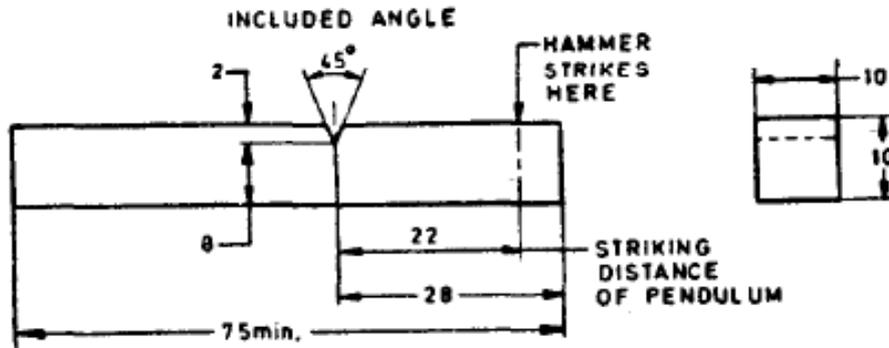
The test piece shall conform to the dimensions given in Fig.1, for square test pieces and Fig.2 for round test pieces.

### PROCEDURE:

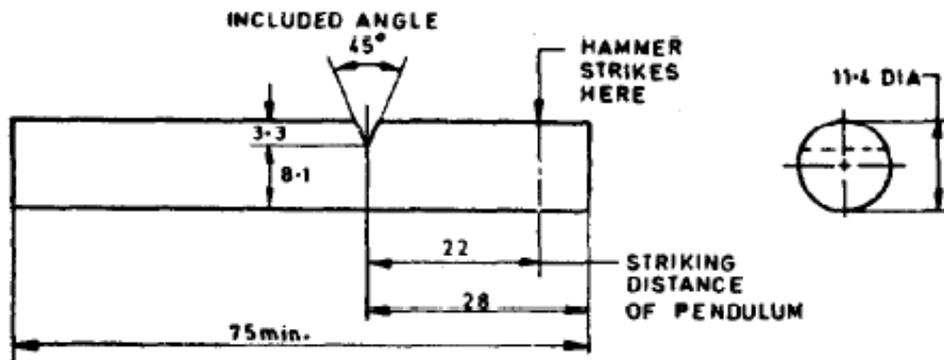
1. Fix up the Izod striker.
2. Mount the latching tube of Izod Test on the bearing housing.
3. Loosen the clamping screw of the support and insert the test specimen.
4. Align the centre line of the notch in the planes of support top, by using the setting gauge and clamp the specimen by clamping screw.
5. Touch the striker to the test specimen and adjust the indicating pointer to the 170J.
6. Adjust specimen and carrier in such a way that it just touches the indicating pointer.
7. Lift the pendulum till it gets latched in position.
8. For releasing the Pendulum operate release lever.
9. Allow the pendulum to swing freely and break the specimen.
10. After rupture, break the pendulum slowly by operating the brake lever.
11. Read the absorbed energy directly on the dial as indicated by the indicating pointer.

**Precautions:**

- Specimen should be fixed with notch centering the striking edge.
- No one should stand near the machine in the striking edge swinging direction.
- Notch should be made with 45° and 2 mm ± 0.01 mm depth accurately.



All dimensions in millimetres.



All dimensions in millimetres.

**OBSERVATIONS:**

Length of the Specimen (L) =

Breadth of the specimen (b) =

Depth of the Specimen (d) =

Depth of the Notch (dn) =

**CALCULATIONS:**

Area of Cross-Section at Notch =

Energy absorbed by Specimen (in J) =

Impact Strength (in J/mm<sup>2</sup>) =

**RESULT:**The impact strength of the given specimen is found to be \_\_\_\_\_

## HARDNESS TEST

Generally hardness is defined based on the test performed. The various hardness tests may be divided into three categories, Elastic hardness, Resistance to cutting or abrasion, Resistance to Indentation.

### **Elastic Hardness:**

This type of hardness is measured by a scleroscope, which is a device for measuring the height of a small diamond tipped hammer after it falls by its own weight from a definite height onto the surface of the test piece. The instrument usually has a self-indicating dial so that the height of rebound is automatically indicated. When the hammer is raised to the starting position, it has a certain amount of potential energy until it strikes the surface of the test piece. Some of the energy is now absorbed in forming the impression, and the rest is returned to the hammer for its rebound. The height of rebound is indicated by a pointer on an arbitrary scale such that the higher the rebound the larger the number and the harder the test piece. This test is really a measure of the resistance of a material that is the energy it can absorb in the elastic range.

### **Resistance to cutting or abrasion:**

**Scratch Test:** This test was developed by Fredric Mohs. The scale consists of 10 different standard minerals arranged in order of increasing hardness. Talc is No.1, Gypsum No.2, etc., up to 9 for Corundum, 10 for Diamond. If an unknown material is scratched noticeably by No.6 and not by No. 5, the hardness value is between 5 and 6. This test has never been used to any great extent in metallurgy but is still used in mineralogy. The primary disadvantage is that the hardness scale is non-uniform. When the hardness of the minerals is checked by another hardness-test method, it is found that the values are compressed between 1 and 9, and there is large gap in hardness between 9 and 10.

### **File Test:**

The test piece is subjected to the cutting action of a file of known hardness •to determine whether a visible cut is produced. Comparative tests with a file depend upon the size, shape and hardness of the file, the speed, pressure and angle of filing during the test, and the composition and heat treatment of the material under test. The test is generally used industrially as one of acceptance or rejection.

In many cases, particularly with tool steels, when the steel is properly heat-treated it will be hard enough so that if a file is run across the surface it will not cut the surface. It is not unusual to find heat-treating specifications, which simply say heat-treated parts to determine whether the treatment has been successful.

### **Resistance to indentation:**

This test is usually performed by impressing into the specimen, which is resting on a rigid platform, an indenter of fixed and known generally, under a known static load applied either directly

or by means of a lever system. Depending on the type of test, the hardness is expressed by a number that is either inversely proportional to the depth of indentation for a specified load and indenter or proportional to a mean load over the area of indenter.

## BRINELL HARDNESS TEST

Equipment: Brinell Hardness Tester  
 Instruments: Vernier Calipers, Brinell Microscope  
 Material: Indenters, Specimen



### DESCRIPTION:

The Brinell Hardness Testing Machine (Fig. 1) consists of a loading system that includes leavers, weights, hydraulic dashpot, and plunger enclosed in the body of the machine. The test material is kept on the adjustable anvil. Using the lever, the spherical ball indenter descends on the material with a pre-decided force.

Brinell hardness testing machine uses a hardened steel ball as the indenter. Balls of different diameter from 2.5 to 10mm are employed with suitable loads.

For softer metals the force used is less than harder metals. The force value varies from 1 kgf to 3000 kgf. Common test forces range from 500 kgf often used for non-ferrous materials to 3000 kgf for steels and cast irons.

### THEORY:

In the Brinell machine, the surface area of the indentation is calculated and used as an index of the indentation hardness of the metal. The surface area of the indentation is dependent upon the depth of the penetration. The load applied divided by the spherical area of the indentation is taken as the Brinell hardness number.

$$\text{Brinell hardness number (B.H.N)} = \text{Load/Spherical area of indentation}$$

Calculation of the spherical or surface area of indentation:

The circle in fig. is the periphery of the indenter whose diameter is 'D'.

The indented portion of the material is shown as shaded. It is the replica of a part of the surface of the indenter.

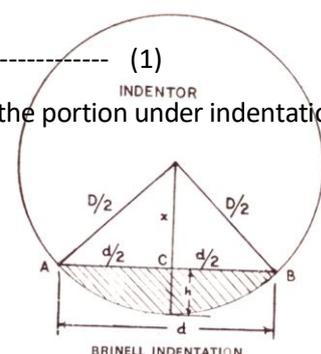
From mensuration principles,

The surface area of a segment of a sphere is  $= \pi Dh$  ----- (1)

Where D=diameter of the sphere, h=height of the portion under indentation

$$h = (D/2 - X)$$

From the right angle triangle,



$$\begin{aligned} (D/2)^2 &= x^2 + (d/2)^2 \\ x^2 &= (D^2 - d^2)/4 \\ x &= (D^2 - d^2)^{1/2} / 2 \\ h &= D/2 - (D^2 - d^2)^{1/2} / 2 \\ &= D - (D^2 - d^2)^{1/2} / 2 \end{aligned}$$

Substituting 'h' in (1), we get the spherical area of indentation

$$A = \frac{\pi D [D - (D^2 - d^2)^{1/2}]}{2}$$

$$B.H.N = 2P / \pi D (D - (D^2 - d^2)^{1/2})$$

Forces and indenters for Brinell hardness test on various metals.

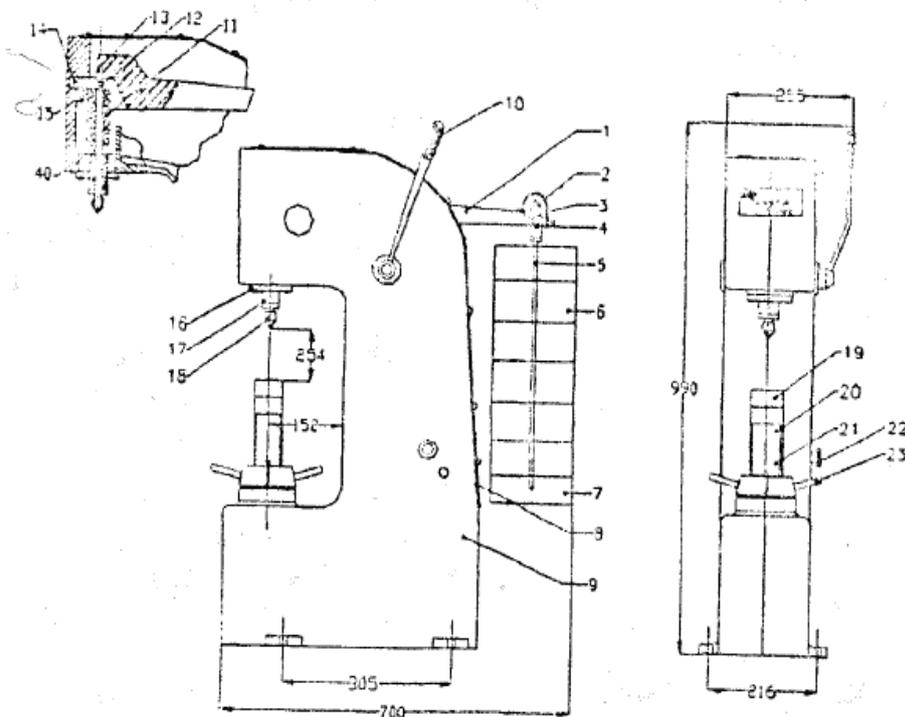
Indenter Dia (D) (mm)	Force in Kg(f).			
	Ferrous Metals	Non Ferrous Metals		
	Steel & Iron 30 D <sup>2</sup>	Brass 10 D <sup>2</sup>	Copper 5D <sup>2</sup>	Soft bearing metals 2.5 D <sup>2</sup>
10	3000	1000	500	250
5	750	250	---	---
2.5	187.5	---	---	--

- The Brinell hardness is denoted by HBW.
- The letters HBW are preceded by the hardness value and supplemented by an index indicating the test conditions in the order
  1. the diameter of the ball, in millimeters;
  2. a figure representing the test-force;
  3. the duration of application of test force, in seconds, if different from the specified time.
- EXAMPLE 1 350 HBW 5/750 = Brinell hardness of 350 determined with a ball of 5 mm diameter and with a test force of 7.355 kN applied for 10s to 15 s.
- EXAMPLE 2 600 HBW 1/30/20 = Brinell hardness of 600 determined with a ball of 1 mm diameter and with a test force of 294.2 N applied for 20s.
- Testing machine must be capable of applying a predetermined test force or forces within the range of 9,807 N to 29.42 kN.

