LABORATORY MANUAL

FOR

MATERIALS TESTING LAB (KME-352)

In Pursuit of Excellence

DEPARTMENT OF MECHANICAL ENGINEERING
MORADABAD INSTITUTE OF TECHNOLOGY
MORADABAD

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DEPARTMENT OF MECHANICAL ENGINEERING

COURSE: - B.Tech
LAB: - MATERIALS TESTING LAB
INTERNAL MARKS: -25

SEMESTER:-III
LAB CODE: - KME- 352
EXTERNAL MARKS: -25

LIST OF PRACTICALS

(A). Material Testing Lab Experiments

1. To find out ultimate tensile stress, elongation and percentage contraction in the cross section area of a given mild steel specimen on UTM.
2. To find out ultimate shear stress of a given test piece on UTM.
3. To determine fracture energy required to fracture a standard notch specimen by an impact testing machine (by Charpy method, by Izod method).
4. Hardness test of a given specimen using Rockwell testing machine.
5. Hardness test of a given specimen using Vicker / Brinell testing machine.
6. To determine the stiffness of the spring and modulus of rigidity of spring wire.
7. Experiment on deflection of beam, comparison of actual measurement of deflection with dial gauge to the calculated one, and or evaluation of young's modulus of beam.
8. Torsion test of a rod using torsion testing machine.

(B). Material Science Lab Experiments (Beyond the syllabus)

9. To prepare plastic mould for small metallic specimen
10. To prepare a specimen for micro structural examination (cutting, grinding, polishing & etching).
11. To determine the grain size of a given specimen.
12. To compare the hardness before and after heat treatment experiment.
13. To compare the micro structures of different given specimens (Mild steel, Aluminum, Copper)..

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(Lab O.C.)

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MATERIALS ENGINEERING

L-T-P: 3-0-0

Objectives:

- Understanding of the correlation between the internal structure of materials, their mechanical properties and various methods to quantify their mechanical integrity and failure criteria.
- To provide a detailed interpretation of equilibrium phase diagrams
- Learning about different phases and heat treatment methods to tailor the properties of Fe- C alloys.

UNIT-I

Crystal Structure: Unit cells, Metallic crystal structures, Ceramics. Imperfection in solids: Point, line, interfacial and volume defects; dislocation strengthening mechanisms and slip systems, critically resolved shear stress.

Mechanical Property measurement: Tensile, compression and torsion tests; Young's modulus, relations between true and engineering stress-strain curves, generalized Hooke's law, yielding and yield strength, ductility, resilience, toughness and elastic recovery; Hardness: Rockwell, Brinell and Vickers and their relation to strength.

UNIT-II

Static failure theories: Ductile and brittle failure mechanisms, Tresca, Von-mises, Maximum normal stress, Mohr-Coulomb and Modified Mohr-Coulomb; Fracture mechanics: Introduction to Stress intensity factor approach and Griffith criterion. Fatigue failure: High cycle fatigue, Stress-life approach, SN curve, endurance and fatigue limits, effects of mean stress using the Modified Goodman diagram; Fracture with fatigue, Introduction to non-destructive testing (NDT).

UNIT-III

Alloys, substitutional and interstitial solid solutions- Phase diagrams: Interpretation of binary phase diagrams and microstructure development; eutectic, peritectic, peritectoid and monotectic reactions. Iron Iron-carbide phase diagram and microstructural aspects ofledeburite, austenite, ferrite and cementite, cast iron.

UNIT-IV

Heat treatment of Steel: Annealing, tempering, normalising and spheroidising, isothermal transformation diagrams for Fe-C alloys and microstructure development. Continuous cooling curves and interpretation of final microstructures and properties austempering, martempering, case hardening, carburizing, nitriding, cyaniding, carbo-nitriding, flame andinduction hardening, vacuum and plasma hardening.