- The Indenter is a polished hard metal ball.
- The test shall be carried out on a surface which is smooth and even, free from oxide scale, foreign matter and, in particular, free from lubricants. The test piece shall have a surface finish that will allow an accurate measurement of the diameter of the indentation.
- Preparation shall be carried out in such a way that any alteration of the surface, for example due to heat- or cold-working, is minimized.
- The “thickness of the test piece shall be at least eight times the depth of indentation.
- Visible deformation at the back of the test piece can indicate that the test piece is too thin.
- In general, the test is to be carried out at ambient temperature within the limits of 10<sup>0</sup> C to 35<sup>0</sup> C. Tests carried out under controlled conditions shall be made at a temperature of (23±5) <sup>0</sup>C.
- The test force shall be chosen so that the diameter of the indentation *d* lies between the values 0.24 *D* and 0.6 *D*.
- The force-diameter ratio ( $F/D^2$ ) shall be chosen according to the material and the hardness test as indicated
- In order to test the largest representative area of the test piece, the diameter of the testing ball shall be chosen to be as large-as possible.
- When the thickness of the test piece permits, a 10 mm diameter ball is preferred.
- The test piece shall be placed on a rigid support. The contact surfaces shall be clean and free from foreign matter (scale, oil, dirt, etc). It is important that the test piece lie firmly on the support so that displacement cannot occur during the test.
- Bring the indenter into contact with the test surface and apply the test force in a direction perpendicular to the surface, without shock, vibration or overrun, until the applied force attains the specified value. The time from the initial application of force to the time the full test force is reached shall not be less than 2s nor greater than 8s.
- Maintain the test force for 10s to 15s. For certain materials, where a longer dwell time is required; this time shall be applied with a tolerance of ± 2s.
- Throughout the test, the testing machine shall be protected from significant shock or vibration which can influence the test result.
- The distance from the edge of the test piece to the centre of each indentation shall be a minimum of two and a half times the mean indentation diameter.
- The distance between the centers of two adjacent indentations shall be at least three times the mean indentation diameter.
- Make at least one periodic check of the testing machine each day that it is used.

- Before making the check, make at least two preliminary indentations to ensure that the test piece, indenter and anvil are seated correctly. The results of these preliminary indentations should be ignored.
- Make at least one hardness indentation on a reference block with approximately the same hardness as the material being tested. If the difference between mean value of the hardness readings of the test material and the hardness of the reference block are within the limits the machine may be regarded as satisfactory.

- |                        |                      |
|------------------------|----------------------|
| 1. MAIN LEVER          | 2. HANGER            |
| 3. HANGER VEE (FEMALE) | 4. HANGER VEE (MALE) |
| 5. WEIGHT HANGER       | 6. WEIGHT            |
| 7. BOTTOM WEIGHT       | 8. COVER             |
| 9. FRAME               | 10. OPERATING LEVER  |
| 11. SPINDLE SPRING     | 12. SPINDLE SHAFT    |
| 13. MAIN KNIFE EDGE    | 14. PIVOT VEE        |
| 15. PIVOT KNIFE EDGE   | 16. SPINDLE BUSHING  |
| 17. SPINDLE            | 18. BALL HOLDER      |
| 19. FLAT ANVIL         | 20. ADAPTOR          |
| 21. ELEVATING SCREW    | 22. ADAPTOR          |
| 23. HAND WHEEL         | 24. METERING VALVE   |



**FIGURE: BRINELL HARDNESS TESTING MACHINE**

**PROCEDURE:**

01. Select the proper indenter and fix it
02. Calculate the load to be applied according to the material of the specimen
03. Place the specimen on the anvil and rotate the hand wheel to raise the screw so that  
there is perfect contact between indenter and the specimen
04. Place the correct weights on the weight pan
05. Apply the load by rotating the lever gradually
06. Weight for a min of 15 to 20 sec and release the load by rotating the lever in the  
opposite direction
07. Remove the specimen and find the diameter of the indentation with the help of Brinell  
Microscope
08. Find the Brinell Hardness Number by substituting the diameters of indenter(D) and  
indentation(d) in the formula

**Precautions:**

1. Surface of the specimen tested must be smooth and flat.
2. Load should be applied gradually.
3. The time of load application must be between 15-20 seconds.
4. Brinell microscope reading must be taken without any parallax error.

**Observations:**

S.No.	Material	Dia of the Indenter (D)	Force P(N)	Dia of the Indentation (mm) d	Hardness Number (Kg/mm <sup>2</sup> )

## Sample Calculations:

$$\text{Brinell Hardness Number} = \frac{2P}{\pi D [D - (D^2 - d^2)^{1/2}]}$$

**Result:** The hardness of the given material is \_\_\_\_\_

## ROCKWELL HARDNESS TEST

Equipment: Rockwell Hardness Tester

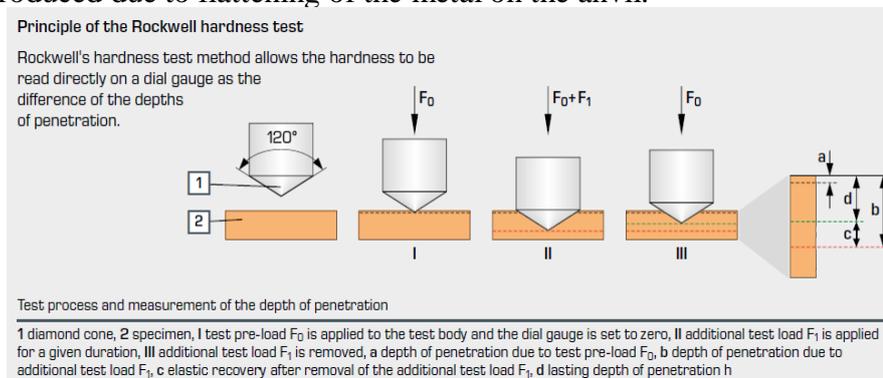
Material: Indenters, Standard Test Piece and Specimen



### DESCRIPTION:

The test consists of forcing an indenter (diamond cone or steel ball) into the surface of a test piece in two steps under specified conditions and measuring the permanent increase of depth of indentation. The unit of measurement for  $d$  is 0.002 mm for Rockwell hardness and 0.001 mm for Rockwell superficial hardness. From the value of  $d$ , a number known as the Rockwell hardness is derived..

- The test shall be carried out on a surface which is smooth and even, free from oxide scale, foreign matter and, in particular, completely free from lubricants ( except for tests on some reactive materials, such as titanium, where lubricants such as kerosene may be required ). If lubricants have been used, it shall be stated in the test report.
- Preparation shall be carried out in such a way that any alteration of surface hardness due to hot or cold working is minimized.
- The thickness of the test piece or of the layer under test shall be at least ten times the permanent increase of depth  $e$ . After the test, no deformation shall be visible on the surface of the test piece opposite to the indentation.
- For tests on convex cylindrical surfaces and spherical surfaces, the corrections shall be applied.
- Special care should be taken when testing sheet metal that is curved. The concave side of the curved metal should face towards the indenter. If such specimens are reversed, an error will be introduced due to flattening of the metal on the anvil.



### Rockwell Hardness Scales and Prefix Letters\*

<i>Scale symbol and prefix letter</i>	<i>Indenter</i>	<i>Major load, kg</i>	<i>Dial numerals</i>	<i>Typical applications of scales</i>
B*	Group one† 1/16-in. ball	100	Red	Copper alloys, soft steels, aluminum alloys, malleable iron.
C†	Diamond cone	150	Black	Steel, hard cast iron, pearlitic malleable iron, deep case-hardened steel
A	Group two Diamond cone	60	Black	Cemented carbides, thin shallow case-hardened steel
D	Diamond cone	100	Black	Thin steel, medium case-hardened steel
E	1/8-in. ball	100	Red	Cast iron, aluminum and magnesium alloys, bearing metals.
F	1/16-in. ball	60	Red	Annealed copper alloys, thin soft sheet metals
G	1/16-in. ball	150	Red	Phosphor bronze, beryllium copper, malleable iron.
H	1/8-in. ball	60	Red	Aluminum, lead, zinc
K	1/8-in. ball	150	Red	Bearing metal and other very soft or thin materials. Use smallest ball and heaviest load that does not give anvil effort.
L	Group three ¼-in. ball	60	Red	
M	¼-in. ball	100	Red	
P	¼-in. ball	150	Red	
R	½-in. ball	60	Red	
S	½-in. ball	100	Red	
V	½-in. ball	150	Red	

\* Based on ASTM E 18.

† Commonly used scales and indenters.

## **THEORY:**

- In general, the test should be carried out at ambient temperature within the limits of 10 to 35 °C. Tests carried out under controlled conditions shall be made at a temperature of  $23 \pm 5$  °C.
  - The test piece shall be placed on a rigid support and shall be supported in such a manner that the surface to be indented is in a plane normal to the axis of the indenter and the line of the indenting force.
  - Products of cylindrical shape shall be suitably supported on centering V-blocks of steel with a Rockwell hardness of at least 60 HRC. Special attention shall be given to correct seating, bearing and alignment of the indenters, the test piece, the centering V-blocks and the specimen holder of the testing machine since any perpendicular misalignment may result in incorrect observations.
  - Flat pieces should be tested on a flat anvil that has a smooth flat bearing surface whose plane is perpendicular to the axis of the penetrator. For pieces that are not perfectly flat, a flat anvil having an elevated 'spot' about 4 to 6 mm in diameter is used. This spot should be polished, smooth, flat and free from pits and heavy scratches. This spot should have a Rockwell hardness of at least 60 HRC.
  - When testing special materials thinner than ten times the depth of indentation using the steel ball indenter, the product standard may specify use of a diamond 'spot' anvil. When such an anvil is used, it should be recorded in the report. It should be noted that the reading obtained may differ from a reading obtained under normal conditions.
  - Bring the indenter into contact with the test surface and apply the preliminary test force  $F_0 = 98.07$  N without shock or vibration for (A-13-C-D-EF- G-H-K) and 29.42 N for ( 15N, 30N, 45N, 15T, 30T and 45T ).
  - Set the measuring device to its datum position and, without shock or vibration, increase the force from  $F_0$  to  $F$  is neither less than 2 s nor greater than 8s. The value of  $F$  is as follows:
    - a)  $F = 588.4$  N for scales A, F and H;                      b)  $F = 980.7$  N for scales B, D and E;
    - c)  $F = 147.1$  N for scales C, G and K;                      d)  $F = 147.1$  N for scales 15N, 15T;
    - e)  $F = 294.2$  N for scales 30N, 30T; and f)  $F = 441.3$  N for scales 45N, 45T;
  - While maintaining the preliminary force  $F_0$ , remove the additional force  $F$ , so that:
    - a) For materials which under the conditions of test, show some time dependent plasticity, the duration of the total test force  $F$  shall be up to 5 s
    - b) For materials which, under the conditions of test, show considerable time-dependent plasticity, the duration of total test force  $F$  shall be neither less than 10s nor greater than 15s.
- NOTE: When the pointer comes to rest within 2 s after the application of full load, material will be categorized as (a).

- Throughout the test, the apparatus shall be protected from shock or vibration.
- Rockwell hardness number is derived from the permanent increase in depth of indentation **d**, and is usually read directly from the measuring device.
- After each change, or removal and replacement, of the indenter or the test piece support, it shall be ascertained that the new indenter or the new support is correctly mounted in its housing, the first two readings after such a change has been made, shall be disregarded.
- The distance between the centers of two adjacent indentations shall be at least four times the diameter of the indentation (but at least 2 mm) for Rockwell hardness and three times the diameter of the indentation for Rockwell superficial hardness. The distance from the centre of any indentation to an edge of the test piece shall be at least two and a half times the diameter of the indentation.
- It is recommended that machine should be calibrated at least once in a year.

**Procedure:**

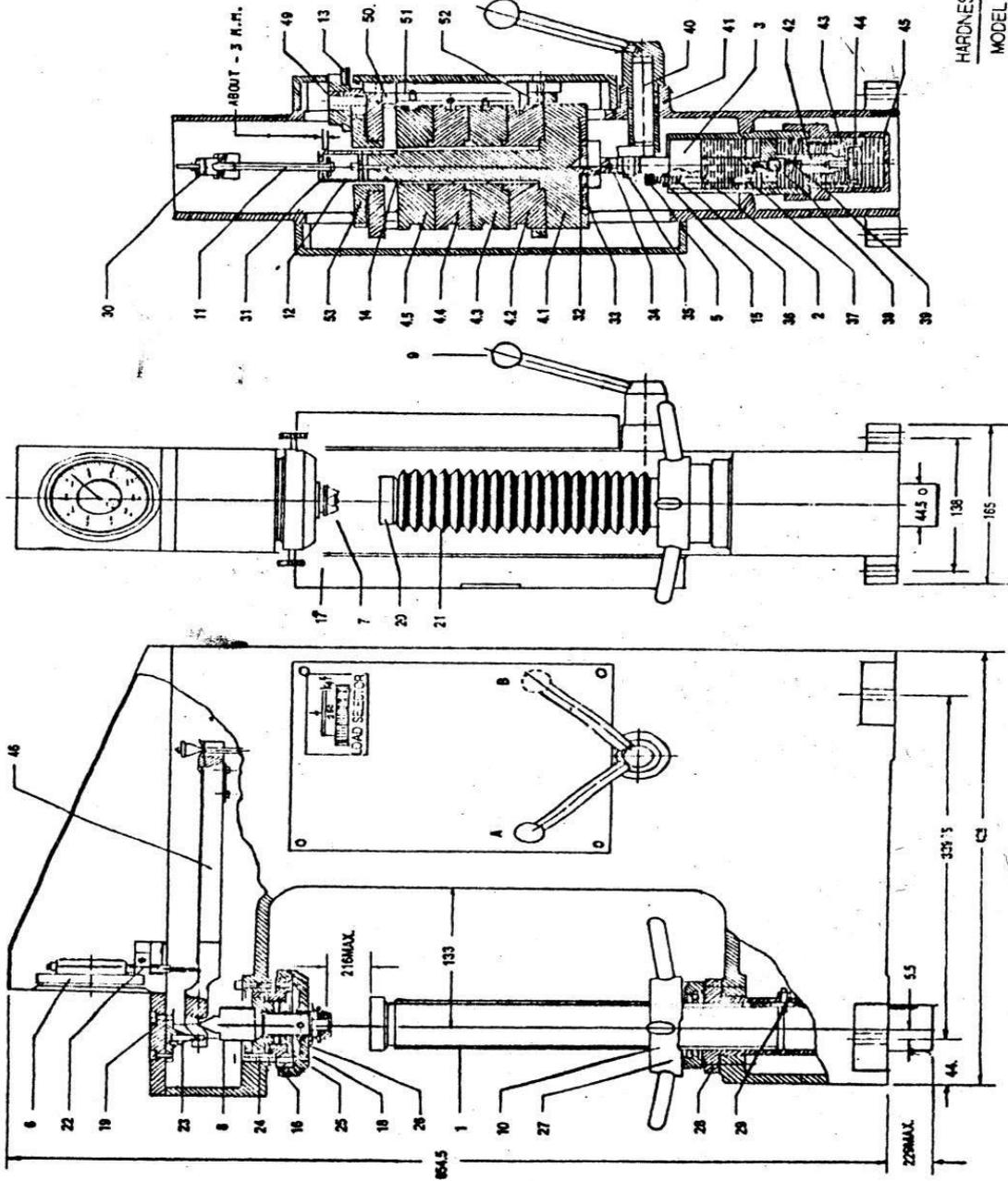
01. Based on the material of the specimen know the combination of the Rockwell Scale, indenter to be used, load to be applied and the dial to be seen from the table attached to the machine
02. Fix the indenter properly by using the align key
03. Place the specimen on the anvil and rotate the hand wheel slowly till the small indicator reaches the red dot
04. Select the correct load by using the load selector
05. Apply the load by rotating the lever gradually
06. Weight for a min of 15 to 20 sec and release the load by rotating the lever in the opposite direction
07. Note down the reading on the appropriate dial

**Precautions:**

1. Surface of the specimen tested must be smooth and flat.
2. Minor Load should be applied carefully.
3. The time of load application must be between 15-20 seconds.

**Result:** The hardness of the given material is \_\_\_\_\_

- 11: MAIN SCREW
- 2: DASH POT
- 3: PLUNGER
- 4: LOAD SET-4 TO 45
- 5: VALVE SCREW
- 6: DIAL GAUGE
- 7: INDENTOR
- 8: DIAMOND HOLDER
- 9: LOADING HANDLE LEVER
- 10: HAND WHEEL
- 11: LOAD HAMMER
- 12: WEIGHT SHAFT CLIP
- 13: LOAD SELECTOR DISC
- 14: CLIP WASHER
- 15: PLASTIC FLUGE
- 16: DIAMOND HOLDER CAP
- 17: CLAMPING CONE
- 18: CLAMPING CHECK NUT
- 19: TOP PLATE
- 20: TEST TABLE
- 21: RUBBER BELLOW
- 22: DAL GAUGE SEAT
- 23: PIVOT YEE
- 24: BEG CAP NUT
- 25: CLAMPING RING
- 26: WINKLED SCREW
- 27: THRUST ENG NO S 1109
- 28: MAIN SCREW SLEEVE
- 29: SCREW GUIDE PIN
- 30: HANGER YEE
- 31: HANGER WASHER
- 32: FELT WASHER
- 33: PLUNGER FACE PLATE
- 34: PLUNGER HARD PIECE
- 35: ECC-PIN ROLLER
- 36: VALV SCREW SPRING
- 37: PLASTIC CAP
- 38: PLUNGER BALL
- 39: PLUNGER BALL SPRING
- 40: ECC-PIN
- 41: ECC-PIN BUSHING
- 42: PLUNGER PIECE
- 43: PLUNGER SPRING
- 44: PLUNGER SPRING CAP
- 45: DASH POT CAP
- 46: MAIN LEVER
- 49: UNIT SMALL GEAR
- 50: UNIT TOP PLATE
- 51: UNIT ROTATING SHAFT
- 52: UNIT BOTTOM PLATE
- 53: UNIT BIG GEAR



HARDNESS TESTING MACHINE  
MODEL :- KAS / KAB / KAB-I

## FLEXURAL TESTS

**Equipment:** Simply Supported Beam Set-up, Cantilever Beam Set-up

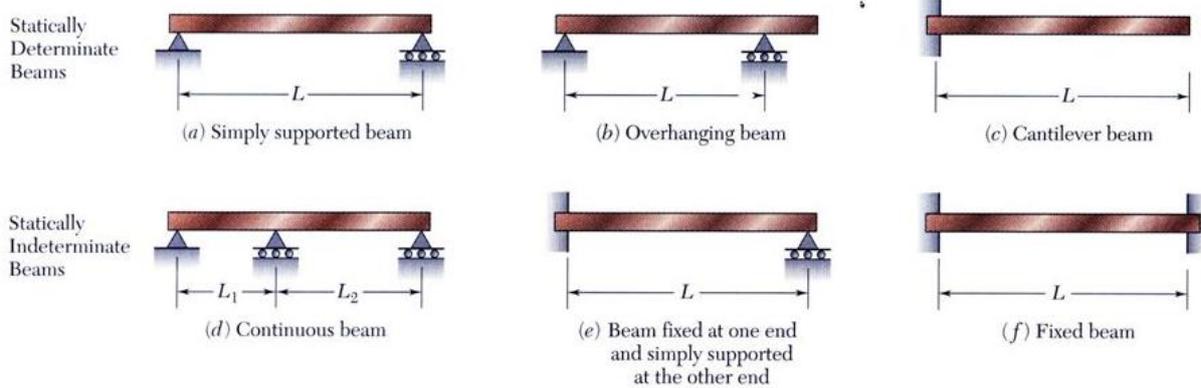
**Instruments:** Vernier Calipers, Scale, Dial Indicator with magnetic stand

**Material:** Weights, Hangers

### THEORY:

Any structural member subjected to a transverse load is known as Beam. On the basis of supports, beams are classified as,

1. Cantilever beam.
2. Simply supported beam.
3. Over- hanging beam.
4. Continuous beam.
5. Propped cantilever beam.
6. Fixed beam.



When the beam is subjected to the external loads (transverse loads) it will undergo some deformation. This deformation is a function of mechanical property-Young's Modulus of the beam material and the geometrical property i.e. Moment of Inertia of the beam. By finding the deflection of the beam with the help of dial gauge and substituting this in the formula which relates the Young's Modulus, Moment of Inertia, load and deflection, we can find the Young's Modulus of the given beam material.

When a segment of beam is in equilibrium under the action of bending moments alone, such a condition is referred to as Pure Bending or Flexure.

A cantilever loaded with concentrated moment at the end, segment of the beam between the concentrated forces are examples of pure bending. In pure bending we made the following assumptions,

- The beam is subjected to pure bending and the effect of shear stresses is neglected
- The beam is initially straight and all longitudinal layers bend into circular arcs with a common center of curvature.
- Transverse cross-sections remain plane and perpendicular to the neutral surface after bending.
- The material is homogeneous, isotropic, and the Young's modulus is same both in tension and compression.
- The radius of curvature is large compared with the dimensions of the cross-section.
- The stress is purely longitudinal and local effects near concentrated loads will be neglected.

The bending equation derived based on the above-mentioned assumptions is,

$$M / I = \sigma / y = E / R$$

Where,

M	=	Bending Moment,
I	=	Moment of Inertia.
$\Sigma$	=	Stress in the fiber at a distance 'y' from neutral axis.
E	=	Young's Modulus of the beam material.
R	=	Radius of curvature of the neutral surface.

For pure bending, where M is constant along the length of the beam, its axis bends in a circular arc. It is customary to call this curved axis of the beam as the elastic line or the deflection curve.

The differential equation of the elastic line for a beam subjected to bending in a plane of symmetry is  $d^2y / dx^2 = M / (E.I)$ . Its solution  $y = f(x)$  defines the shape of the elastic line or the deflection curve as it is frequently called. The equation  $d^2y / dx^2 = M / (E.I)$  carries with it two important limitations. First, the stress is proportional to strain i.e. Hooke's law applies. Second, it is limited to the treatment of small deflections. Most beams encountered in engineering practice will be well within the validity of these two limitations. The above equation originally for pure bending does not account for any deflection resulting from shear deformation of the material. For beams of ordinary proportions the deflections due to shear deformation are usually small and can be neglected.

## FLEXURAL TEST ON SIMPLY SUPPORTED BEAM

### PROCEDURE:

1. Measure the distance between the two supports of the beam with scale
2. Measure the width and depth of the beam with vernier calipers
3. Place the two hangers at a distance of  $L/4$  from both the supports
4. Fix the dial indicator exactly at the centre of the span of the beam and ensure that there is contact between the plunger of the dial gauge and the beam
5. Apply same weights on two hangers gradually and note down the deflection of the beam
6. Increase the weights on the hangers in steps and note down the corresponding deflections of the beam
7. Do the same by removing the weights one by one from the hangers

### OBSERVATIONS:

#### Width of the beam (b):

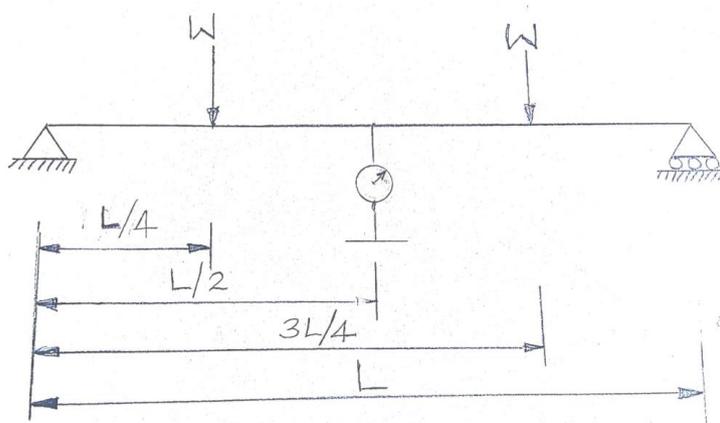
S.No.	Main Scale Reading (MSR)(mm)	Vernier Coincidence (V C)	Vernier Reading (VR)= V C X L C (Least Count)	Total Reading = MSR + VR (mm)
01				
02				
03				
	<b>Average</b>			

#### Depth of the beam (d):

S.No.	Main Scale Reading (MSR)(mm)	Vernier Coincidence (V C)	Vernier Reading (VR)= V C X L C (Least Count)	Total Reading = MSR + VR (mm)
01				
02				
03				
	<b>Average</b>			