UNIT-V

Alloying of steel, properties of stainless steel and tool steels, maraging steels- cast irons;grey, white, malleable and spheroidal cast irons- copper and copper alloys; brass, bronze andcupro-nickel; Aluminium and Al-Cu – Mg alloys- Nickel based superalloys and Titaniumalloys.

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Course Outcomes:

- Student will be able to identify crystal structures for various materials and understand the defects in such structures.
- Understand how to tailor material properties of ferrous and non-ferrous alloys.
- How to quantify mechanical integrity and failure in materials.

Books and References:

1. W. D. Callister, 2006, "Materials Science and Engineering-An Introduction", 6th Edition, Wiley India.
2. Kenneth G. Budinski and Michael K. Budinski, "Engineering Materials", Prentice Hall of India Private Limited, 4th Indian Reprint, 2002.
3. V. Raghavan, "Material Science and Engineering', Prentice Hall of India Private Limited, 1999.
4. Mechanics of materials by James M.Gere.
5. Introduction to engineering materials by B.K. Agarwal.
6. Physical metallurgy and advanced materials by R.E. Smallman.
7. Engineering mechanics of composite materials by Isaac M. Daniel.
8. U. C. Jindal, "Engineering Materials and Metallurgy", Pearson, 2011.

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EXPERIMENT NO. 1

1. **Name of the Experiment:** Ultimate Tensile Test

2. **Objective of the experiment:** To find out ultimate tensile stress, % elongation and % contraction in the cross section area of a given specimen.

3. **Instrument used:** Universal testing machine, Test specimen, Vernier Caliper

4. **Experimental Knowledge**
   - Function of the instruments used
   - Design principle of the instruments used
   - Calibration method of instruments used
   - Detailed hardware of the experimental set-up
   - Main element of set up , their functions, design principles and materials used
   - Basic building block of circuit on which experiment set-up is based
   - Design of experiment

5. **Methodology of experiment :**

i) Ensuring that both the ends of the test specimen is secured tight between the clamping / gripping jaws.

ii) Switch on the machine for the indicator lamp provided between the push button actuator to glow.

iii) Keep the release valve in closed position, and press the push button actuator marked ON for the hydraulic pump to activate.

iv) Make sure that the released valve & control valve are in closed position.

v) Open the control valve slightly.

vi) The pendulum dynamometer system gets activated and in turn activates the rack & pinion, thus tensile load is transmitted to the test specimen

vii) Both live & dummy pointers on the dial mechanism start moving.

viii) As the load advances slightly on the dial by the movement of the pointers ,open both the chuck levers of the grips

ix) If the breaking load of the specimen is with in the range collected, the specimen will break at its breaking load. The DUMMY Pointer will stay put at the load where the test specimen break and the LIVE Pointer will gradually recede back to zero.

x) Note down the reading of the dummy pointer.

xi) Switch off the motor by pressing the push button actuator marked "OFF" after the test specimen breaks.

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6. Observation table

i) Original diameter of specimen (d_1) = ………..mm

ii) Original cross section area of specimen = $\pi /4 \times (d_1)^2$ mm^2

iii) Original length of specimen (L) = ………………… mm

iv) Increase in length of specimen (δL) = ……… ……….mm

v) Final diameter of specimen (d_2) = ……………… mm

vi) Final cross section area of specimen = $\pi /4 \times (d_2)^2$ mm^2

Vii) Ultimate Load = ………………..kgf

7. Calculation and graph preparation

- Formula used

  i) Ultimate tensile stress = ultimate load / original area of specimen.

  ii). %elongation = ((Final - original length) /original length) x 100

  iii). % reduction in area = ((Original area -Final area at broken point)/ Original area) x100

8. Discussion of result

i) Ultimate tensile stress = …………………………..

ii) % elongation = ………………………………

iii) % reduction in area = ………………………………

9. Application of experiment result used

i) Generate a stress/strain diagram from experimental data.

ii) Use a stress/strain diagram to determine yield point, ultimate tensile strength, Young's modulus, ductility, and toughness.

iii) Spring Testing

10. Remarks

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EXPERIMENT NO. 2

1. **Name of the Experiment:** Ultimate Shear test

2. **Objective of the experiment:** To find out Ultimate Shear Stress of a given test piece.