**Load – Deflection Readings**

S. No	Load (W)	Dial Indicator Reading			Deflection (mm) (y = Mean x 0.01)
		Ascending order	Descending Order	Mean	
1					
2					
3					
4					
5					



**Graph:** Draw the graph between Load and deflection

**Calculations:**

Width of the beam      b      =

Depth of the beam      d      =

Length of the beam      L      =

Moment of Inertia of cross-sectional area of the beam about its neutral axis

$$I = \frac{b d^3}{12}$$

Slope of the load – deflection curve from the graph       $(\delta W) / (\delta y) = W/y$

Modulus of elasticity of the beam material       $E = \frac{5 W L^3}{192 y I}$

**Result:** After conducting the flexural test on the given simply supported beam, the modulus of elasticity (Young’s modulus) of the beam material is found to be \_\_\_\_\_

## FLEXURAL TEST ON CANTILEVER BEAM

### PROCEDURE:

1. Measure the distance between the fixed support and free end of the beam with scale
2. Measure the width and depth of the beam with vernier calipers
3. Place the hanger at some distance (**a**) from both the fixed support
4. Fix the dial indicator at a distance of (**x**) from the fixed support such that  $x > a$  and ensure that there is contact between the plunger of the dial gauge and the beam
5. Apply the weights in steps on the hanger gradually and note down the corresponding deflection of the beam
6. Do the same by removing the weights one by one from the hanger

### Formula:

Modulus of elasticity of the beam material

$$E = \frac{W}{y \cdot I} \left[ \frac{a x^2}{2} - \frac{x^3}{6} - \frac{(x-a)^3}{6} \right]$$

Moment of Inertia of cross-sectional area of the beam about its neutral axis

$$I = \frac{b d^3}{12}$$

**Graph:** Draw the graph between Load and deflection

### Observations:

#### Width of the beam (b):

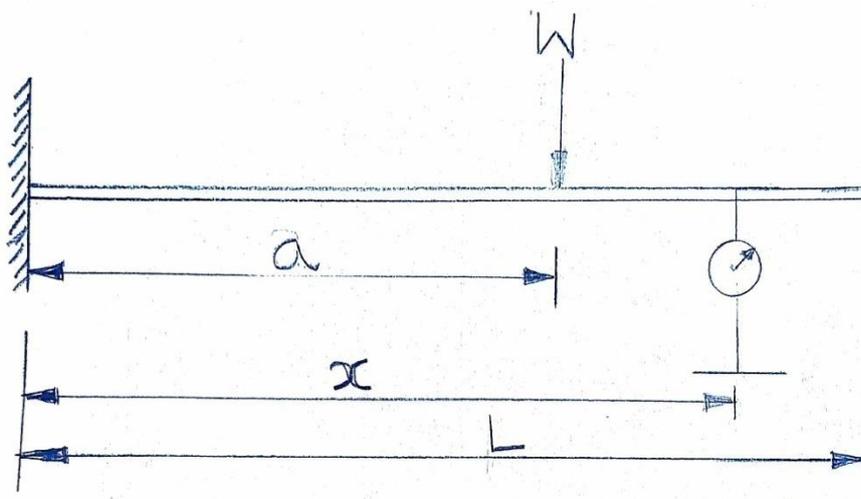
S.No.	Main Scale Reading (MSR)(mm)	Vernier Coincidence (V C)	Vernier Reading (VR)= V C X L C (Least Count)	Total Reading = MSR + VR (mm)
01				
02				
03				
	<b>Average</b>			

**Depth of the beam (d):**

S.No.	Main Scale Reading (MSR)(mm)	Vernier Coincidence (V C)	Vernier Reading (VR)= V C X L C (Least Count)	Total Reading = MSR + VR (mm)
01				
02				
03				
<b>Average</b>				

**Load - Deflection Readings:**

S. No	Load (W)	Dial Indicator Reading			Deflection (mm) (y = Mean x 0.01)
		Ascending order	Descending Order	Mean	
1					
2					
3					
4					
5					



**Calculations:**

Width of the beam      b      =

Depth of the beam      d      =

Length of the beam      L      =

Moment of Inertia of cross-sectional area of the beam about its neutral axis

$$I = \frac{b d^3}{12}$$

Slope of the load – deflection curve from the graph       $(\delta W) / (\delta y)$       =      W/y

Modulus of elasticity of the beam material

$$E = \frac{W}{y \cdot I} \left[ \frac{a x^2}{2} - \frac{x^3}{6} - \frac{(x - a)^3}{6} \right]$$

**Result:**

After conducting the flexural test on the given simply supported beam, the modulus of elasticity (Young's modulus) of the beam material is found to be \_\_\_\_\_

## COMPRESSION TEST ON SPRING

**Equipment:** Spring Testing Machine / Spring Test Attachment / Spring Test Set-up

**Instruments:** Vernier Caliper, Dial Indicator

**Material:** Close coiled helical spring, Weights

### THEORY:

Any member that elastically deforms under a load can act as a spring but the term spring is normally restricted to those bodies which deform considerably under the action of forces without exceeding the safe stress and which satisfy other design considerations to get the shape and size with minimum cost.

The main functions of springs are,

- They absorb energy and release this energy according to the desired functions to be performed by the springs - The spring of clock work is an example where absorbed energy is released slowly.
- The springs absorb shocks such as in case of springs of railway buffers, springs of all automobiles and aircraft landing gear.
- The springs deflect under external forces to provide the desired motion to a machine component to perform a certain function e.g. the springs of safety valves deflect to operate them.

Springs have been made to act in tension, compression, bending, torsion or combination of these loads. The most important springs are:

1. Coiled springs
2. Leaf springs (or Plate springs)
3. Torsional bar springs

**Coiled springs:** The springs in the form of a coil or spiral are called coil springs. The coil springs are three types

- a) Helical springs (sometimes called helical spiral springs or cylindrical spiral springs or cylindrical helical springs or simply as cylindrical springs or spiral springs). These springs may be of closed coil type or open coil type.
- b) Conical spiral springs (sometimes called helical conical springs or simply conical springs).
- c) Flat spiral springs.

## Helical springs:

Winding a wire in the form of a circular cylindrical helix forms these springs. These springs are usually subjected to axial or torsional or combined axial and torsional loads. Sketches of a helical spring are shown in Fig. The angle  $\alpha$  which the coil makes with the horizontal is called helix angle.

Let,

$G$  = Rigidity modulus  
radius of spring coil.

$d$  = Diameter of spring wire

$R$  = Mean radius of spring coil.

$n$  = Number of coils

$W$  = Axial force applied on the spring

$\delta$  = Deflection of the spring.

When an axial load of  $W$  is applied on the spring every section of the rod will be subjected to a torque of  $WR$ . Then the maximum shear stress at any section of the rod is,

$$\tau = \frac{T}{Z_p} = \frac{WR}{(\pi d^3/16)} = \frac{16WR}{\pi d^3}$$

Length of the spring =  $L = 2\pi Rn$

Strain energy stored by the spring  $\frac{\tau}{4G}$  x volume

$$= [(16WR/\pi d^3)^2] \times [1/4G] \times [\pi d^2/4] \times [2\pi Rn]$$

$$= 32 \frac{W^2 R^3 n}{G d^4}$$

If  $\delta$  be the deflection of the spring i.e., the downward movement of the load

Work done on the spring =  $1/2 (W \delta)$

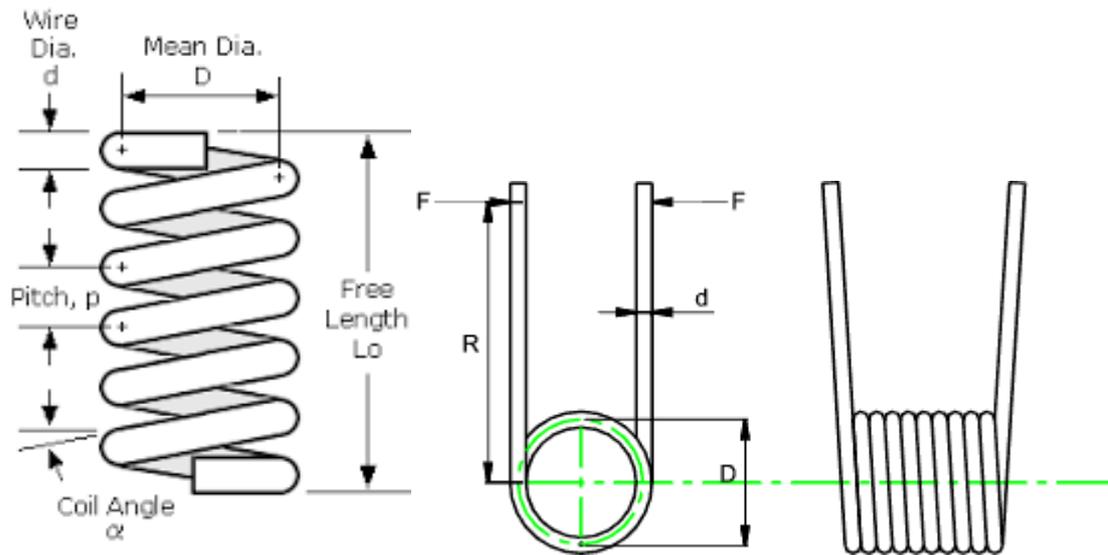
Equating the work done to energy stored, we have,

$$\frac{1}{2} W \delta = 32 \frac{W^2 R^3 n}{G d^4}$$

$$\delta = \frac{64 W R^3 n}{G d^4}$$

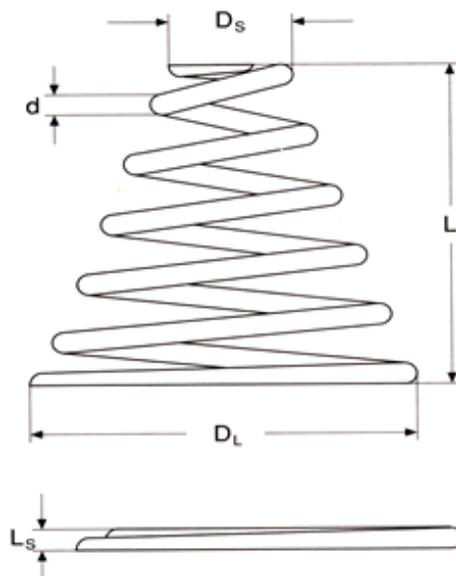
$$G = \frac{64 W R^3 n}{\delta d^4}$$

## Nomenclature of the Helical Springs



### Compression Spring

### Torsion Spring



### Conical Spring

## TYPES OF SPRINGS



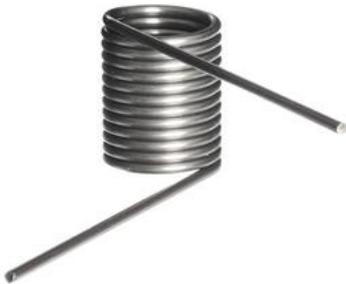
Helical Compression Spring



Helical Extension Spring



Conical Spring



Torsion Spring



Laminated or Leaf Spring



Disc or Belleville Spring

### PROCEDURE:

1. Measure the Outer and Inner diameters of the given spring with the vernier calipers
2. Count the number of effective turns of the spring
3. Place the spring centrally in the spring testing machine
4. Note down the dead weight reading
5. Apply the loads gradually on the spring in steps and note down the corresponding deflections of the spring
6. Also note down the deflections of the spring by removing the loads in steps

**Formulae:**

- Stiffness of the spring : It is the Slope of Load – deflection curve

$$k = (\delta W) / (\delta y)$$

- Rigidity modulus of the spring material:

$$G = \frac{64 W R^3 n}{y d^4}$$

**Graph:** Draw the graph between Load and deflection

**OBSERVATIONS:**

**Outer diameter of the spring (D<sub>0</sub>):**

S.No.	Main Scale Reading (MSR)(mm)	Vernier Coincidence (V C)	Vernier Reading (VR)= V C X L C (Least Count)	Total Reading = MSR + VR (mm)
01				
02				
03				
<b>AVERAGE</b>				