3. **Instrument used:** Universal testing machine, Test specimen, Bushes, Test Block,Vernier Caliper

4. **Experimental Knowledge**
   - Function of the instruments used
   - Design principle of the instruments used
   - Calibration method of instruments used
   - Detailed hardware of the experimental set-up
   - Main element of set up , their functions, design principles and materials used
   - Basic building block of circuit on which experiment set-up is based
   - Design of experiment

5. **Methodology of experiment :**

i) Let us presume that 12 mm diameter test specimen is being tested for its double shear strength determination. First take all the three pieces of 12 mm set bush, of the three pieces, two pieces have collars around them whole, the third one is a plain circular block.

ii) All these 3 pieces shall have in their center a 12 mm. hole duly punched.

iii) Fix the plain circular piece in hole provided in the sliding plate of double shear block in flush.

iv) Slide the plate through the top slot of the double shear block such that the circular block coincides with the hole on either sides of the double shear block .Ensure that the test specimen protrudes at lest 2" on either sides of the double shear test block.

v) Place the double shear block holding the specimen on the bottom cross head of the loading unit and keeping the release valve in closed position , and after necessary adjustment of the middle cross head to the required height.

vi) Switch on the machine and open the control valve to allow the ram to rise and come in contact with the jutting portion of the slide plate of the double shear block.

vii) Record the reading shown by the Dummy pointer for the double shear breaking load

6. **Observation table**

   i) Original diameter of specimen (d) = ...mm

   ii) Original cross section area of specimen = $\pi /4 \times (d)^2$ mm

   iii) Ultimate Shear Load = ...kgf

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7. Calculation and graph preparation

- Formula used

  Ultimate shear stress = P/2A.

8. Discussion of result

i) Ultimate Shear stress = ...

9. Application of experiment result used

i) Riveted joint

ii) Bolted joint

iii) Punching

iv) Knuckle Joint

10.Remarks

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EXPERIMENT NO. 3

1. **Name of the Experiment:** Impact Test

2. **Objective of the experiment:** To determine the Fracture Energy required fracturing a standard Notched specimen by an Impact testing machine (IZODE TEST)

3. **Instrument used:** Impact Testing Machine, Alenkey, Spanner, Izode Striker,

4. **Experimental Knowledge**

   - Function of the instruments used
   - Design principle of the instruments used
   - Calibration method of instruments used
   - Detailed hardware of the experimental set-up
   - Main element of set up , their functions, design principles and materials used
   - Basic building block of circuit on which experiment set-up is based
   - Design of experiment

5. **Methodology of experiment :**

i) Place the machine on a solid level surface and level the machine with the sprit level.
ii) Select the test mode (IZOD) and fix the specimen on the anvil
iii) Bring pointer of the dial to read at 164 J.
iv) Ensure no person or object are in the way of the pendulum swing and release the pendulum by the hand lever provided.
v) Note the reading observed to know the Izode impact value of the test specimen
vi) The reading obtained is the direct Izod value and does not need any conversion

6. **Discussion of result**

Fracture energy required to fracture the given specimen (by Izode Test) = ______joule

7. **Application of experiment result used**
   i) Pressure Vessel design
   ii) Axle

8. **Remarks**

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EXPERIMENT NO. 4

1. **Name of the Experiment:** Rockwell Hardness Test
2. **Objective of the experiment:** - To Determine The Rockwell Hardness No of a given Specimen
3. **Instrument used:** Rock Well Hardness, Testing Machine, Specimen, Allen Key, Indenter (Diamond & Ball Type)
4. **Experimental Knowledge**