**Inner diameter of the spring (D<sub>i</sub>):**

S.No.	Main Scale Reading (MSR)(mm)	Vernier Coincidence (V C)	Vernier Reading (VR)= V C X L C (Least Count)	Total Reading = MSR + VR (mm)
01				
02				
03				
<b>AVERAGE</b>				

**LOAD – DEFLECTION READINGS:**

Dead weight Reading: \_\_\_\_\_

S. No	Load (W)	Vernier Reading			Deflection (mm) Vernier Reading – Dead weight Reading
		Main Scale Reading	Vernier coincidence	M.S.R + V.C. (0.1)	
1					
2					
3					
4					
5					

**CALCULATIONS:**Outer diameter of the spring  $D_0$  =Inner diameter of the spring  $D_i$  =Mean Diameter of the Spring  $D$  =  $(D_0 + D_i) / 2$ Mean Radius of the spring  $R$  =  $D / 2$ Diameter of the coil wire  $d$  =  $(D_0 - D_i) / 2$ Number of turns  $n$  =Stiffness of the spring  $k$  =  $(\delta W) / (\delta y)$  =  $W/y$  from the graphRigidity modulus of the spring material  $G$  =  $\frac{64 W R^3 n}{y d^4}$ **Result:**

After conducting the deflection test on the given close coiled helical spring, the following are determined

Stiffness of the spring  $k$  =Modulus of rigidity of the spring material  $G$  =

## STUDY OF MICROSTRUCTURE OF METALS

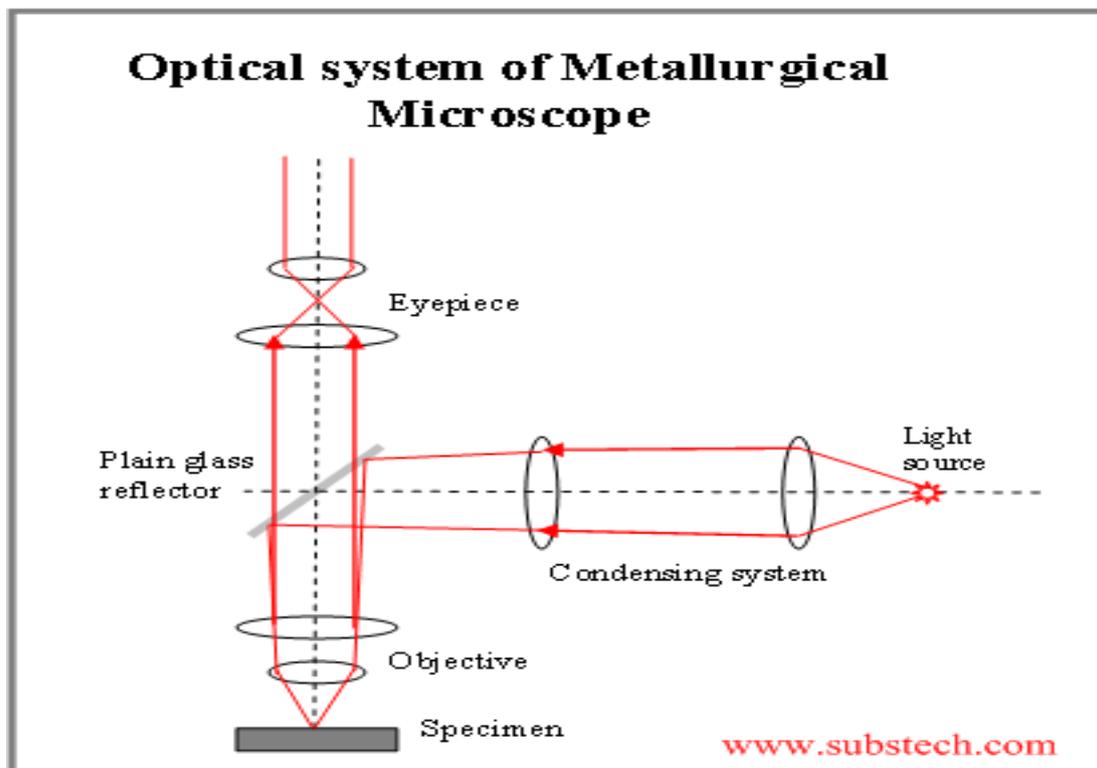
**Equipment:** Monocular / Binocular Optical Metallurgical Microscope

**Material:** Optical Lenses, Metallographic Specimen

### DESCRIPTION:

**Metallurgical Microscope:** It is important to know the principles of the metallurgical microscope. In comparison with a biological type the metallurgical microscope differs in the manner by which the specimen is illuminated. Since a metallographic sample is opaque to light, the sample must be illuminated by reflected light. As shown in figure 03, a horizontal beam of light from some light source is reflected, by means of plane-glass reflector, downward through the microscope objective into the surface of the specimen. Some of this incident light reflected from the specimen surface will be magnified in passing through the lower lens system, the objective, and will be magnified in passing through the plane-glass reflector and be magnified again by the upper lens system, the usually engraved on the lens mount. When a particular combination of objective and eyepiece is used at the proper tube length, the total magnification is equal to the product of the magnifications of the objective and the eyepiece.

It is possible to mount a camera bellows above the eyepiece and use the table-type microscope for photomicrography. However, the bench-type metallograph which is specifically designed for both visual examination and permanent recording of metallographic structures by photographic methods will give superior photomicrographs. The maximum magnification obtained with the optical microscope is about 2000X.



## **Parts of Metallurgical Microscope**

- 1) Halogen Lamp: It is used as a light source. This light source is especially suitable for color photomicrography.
- 2) Intensity Variation Knob: Intensity of halogen lamp can be adjusted by this knob.
- 3) Aperture Diaphragm: It is placed in front of the lamp or condenser. It is used to control resolving power, contrast and depth of the focus.
- 4) Filters: They are required to modify the light for optimum visual examination or photomicrography. Green filters are used for observation and blue filters are used for photography.
- 5) Plane Glass Reflector: Used to divert the horizontal beam of light coming from light source onto the specimen. It also transmits the reflected light from the specimen to eye-piece.
- 6) Objective: It forms the primary image in conjunction with the field lens of eyepiece. It collects as much light as possible coming any point on the specimen and combines this light to form the image. The Numerical aperture is a measure of the light collection capability of the objective.
- 7) Stage/Mounting table: It is used to hold the specimen. Separate knob is provided for X-Y movement of the table.
- 8) Focusing (Fine & Coarse): From these one can move the stage of the microscope up and down in respective type for getting clear image.
- 9) Eyepiece: It forms the second optical system. They are used to enlarge the primary image formed by the objective.
- 10) Trinocular Head: This is a part of microscope in which one can attach any system like CCD camera and get image on computer.
- 11) CCD camera: CCD stands for "Charge Coupled Device". A CCD camera uses the same technology as the popular digital cameras used for everyday photography. They are used to transfer virtual image visible in the eye piece to computer.
- 12) Frame Grabber Card: A device that lets you capture individual frames out of a video camera or off a video tape.

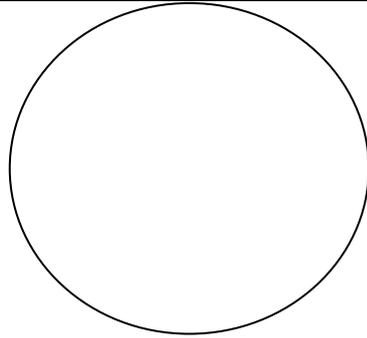


© OnFocus Laboratories

### PROCEDURE:

01. Assemble the parts of the given microscope
02. Put the eye lenses
03. Select the object lens for the required magnification
04. Connect the microscope to the electrical power source
05. Switch on the lamp
06. Place the specimen gently on the table
07. Adjust the specimen by giving to and fro / left and right motions to the table so that light falls exactly on the specimen
08. Initially bring the table to the bottom most position
09. Slowly move the table upwards with the coarse threaded knob
10. When it is nearer to the focal point move the table very slowly using fine threaded knob
11. After setting the focal length see the micro structure and draw it on the paper
12. By seeing the micro structure name the material of the specimen

## METALLOGRAPHY OF



Magnification:

Specimen Material:

Composition:

Microstructure Details:

Etchant:

Etching Time:

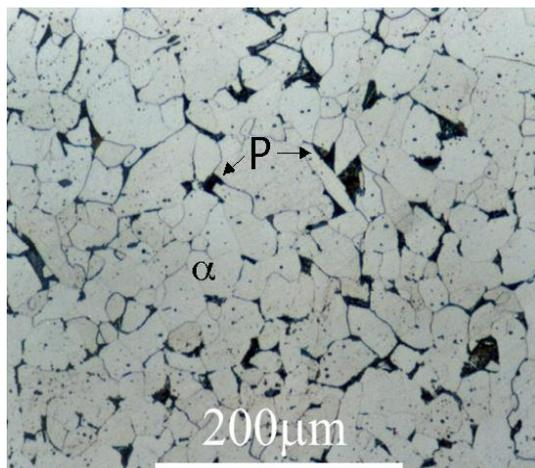
## MICRO STRUCTURES OF METALS

### LOW CARBON STEEL:

**Composition:** 0.05-0.309% Carbon, up to 0.4% Mn

and the bulk being iron (Fe) with trace impurities.

- Microstructure consists of Pearlite (P) and Ferrite ( $\alpha$ ). Pearlite itself consists of bands of ferrite( $\alpha$ ) and cementite.



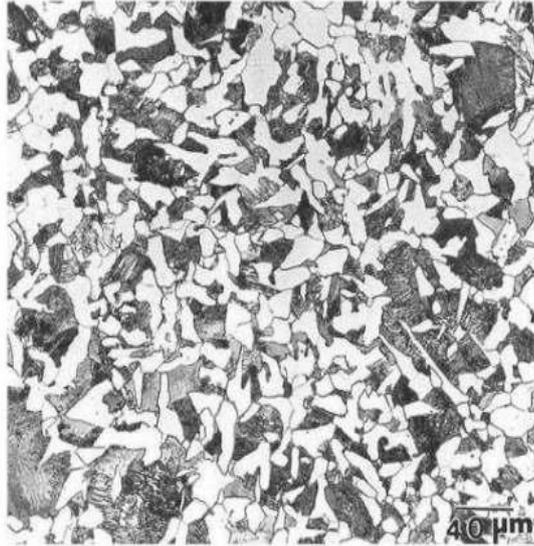
**Observation:** Light phase being 'Ferrite ( $\alpha$ )' and dark phase being 'Pearlite'

## MEDIUM CARBON STEEL

**Composition:** 0.3-0.8% Carbon, 0.6% - 1.6% Mn  
and the bulk being iron (Fe) with trace impurities.

- Microstructure consists of Pearlite (P) and Ferrite ( $\alpha$ ). Pearlite itself consists of bands of ferrite( $\alpha$ ) and cementite.

**Observation:** Bright phase being 'Ferrite ( $\alpha$ )' and dark phase being 'Pearlite'

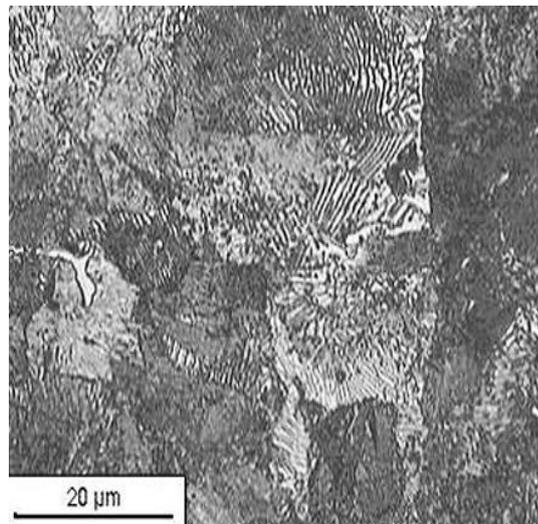


## HIGH CARBON STEEL

**Composition:** 0.8 - 2% Carbon, 0.6% - 1.6% Mn  
and the bulk being iron (Fe) with trace impurities.

- Microstructure consists of Pearlite (P) and Ferrite ( $\alpha$ ). Pearlite itself consists of bands of ferrite( $\alpha$ ) and cementite.

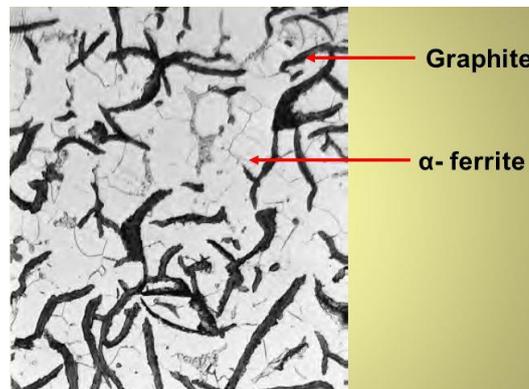
**Observation:** Bright phase being 'Ferrite ( $\alpha$ )' and dark phase being 'Pearlite'



## GRAY CAST IRON

**Composition:** 2 - 4.5% Carbon, 1 - 3% Silicon  
and the bulk being iron (Fe) with trace impurities.

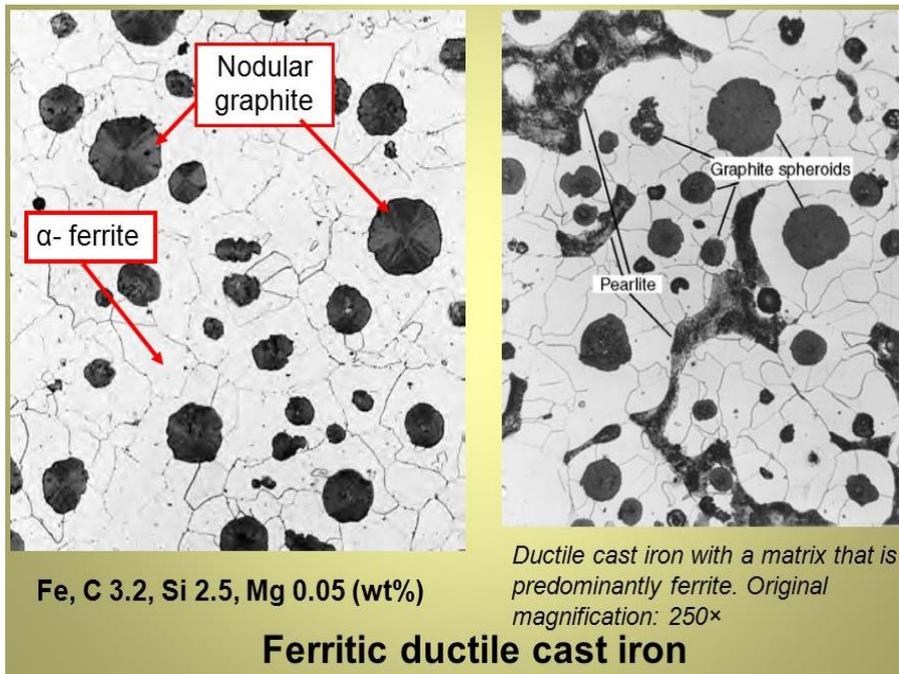
- Microstructure consists of Ferrite ( $\alpha$ ) and Graphite flakes.



**Observation:** Bright phase being 'Ferrite ( $\alpha$ )' and dark phase being 'graphite'

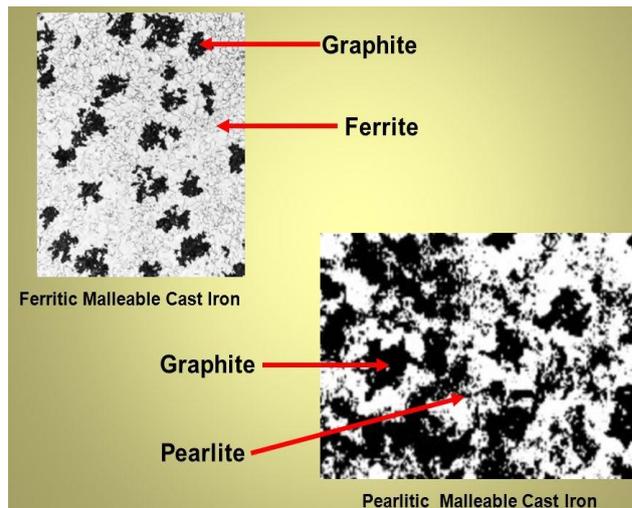
# NODULAR CAST IRON (SPHEROIDAL CAST IRON)

- Addition of Mg and/or Cerium to gray iron converts the graphite flakes into nodules
- Composition: C=3.2-3.5%, Si=2.5%, Mg=0.03-0.05%, and the rest being iron



# MALLEABLE CAST IRON

- Produced by heat treatment of white cast irons at temperatures between 800 °C to 1470 °C for a prolonged time period (10-30 h), in a neutral temperature.
- Causes decomposition of cementite, forming graphite, which exists in the form of clusters or rosettes surrounded by a ferrite or pearlite matrix, depending on the cooling rate.



**Composition:** C=2-2.7%, Mn=0.25-1.25%, Si=1-1.75%, S=0.03-0.18%, P=0.05%max and the rest being iron

# COPPER

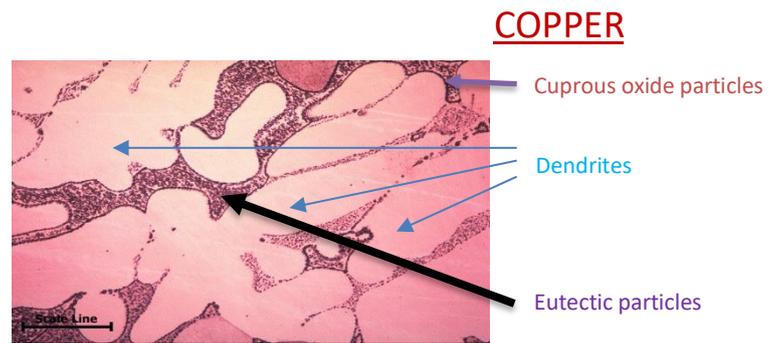
**Composition:** 99.90% Cu

**Observations:** The copper metal solidifies from the liquid state by the growth of crystals. The crystals grow in preferred directions and form open, *tree like structures*

*called dendrites*. The dendritic structure is very typical of cast metals.

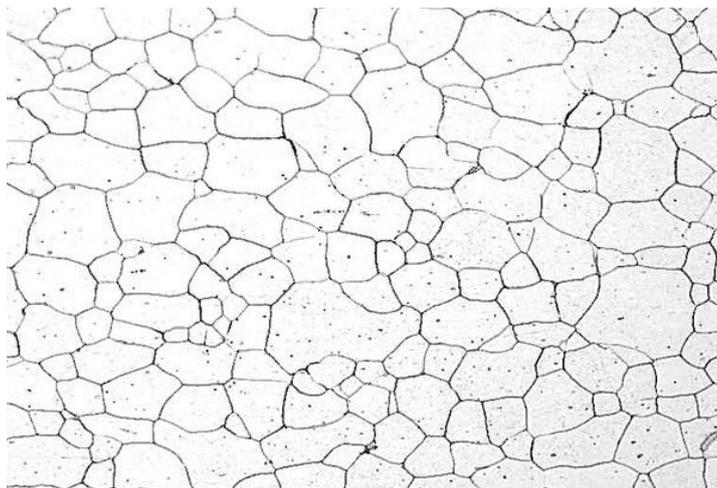
A lower melting point mixture of pure copper and cuprous oxide, called a eutectic, forms in the open spaces between the dendrites. The *eutectic particles are usually dark, globular bodies dispersed in a copper background*.

The *cuprous oxide particles form a network, outlining the dendritic cells*. Pores, seen as dark spots in the microstructure, are also present in the as-cast material.

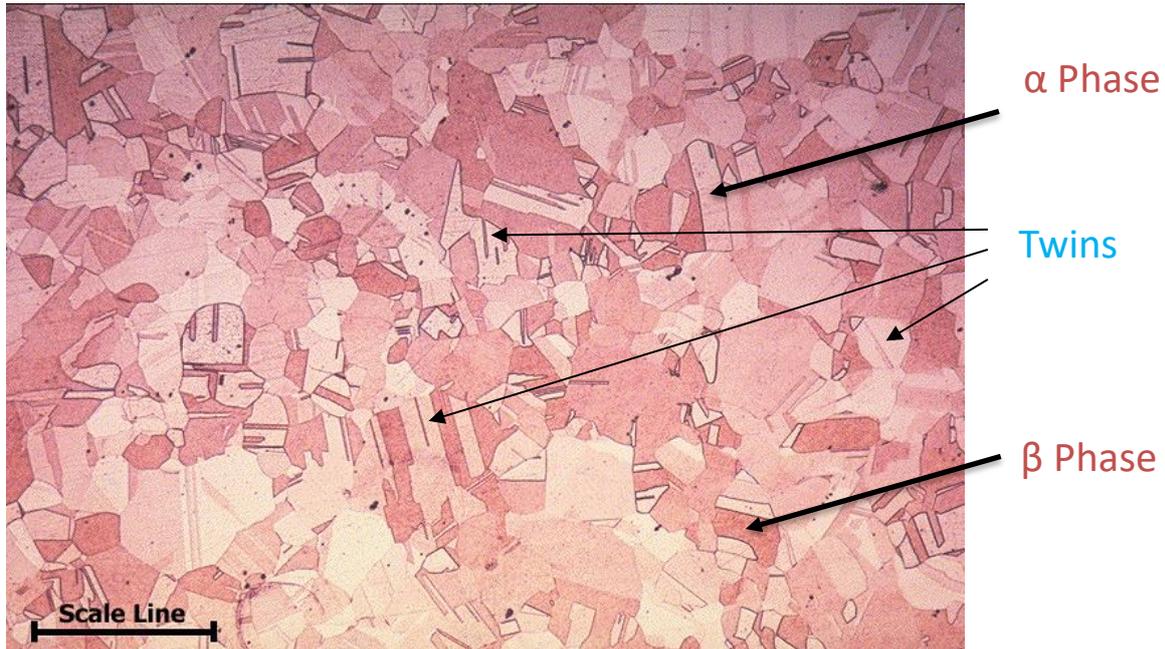


# ALUMINIUM

**Observations:** The microstructure of pure aluminium reveals their grain sizes and grain boundaries.



# BRASS



*Microstructure of “**Brass**”, scale line length 125 microns, product in ‘Wrought’ form*

**Observations:** The microstructure of brasses containing up to approximately 40% zinc consists of alpha dendrites with beta surrounding the dendrites. The wrought materials consist of grains of alpha and beta.

# M-308 MATERIAL TESTING AND METALLOGRAPHIC LAB

## VIVA – VOCE EXAM QUESTIONS

01. Define stress
02. Define Strength
03. Differences between stress and strength
04. Define Young's Modulus
05. Define Rigidity Modulus
06. Define Bulk Modulus
07. Define Poisson's Ratio
08. Differences between Longitudinal and Lateral strains
09. Define Spherical / Hydrostatic Stress
10. Draw the stress-strain diagram for brittle and ductile materials and locate salient points on them
11. Define hardness
12. Define Stiffness
13. Define toughness
14. Define Ductility
15. Define Brittleness
16. Differences between ductile and brittle materials
17. Examples for ductile and brittle materials
18. Define Yield Strength
19. Define Proof Strength
20. What is off-set method?
21. What is necking?
22. Define Resilience
23. Define Proof Resilience
24. Define Modulus of Resilience
25. Define Impact strength
26. How do you measure the Impact Strength? (Units)
27. What are the differences between Charpy and Izod Impact tests?
28. What is the purpose of notch in the impact test specimen?
29. Compare the impact strength of ductile and brittle materials for the same dimensions?
30. On which principle the Impact test works?