   - Function of the instruments used
   - Design principle of the instruments used
   - Calibration method of instruments used
   - Detailed hardware of the experimental set-up
   - Main element of set up , their functions, design principles and materials used
   - Basic building block of circuit on which experiment set-up is based
   - Design of experiment

5. **Methodology of experiment :**

i) Place the required weights on the dashpot lever.
ii) Place the specimen to be tested securely on testing table.
iii) Select and fix the indentor diamond or ball depending upon the test scale and load applied (weight fixed).
iv) Ensuring that the needle (pointer) of the dial gauge is at '0' or at '80' bring the specimen into contact with the indentor by rotating the elevating screw in clock–wise direction until the small needle of dial gauge reaches the mark '2'. This also causes the application of minor 10kg load.
v) Turn the hand lever away from the operator thereby loading the specimen for major load.
vi) Watch the pointer till it comes to rest
vii) Move the hand lever back to its original position to ensure that the specimen under test is only under the initial 10 kg. Load.
viii) Now read the 'ROCKWELL HARDNESS NUMBER' shown by the large pointer.

6. **Discussion of result**

Rockwell Hardness of a given specimen =

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7. Application of experiment result used

i) Cam shaft
ii) Gears
iii) Cutting Tools

8. Remarks

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EXPERIMENT NO. 5

1. **Name of the experiment:** Vickers Hardness Test

2. **Objective of the experiment:** To determine the Vickers hardness no (VHN) or diamond pyramid hardness no (DPN) of a given specimen.

3. **Instrument used:** Computerized Vickers Hardness Tester, Indenter (Square Based Diamond Pyramid), Specimen.

4. **Experimental Knowledge**
   - Function of the instruments used
   - Design principle of the instruments used
   - Calibration method of instruments used
   - Detailed hardware of the experimental set-up
   - Main element of set up , their functions, design principles and materials used
   - Basic building block of circuit on which experiment set-up is based
   - Design of experiment

5. **Methodology of experiment:**
   i. Select the weights accordingly to the expected hardness of specimen to be tested by turning the 'Weight Selection Knob".
   ii. Place specimen securely on testing table.
   iii. Turn the hand wheel clockwise slowly so that specimen will get focused on monitor sharply. At this stage a gap of about 0.2 to 0.25 mm expected between tip of Diamond Indentor and top face of specimen.
   iv. Press start button. The loading cycle start gradually thro a gear motor provided with a drive cam. The loading /Dwell/Unloading cycle is fully automatic.
   v. Index Indentor head to the next position so that objective of the optical system will be exactly over the indentation.
   vi. Make the machine is in Enable auto mode by clicking the mouse of the button or right vertical tool bar. First hardness reading will automatically display on the monitor when objective is brought on the indentation.
   vii. To have next test change the position of the specimen where hardness is to be checked. Verify from the monitor live processes image that there is no earlier indentation near about expected new indentation. Index the head to original position and bring back indentor on specimen. Repeat operation

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6. Discussion of result

Vickers Hardness No (VHN) of a given specimen =

7. Application of experiment result used

i) Hardness inspection of Cam shaft
ii) Hardness inspection of Gears
iii) Hardness inspection of Cutting Tools

8. Remarks

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EXPERIMENT NO. 6

1. **Name of the Experiment:** Spring Test

2. **Objective of the experiment:** To determine the stiffness of spring and modulus of rigidity of the spring wire (Compression Test/Tensile test).

3. **Instrument used:** Spring Testing machine (hand operated or motorized), closely coiled helical springs: tension & compression types, Micrometer Vernier Calipers.

4. **Experimental Knowledge**
   - Function of the instruments used
   - Design principle of the instruments used
   - Calibration method of instruments used
   - Detailed hardware of the experimental set-up
   - Main element of set up , their functions, design principles and materials used
   - Basic building block of circuit on which experiment set-up is based
   - Design of experiment

5. **Methodology of experiment :**

i) By using the micrometer measure the diameter of the wire of the spring

ii) By using the venire caliper measure the diameter of spring coil.

iii) Count the number of turns.

iv) Insert the spring in the spring testing machine and load the spring by a suitable weight and note the corresponding axial deflection in tension or compression.

v) Increase the load and take the corresponding axial deflection reading.

vi) Plot a curve between load and deflection. The shape of the curve gives the stiffness of spring.

6. **Observation table**

Least count of microscope = ...mm

Diameter of spring of wire, d= .... mm

(Mean of three reading)

Least count of vernier caliper =.........................mm

Diameter of the spring coil, D = ...mm

(Mean of three readings)

Mean coil diameter, Dm = D-d ....mm

Number of Turns n=

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S .No	Load W (N)	Deflection δ (mm)	Stiffness K= W /δ(N/mm)
1 .			
2 .			
3 .			
4 .			
5 .			

7. Calculation and graph preparation

- Formula used

i) Spring stiffness $K = W/\delta$

ii) $\delta = \frac{8W\,Dm^3 n}{Cd^4}$

iii) Spring index $= \frac{Dm}{d}$

8. Discussion of result

i) Spring stiffness K = …………………………..

ii) Modulus of rigidity of the spring wire = ………………………………

9. Application of experiment result used

i) Shock absorber

ii) Spring Balance

10.Remarks

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EXPERIMENT NO. 7

1. **Name of the Experiment:** Deflection Test or Bending Test

2. **Objective of the experiment:** To conduct the deflection test on mild steel beam to determine,

   i) Stress at limit of proportionality.
   ii) Bending stress at ultimate load of ultimate stress.
   iii) Modulus of elasticity.

3. **Instrument used:** UTM, Scale.

4. **Experimental Knowledge**
   - Function of the instruments used
   - Design principle of the instruments used
   - Calibration method of instruments used
   - Detailed hardware of the experimental set-up
   - Main element of set up , their functions, design principles and materials used
   - Basic building block of circuit on which experiment set-up is based
   - Design of experiment

5. **Methodology of experiment :**

i) To begin with, the dimensions of the specimen are measured.
ii) Place the specimen on the bending dogs of the UTM. The bending dogs should be equally spaced with respect to center and effective span of the beam is noted.
iii) The load is applied gradually at the center by ram and corresponding deflection is noted on the straining unit of the UTM.
iv) A graph of load 'W' v / s 'δ' is then plotted & bending stress at limit of proportionality and ultimate load are calculated.

6. **Observation table**

   1) Length of the specimen = ------mm.
   2) Effective length = ------mm.

S.No.	Load 'W' in KN	Deflection δ
1.		
2.		
3.		

7. **Plotting of the graph: -**

   Plot the graph of W v/s δ

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8. Calculation and graph preparation When material is subjected to loading (especially along transverse axis), it undergoes certain deformation i.e., displacement of longitudinal axis in the direction of load and is called deflection. This test is carried out to know the maximum load carrying capacity of beam in transverse direction and corresponding maximum deflection under the load.

From simple bending theory

$M / I = f_b / y = E / R$

M= Maximum bending moment.

I = Moment of inertia of the section of beam

f_b = Bending stress.

y = Distance of extreme fiber from neutral axis.

E = Modulus of elasticity.

R = Radius of curvature of deflection.

The deflection for a span of longitudinal beam when subjected to concentrated load at the center is given by

$\delta = (wl^3) / 48EI$

By knowing load and corresponding deflection the modulus of elasticity can be calculated.