31. What are the qualitative hardness tests?
32. What are the quantitative hardness tests?
33. What is the importance of minor load in Rockwell hardness Test?
34. Why is the minor load is absent in Brinell hardness test?
35. What are the limitations of the Brinell hardness Tester?
36. Is 100 HRC equals to 100 HRB?
37. Which parameter is used in Brinell and Rockwell hardness tests?
38. What is the difference between single shear and double shear?
39. Write the formula for shear strength of given specimen in the case of single shear and double shear
40. What are the different types of supports?
41. What are the different types of beams?
42. What are the assumptions made in the derivation of flexural formula?
43. What is Neutral Axis?
44. What is Neutral Layer?
45. Define stiffness of the spring
46. What are the different types of springs?
47. List the important parts of the Metallurgical Microscope
48. How do you calculate Least count of the Vernier callipers?
49. How do you calculate the total magnification of the microscope?
50. What is microstructure?
51. What is the difference between metallurgical and biological microscope?
52. What is the purpose of polishing in the preparation of metallographic specimen?
53. What is the form of carbon in Gray Cast Iron, Nodular Cast Iron and Malleable Cast Iron?
54. What is Etching?
55. What is the difference between ferrous and Non-Ferrous materials?
56. Match the following
 

a) Young's Modulus	01)	Lateral Strain	(    )
b) Rigidity Modulus	02)	Normal Stress	(    )
c) Bulk Modulus	03)	Shear Stress	(    )
d) Poisson's Ratio	04)	Volumetric Strain	(    )
57. Match the following
 

a) Rockwell Hardness Tester	01)	Brinell Microscope	(    )
b) Impact Test	02)	Diamond Cone Indenter	(    )
c) Brinell hardness Tester	03)	Stiffness	(    )
d) Spring Test	04)	Toughness	(    )

# PREPARATION OF METALLOGRAPHIC SPECIMEN

**Aim:** To prepare a specimen of the given metallic material for viewing the microstructure in the microscope at a selected magnification.

**Apparatus:** Belt grinding machine, disc polishing machine (or) lapping machine, metallurgical microscope.

**Materials Required:** Thermosetting or thermoplastic mounting material with liquid, different grades of emery papers, metallographic polishing cloths, Alumina powder, and suitable etchant.

**Sequence of operations:**

1. Sampling
2. Mounting
3. Rough grinding
4. Intermediate grinding
5. Fine grinding
6. Fine polishing
7. Etching
8. Drying
9. Microscopic examination.

## PROCEDURE:

1. The specimen should be selected and removed from the particular region of the component.
2. If the specimen size is too small that is inconvenient and uncomfortable to handle, then the specimen is to be mounted.
3. The surface of the specimen that is to be examined is first made plane by means of motor-driven emery belt.
4. In order not to alter the structure of the metal undergoing grinding the specimen should be kept cool by frequently dipping it into water during the grinding operation.
5. When the specimen appears to be flat over the entire surface and grinding has removed all surface imperfections, this operation is considered to be completed.
6. Intermediate grinding has to be done to the specimen different grades of emery papers.
7. The emery paper is placed on a bench plate on any clean, hard, level surface, such as a sheet of plate glass.
8. The specimen is gently drawn back and forth across the entire length of the paper under moderate applied pressure.
9. Fine grinding operation has to be performed using finer grades of emery papers.
10. The preliminary and final polishing operations on the specimen are performed on polishing wheels or polishing laps covered with fine grade wool or velvet cloth.

11. When final polishing is completed, the specimen is thoroughly washed in running water and swabbed with water-wet cotton.
12. The specimen is dried with the help of drier.
13. Observe the microstructure in the microscope in unetched condition.
14. Apply the suitable etchant on the surface of the specimen, see the microstructure again.
15. Draw the obtained microstructure of the given specimen.

**PRECAUTIONS:**

1. Do not apply excessive pressure during rough grinding, as well as during subsequent hand grinding on the emery papers. Higher pressure leads to deep scratches on the specimen that will be very difficult to remove.
2. Bevel the sharp edges and corners of the specimen to prevent tearing the emery papers and polishing cloths in later operations.
3. During grinding on each successive paper, the specimen is held as described for intermediate grinding, i.e., with the newly formed scratches at right angles to those which are introduced on the preceding paper.
4. Through washing of the specimen in running water is required at every stage of operation.

**THEORY:**

Metallography is the study of the microstructure of metals and alloys by means of microscopy. It is an art and science of preparing, interpreting, and analyzing microstructures in materials, to better understand materials behavior and performance. The method is used for the evaluation of metallic materials in the various industries, including the aerospace industry, the automotive industry and parts of the construction industry. It is also used for process control including the examination of defects that appear in finished or partly finished products, as well as the studies of parts that have failed during service. A well prepared metallographic specimen is:

- a. A representative sample
- b. Sectioned, ground and polished so as to minimize disturbed or flowed surface metal caused by mechanical deformation, and thus to allow the true microstructure to be revealed by etching.
- c. Free from polishing scratches and pits and liquid staining
- d. Flat enough to permit examination by optical microscope or SEM

In preparing a specimen for microscopic examination, it is first necessary to produce the surface which appears perfectly flat and scratch free when viewed with the aid of a microscope. The procedure to be followed in the preparation of a specimen involves different steps as explained below.

a. Sectioning

b. Mounting (which is necessary when the sample cannot be held properly due to its shape and/or size, while polishing)

c. Grinding

d. Polishing

e. Etching

**Procedure:**

**Selecting the Specimen (Sampling):** The selection of a specimen for microscopic examination calls for a little thought, since a large body of metal may not be homogeneous either in composition or crystal structure, some times more than one specimen will be necessary in order adequately to represent the material. In some alloys, the structure may also exhibit directionality. For the examination of surface defects a specimen must be chosen so that a section through the surface layer is included in the face to be polished. Surface cracks and the like should be investigated by cutting a piece of metal containing the crack and mounting it in Bakelite or a similar compound. The surface to be polished is then ground sufficiently so that a section through the crack is obtained. It is difficult to grind a perfectly flat surface on smaller specimens, and these best mounted as described below.

**Mounting:** When a specimen is so small that it is difficult to hold it flat on the emery paper, the specimen may be mounted in a suitable compound. This can be done most satisfactorily by using a proprietary plastics mounting material. These are generally either acrylic, polyester or epoxide resins. The kit supplied often consists of a powder and liquid. When these are mixed, polymerization takes place and a hard plastics substance is produced which will retain a metal specimen during and after the polishing operation.

Specimens can be mounted more quickly by using some thermosetting substance, such as Bakelite or alternatively, a transparent thermoplastic material. These substance mould at about  $150^{\circ}\text{C}$ , which is usually too low a temperature to cause any structural change in the specimen. They can be ground and polished easily and do not promote any electrolytic action during etching. A small mould (fig. 01) is required in conjunction with a press capable of giving pressures up to about  $2\text{ N/mm}^2$ . Some of the thermoplastic materials mould satisfactorily at such low pressures that a sturdy bench vice can be used to apply the necessary force to this small moulding unit.

After placing the specimen, the powder and the plunger in the mould the latter is heated by means of a special electric heart which encircles it. If this is not available a Bunsen burner will suffice. In either case a thermometer should be inserted in a hole provided in the plunger so that overheating of the mould is avoided.

**Rough Grinding:** It is first necessary to obtain a reasonably flat surface on the specimen. This can be done either by using a fairly coarse file, or preferably, by using a motor-driven emery belt.

A soft sample may be made flat by slowly moving it up and back across the surface of a flat smooth file. The soft or hard specimen may be rough-ground on a belt sander, with the specimen kept cool by frequent dropping in water during the grinding operation. In all grinding and polishing operations the specimen should be moved perpendicular to the existing scratches. This will facilitate recognition of the stage when the deeper scratches have been replaced by shallower ones characteristic of the finer abrasive. The rough grinding is continued until the surface is flat and free of nicks, burrs, etc., and all scratches due to the hacksaw or cutoff wheel are no longer visible.

**Intermediate grinding and polishing:** Intermediate grinding is carried out on emery papers of progressively finer grade. These must be of the very best quality, particularly in respect of uniformity of particle size. For this purpose generally four grades of emery papers are used. (220, 320, 400 and 600 grades or 1/0,2/0,3/0,4/0 grades from coarse to fine) Rotary grinding decks are available on to which discs of grinding paper are clamped. These are driven by two speed motors and are fitted with water drip-feeds and suitable drains.

The intermediate polishing operations using emery paper are usually done however, in certain cases such as the reparation of soft materials; silicon carbide abrasive may be used. As compared to emery paper, silicon carbide has a greater removal rate and, as it is resin-bonded, can be used with a lubricant. Using a lubricant prevents overheating the sample, minimizes smearing of soft metals, and also provides a rinsing action to flush away surface removal products so the paper will not become clogged.

**Fine Polishing:** The time consumed and the success of fine polishing depend largely upon the care that was exercised during the previous polishing steps. The final approximation to a flat scratch-free surface is obtained by use of a wet rotating wheel covered with a special cloth that is changed with carefully sized abrasive particles. A wide range of abrasives are available for final preference for the gamma form of aluminum, magnesium, and their alloys. Other final polishing abrasives often used are diamond paste, chromium oxide, and magnesium oxide.

The choice of a proper polishing cloth depends upon the particular material being polished and the purpose of the metallographic study. Many cloths are available such as silk, broadcloth, billiard cloth, and canvas duck, velvet cloth. Synthetic polishing cloths are also available for general polishing purposes.

The most important factors affecting a successful finish are:

- a) Care should be taken not to overheat the specimen during grinding.
- b) Absolute cleanliness is essential at every stage.
- c) If a specimen has picked up deep scratches in the later stages of grinding it is useless to attempt to remove them on the polishing pad. If a specimen is polished for too long on the pad its surface may become rippled.
- d) Apply light pressure at all times during grinding and polishing.

**Etching:** The purpose of etching is to make visible the many structural characteristics of the metal or alloy. The process must be such that the various parts of the microstructure may be clearly differentiated. This is accomplished by use of an appropriate reagent which subjects the polished surface to chemical action.

In alloys composed of two or more phases, the components are revealed during etching by a preferential attack of one or more of these constituents by the reagent, because of difference in chemical composition of the phases. In uniform single-phase alloys or pure metals, contrast is obtained and grain boundaries are made visible because of differences in the rate at which various grains are attacked by the reagent. Because of chemical attack by the etching reagent, the grain boundaries will appear as valleys in the polished surface. Light from the microscope hitting the side of these valleys will be reflected out of the microscopes, making the grain boundaries appear as dark lines.

The selection of the appropriate etching reagent is determined by the metal or alloy and the specific structure desired for viewing.

## **MICROSTRUCTURE OF METALS**

### **MILD STEEL**

Mild steels contains carbon content from 0.15 to 0.3% the mild steels in which carbon content is less than 0.15% are known as dead mild steels. Microstructures consist of ferrite and pearlite constituents. These are not affected by heat treatment processes, especially hardening process these are relatively soft and weak but have outstanding ductility and toughness. They are machinable, weldable, and of all steels, are the least expensive to produce. The disadvantage of mild steels is that it is subjected to corrosion when exposed to the atmosphere. They are used for making wires, rivets, nuts, bolts, screws, sheets, plates, tubes, rods, shafts, structural steel sections and for general workshop purpose etc.

### **MEDIUM CARBON STEEL**

Medium carbon steels contain 0.3 to 0.6% carbon content these alloys may be heat treated by austenitizing, quenching and then tempering to improve their mechanical properties. Addition of chromium, nickel, and molybdenum improve the capacity of these alloys to be heat treated, giving rise to a variety of strength – ductility combinatory. These heat treated alloys are stronger than the low-carbon steels, but at a sa of ductility and toughens. They are used for making railway wheels and tracks, gears, crank shafts, spring, large forging dies, agricultural tools etc.

### **HIGH CARBON STEELS**

The high carbon steels having carbon contents between 0.6 to 1.5 wt%, are the hardest, strongest and yet least ductile of the carbon steels. The tool and die steels are high-carbon alloys, usually containing

chromium, vanadium, tungsten, and molybdenum. These alloying elements combine with carbon to form very hard and wear - resistant carbide compounds. These steels are utilized as cutting tools, knives, razors, springs, hacksaw blades, press work dies and punches, hand files etc.

## **GRAY CAST IRON**

The various elements in gray cast iron are carbon (C) = 2.5 to 4%, silicon (Si) = 1 to 3%, Manganese (Mn) = 0.4 to 1%, Phosphorous (P) = 0.15 – 1%, Sulphur (S) 6.62 to 15%, Iron (Fe) = Remaining. For most of the gray cast irons, the graphite exists in the form of flakes, which are normally surrounded by an  $\alpha$  – ferrite or pearlite matrix. Because of the graphite flakes, a fractured surface takes on a gray appearance, hence its name.