- **Formula used**

  Bending stress at limit of proportionality $(\sigma_{by}) = (3/2)\ (w_y\ l/bd^2)$ for rectangular c/s

  Bending stress at limit of proportionality $(\sigma_{by}) = 8w_y\ l/\pi d^3$ for circular c/s

  Bending stress at ultimate load $= (3/2)\ (w_u\ l/bd^2)$ for rectangular c/s

  Bending stress at ultimate load $= 8w_u\ l/\pi d^3$ for circular c/s

  Modulus of elasticity = (w/δ) X $(l^3/ 48\ I)$

9. Discussion of result

1) Stress at limit of proportionality (σ_{by}) = ________ N / mm^2
2) Ultimate bending stress (σ_{bu}) = _______ N / mm^2
3) Modulus of elasticity (E) = _________ N / mm^2

10. Application of experiment result used

i) Shaft
ii) Beams

11. Remarks

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EXPERIMENT NO. 8

1. **Name of the Experiment:** Torsion Test

2. **Objective of the experiment:** To determine the torsional yield strength & modulus of rigidity in torsion of the given M.S specimen.

3. **Instrument used:** Equipment: Torsion testing machine. Measuring tools: vernier calipers. Consumable: Specimen.

4. **Experimental Knowledge**
   - Function of the instruments used
   - Design principle of the instruments used
   - Calibration method of instruments used
   - Detailed hardware of the experimental set-up
   - Main element of set up , their functions, design principles and materials used
   - Basic building block of circuit on which experiment set-up is based
   - Design of experiment

5. **Methodology of experiment :**
   i. The diameter & length of the specimen are measured. The diameter is measured at various sections and average diameter is found.
   ii. The specimen is fixed between the grips of the machine.
   iii. The torque is applied initially by hand up to an angle of twist of 1^0.Torque is recorded at an interval of 1^0 to 3^0.
   iv. From the experimental value of torque& the angle of twist, plot the graph of T v/s θ.

6. **Observation table**
   1. Average diameter of the specimen = d = ------mm ($d_1+d_2+d_3/3$)
   2. Gauge length of the specimen = L = --------mm.

S. No.	Torque	"θ"In degrees	"θ"In Radians
1			
2			
3			

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7. Calculation and graph preparation

- Formula used

  a) Torsional yield strength (fsy) = $16\ Ty/\pi d3$=------- N/mm^2

  b) Shear stress at ultimate torque = $16\ Tu/\pi d3$= ------N/mm^2

  c) Modulus of rigidity (C) = (T/θ) graph X (L/J)= ------N/mm^2

- Plotting of the graph

  Plot the graph of torque versus angle of twist, ie, **T** v/s θ

8. Discussion of result

a) Torsional yield strength (fsy) = ___________N/mm^2

b) Shear stress at ultimate torque = __________N/mm^2

c) Modulus of rigidity (C) = ___________N/mm^2

9. Application of experiment result used

a) Rotating shaft

b) Clocks: Torsion springs are used in torsion pendulum

10. Remarks

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EXPERIMENT NO. 9

1. **Name of the Experiment:** plastic mould Preparation.
2. **Objective of the experiment:** To prepare plastic mould for small metallic specimen.
3. **Instrument used:** - A specimen, mounting press, bakelite powder as the raw material and one pair of asbestos hand gloves to hold the hot specimen.
4. **Experimental Knowledge**
    - Function of the instruments used
    - Design principle of the instruments used
    - Calibration method of instruments used
    - Detailed hardware of the experimental set-up
    - Main element of set up , their functions, design principles and materials used
    - Basic building block of circuit on which experiment set-up is based
    - Design of experiment

5. **Methodology of experiment :**

i) First we will lift the ram with the help of hydraulic pressure.
ii) Then put the specimen on the ram.
iii) Now release the hydraulic pressure to come back the ram to its original position.
iv) Near about one & half spoon bakelite powder will be poured in the die.
v) Then the small cylindrical piece will be put on the bakelite powder in the die and die assembly will be closed now.
vi) Then maintain the temp of near about 75 °C to 80 °C for one minute & during this operation we will also apply the hydraulic pressure (2000 ibs /sq inch
vii) After some time the specimen will fix in the bakelite powder & take it out with help of high pressure

6. **Discussion of result** ....
7. **Application of experiment result used**
    i) Material testing
    ii) Microstructure
8. **Remarks**