Mechanically gray iron is comparatively weak and brittle in tension as a consequence of its microstructure, the tips of the graphite flakes are sharp and pointed, and may serve as points of stress concentration when an external tensile stress is applied. Strength and ductility are much higher under compressive loads. Gray iron are very effective in damping vibrational energy. Base structures for machines and heavy equipment that are exposed to vibrations are frequently constructed of this material. Typical applications includes cylinder blocks, cylinder heads, pistons, clutch plates, transmission cases, diesel engine castings, lines water main pipes, flywheels, pulleys, machine frames.

## **COPPER (CU):**

Copper is a face centered cubic (FCC metal) with very high ductility, electrical and thermal conductivity. This is very soft too. It is used in electrical applications, industrial machinery, hearth for arc furnaces. In the alloyed form, it also finds enormous importance. One such application is duralumin (Al-4.5% Cu), which is common material for airplane body material. When it is alloyed with Zn, it is called brass. 70:30 brass is very common in making pipe lines for water.

## **ZINC (ZN):**

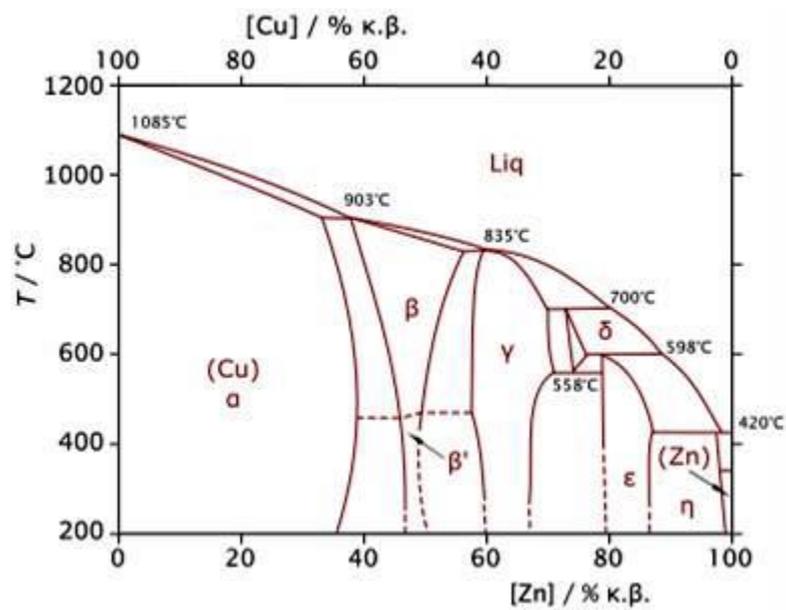
Zinc is hexagonal closed packed structure with limited ductility. However, when formed alloys with Cu, it forms one of the exciting engineering alloy, called Brass. Zinc finds some crucial engineering applications, like galvanization of steel (for corrosion protection), sacrificial anode for protecting underground metallic structures (cathodic protection), etc.

## **BRASS:**

Figure shows the Cu-Zn phase diagram with different phases. Cu-rich portion of the phase diagram reveals a cascade of peritectic reactions. The peritectic reactions corresponding to  $\alpha + \beta$  brass is marked. In the laboratory exercise, you will study the microstructure of composition of alloy Cu:Zn = 60:40. The microstructure will reveal presence of both the  $\alpha$  and  $\beta$  phases because of incomplete peritectic reaction. Apart from Brass, many other technically important alloy systems such as steels, CuSn (Bronze), rare earth permanent magnets (Nd-Fe-B) and high  $T_c$

superconductors (Yb-B-Cu-O) display peritectic reactions, where phase and microstructure selection plays an important role for the processing and the properties of the material. The peritectic reaction can be written as  $\alpha + L \rightarrow \beta$  on cooling,

where  $\alpha$  and  $\beta$  are solid phases and  $L$  stands for liquid. Therefore, a primary solid phase reacts with liquid leading to formation of another solid phase. The second solid phase is called peritectic phase. The equilibrium microstructure of such alloys will show  $\beta$  as dendrites (tree like structure). During normal freezing of the peritectic alloy, the reaction never goes to completion and hence, some amount of primary  $\alpha$  phase remains in the microstructure surrounded by the  $\beta$  phase.



## Model Question Papers

### MARKS DISTRIBUTION: TOTAL MARKS – 60

- (a) Lower Order Question : 06 M
- (b) Middle Order Question: 20 M
- (c) Higher Order Question : 28 M
- Viva-Voce : 06 M

### UNIT TEST – I

01.

- a) Locate 5 gauge points on the given specimen of tension test (LO)
- b) Fix the given specimen in shear shackles to conduct the double shear test.(MO)
- c) Note down the load vs deformation readings in the Tension Test (HO)

02.

- a) Measure the final gauge length and neck diameter with the Vernier calliper(LO)
- b) Fix the specimen in UTM to conduct the tension test(MO)
- c) Calculate stress and strain values for the given loads, deformations and initial dimensions of the specimen.(HO)

03.

- a) Measure the diameter of the given cylindrical specimen with the Vernier Calliper and find the gauge length (LO)
- b) Find the allowable shear strength of the given specimen for a given factor of safety.(MO)
- c) Draw the stress strain diagram for the given values and find the Young's modulus and yield strength.(HO)

04.

- a) Measure the cross sectional dimensions of the given concrete specimen.(LO)
- b) Find the mean diameter of the given spring. (MO)
- c) Note down load vs deflection readings (HO)

05.

- a) Fix the specimen in UTM/CTM to conduct the compression test.(LO)
- b) Draw the graph between load vs deflection for the given data (MO)
- c) Find the rigidity modulus of the spring material from the given data (HO)

06. a) Find the compressive strength of the given specimen for the given data (LO)

- b) Draw the graph between load vs deflection for the given data (MO)
- c) Find the stiffness of the spring material from the given data (HO)

- 07.
- Draw the shape of the specimen for Charpy impact test(LO)
  - Fix the appropriate striker to conduct the Charpy impact test(MO)
  - Prepare the Izod specimen with accurate dimensions(HO)
- 08.
- Draw the shape of the specimen for Izod impact test(LO)
  - Fix the pendulum at appropriate position to conduct the Charpy impact test(MO)
  - Prepare the Charpy specimen with accurate dimensions(HO)
- 09.
- Fix/Place the given specimen correctly to conduct the Charpy impact test(LO)
  - Break the specimen by releasing the pendulum and note down the energy(MO)
  - Calculate the impact strength of the given specimen and data(HO)

## UNIT TEST – II

- 01.
- Fix the given ball indenter in the Brinell Hardness tester (LO)
  - Find the Brinell hardness number for the given data (MO)
  - Find the Rockwell hardness by applying minor and major loads (HO)
- 02.
- Select the correct set of indenter, scale, dial and load for a given material (LO)
  - Apply the correct load on the specimen/load lever for a given material in the Brinell Hardness Test(MO)
  - Measure the diameter of the indentation using Brinell microscope (HO)
- 03.
- Fix the correct indenter in the Charpy Hardness tester (LO)
  - Check whether the tester is working properly with the help of standard specimen (HO)
  - Measure the diameter of the indentation using Brinell microscope (HO)
- 04.
- Measure the cross sectional dimensions of the given Simply Supported Beam with the Vernier calliper (LO)
  - Note down the dial indicator readings while applying and removing the loads on cantilever beam (MO)
  - Find the stiffness of the Simply Supported Beam material for the given data (HO)

05.

- a) Place the hangers (weight pans) and dial indicator at the appropriate positions on Cantilever Beam (LO)
- b) Fix the dial indicator properly on the cantilever beam (MO)
- c) Find the Young's modulus of the simply supported beam material for the given data (HO)

06.

- a) Measure the cross sectional dimensions of the Cantilever Beam with the Vernier calliper (LO)
- b) Note down the dial indicator readings while applying and removing the loads on simply supported beam (MO)
- c) Find the Young's Modulus of the Cantilever Beam material for the given data (HO)

07.

- a) Assemble the parts of given microscope. (LO)
- b) Adjust the focal length (MO)
- c) Draw the microstructure of the given specimen. (HO)

08.

- a) Calculate the magnification for the given set of object and eye lenses (pieces) (LO)
- b) Adjust the focal length (MO)
- c) Identify the different compositions of material for the given micro structure and name the material. (HO)

### **EXTERNAL EXAMINATION**

01.

- d) Locate 5 gauge points on the given specimen of tension test (LO)
- e) Fix the given specimen in shear shackles to conduct the double shear test.(MO)
- f) Note down the load vs deformation readings in the Tension Test (HO)

02.

- d) Measure the final gauge length and neck diameter with the Vernier calliper(LO)
- e) Fix the specimen in UTM to conduct the tension test(MO)
- f) Calculate stress and strain values for the given loads, deformations and initial dimensions of the specimen.(HO)

03.

- d) Measure the diameter of the given cylindrical specimen with the Vernier Calliper and find the gauge length (LO)
- e) Find the allowable shear strength of the given specimen for a given factor of safety.(MO)
- f) Draw the stress strain diagram for the given values and find the Young's modulus and yield strength.(HO)

- 04.
- d) Measure the cross sectional dimensions of the given concrete specimen.(LO)
  - e) Find the mean diameter of the given spring. (MO)
  - f) Note down load vs deflection readings (HO)
- 05.
- d) Fix the specimen in UTM/CTM to conduct the compression test.(LO)
  - e) Draw the graph between load vs deflection for the given data (MO)
  - f) Find the rigidity modulus of the spring material from the given data (HO)
- 06.
- a) Find the compressive strength of the given specimen for the given data (LO)
  - b) Draw the graph between load vs deflection for the given data (MO)
  - c) Find the stiffness of the spring material from the given data (HO)
- 07.
- a) Draw the shape of the specimen for Charpy impact test(LO)
  - b) Fix the appropriate striker to conduct the Charpy impact test(MO)
  - c) Prepare the Izod specimen with accurate dimensions(HO)
- 08.
- a) Draw the shape of the specimen for Izod impact test(LO)
  - b) Fix the pendulum at appropriate position to conduct the Charpy impact test(MO)
  - c) Prepare the Charpy specimen with accurate dimensions(HO)
- 09.
- a) Fix/Place the given specimen correctly to conduct the Charpy impact test(LO)
  - b) Break the specimen by releasing the pendulum and note down the energy(MO)
  - c) Calculate the impact strength of the given specimen and data(HO)
- 10.
- a) Fix the given ball indenter in the Brinell Hardness tester (LO)
  - b) Find the Brinell hardness number for the given data (MO)
  - c) Find the Rockwell hardness by applying minor and major loads (HO)
- 11.
- a) Select the correct set of indenter, scale, dial and load for a given material (LO)
  - b) Apply the correct load on the specimen/load lever for a given material in the Brinell Hardness Test(MO)
  - c) Measure the diameter of the indentation using Brinell microscope (HO)
- 12.
- a) Fix the correct indenter in the Charpy Hardness tester (LO)
  - b) Check whether the tester is working properly with the help of standard specimen (HO)
  - c) Measure the diameter of the indentation using Brinell microscope (HO)

13.

- a) Measure the cross sectional dimensions of the given Simply Supported Beam with the Vernier calliper (LO)
- b) Note down the dial indicator readings while applying and removing the loads on cantilever beam (MO)
- c) Find the stiffness of the Simply Supported Beam material for the given data (HO)

14.

- a) Place the hangers (weight pans) and dial indicator at the appropriate positions on Cantilever Beam (LO)
- b) Fix the dial indicator properly on the cantilever beam (MO)
- c) Find the Young's modulus of the simply supported beam material for the given data (HO)

15.

- a) Measure the cross sectional dimensions of the Cantilever Beam with the Vernier calliper (LO)
- b) Note down the dial indicator readings while applying and removing the loads on simply supported beam (MO)
- c) Find the Young's Modulus of the Cantilever Beam material for the given data (HO)

16.

- d) Assemble the parts of given microscope. (LO)
- e) Adjust the focal length (MO)
- f) Draw the microstructure of the given specimen. (HO)

17.

- d) Calculate the magnification for the given set of object and eye lenses (pieces) (LO)
- e) Adjust the focal length (MO)
- f) Identify the different compositions of material for the given micro structure and name the material. (HO)