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EXPERIMENT NO. 10

1. **Name of the Experiment:** Micro structural examination
2. **Objective of the experiment:** To prepare a specimen for micro structural examination cutting, grinding, polishing, and etching.
3. **Instrument used:** Polishing machine, alumina powder, diamond powder Water, aluminum or any other metallic/alloy specimen, etchant
4. **Experimental Knowledge**
    - Function of the instruments used
    - Design principle of the instruments used
    - Calibration method of instruments used
    - Detailed hardware of the experimental set-up
    - Main element of set up , their functions, design principles and materials used
    - Basic building block of circuit on which experiment set-up is based
    - Design of experiment

i) **<u>ROUGH GRINDING:</u>** Emery paper used in the preparation of metallographic specimen must be of high quality. Particularly with respect to size uniformity of the emery particles many excellent paper of this kind are available. such as French, Hubert he her mapping, Maxine and electrocute paper, all of which have been found satisfactory for metallographic purpose. Grinding is done by emery papers of suitable grade viz. ranging in between 100 to 600 grits.It is always desirable to use a new emery paper of appropriate grade for each specimen undergoing preparation. A paper that has been for example, in the preparation of a steel specimen many have embedded on its surface sufficiently hard debris to cause coarse and deep scratches on the surface of a softer specimen such as brass, during subsequent grinding.

ii) **<u>FINE GRINDING:</u>** During grinding on each successive paper the specimen is held as described for intermediate grinding with newly formed scratch at right angle to those which were introduced on the preceding paper. A change from one paper to another or from the last paper to the lapping wheel requires in keeping with good technique a thorough washing of the specimen in running water. If upon visual examination the surface of the specimen appears to contain more or less uniform scratches from the fine grinding operation and if the coarser scratches from the intermediate grinding operation have been completely removed the specimen is then ready for the fine and final polishing operation.

iii) **POLISHING:** Fine polishing of a metallographic specimen is for the purpose of removing scratch from the surface of the specimen ,the fine scratches introduced during the last grinding operation and ultimately producing a highly polished scratch free surface .

iv) **METALLOGRAPHIC POLISHING UNITS: -** Preliminary and final polishing operation on ground metallographic specimen are performed on or more polishing wheel or laps. Such laps are essentially brass or bronze disks 8 to 10 inch are covered with an appropriate grade of polishing cloth. The wheel are generally rotated in a horizontal plane are usually individually motor driven to facilitate control. Plane and adjustment of rotational speed when such change are necessary The design of modern polishing unit permit their use on a bench top or they may be flush mounted in to table top. As illustrated to convenient and permanent polishing arrangement.

v) **ETCHING:** Etching is done by immersing a specimen in an etchant.Etching should be done for 15 to 30 seconds

5. Methodology of experiment :

i) We will take the specimen and rub it on emery paper from coarse to fine & remove the scratches.

ii) Then we will rub it against rotating disc on polishing machine. Then we will obtain a mirror like surface.

iii) After that we will do etching and see the structure with help of microscope.

6. Observation table

Note down the grade of emery paper used, polishing compound used and etching time

- Grades of emery paper : ________________________________
- Polishing compound: for (i) Rough polishing_______________

  (ii)Fine polishing______
- Etching time: ____________

7. Discussion of result

8. Application of experiment result used

i) Material testing

ii) Microstructure preparation

iii) Grain size no.

9. Remarks

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EXPERIMENT NO. 11

1. **Name of the Experiment:** Grain size no.
2. **Objective of the experiment:** To determine the grain size of a given specimen.
3. **Instrument used:** A polished & etched metallic specimen or an electrolytic polishing and etching system to prepare it and metallurgical microscope.
4. **Experimental Knowledge**
    - Function of the instruments used
    - Design principle of the instruments used
    - Calibration method of instruments used
    - Detailed hardware of the experimental set-up
    - Main element of set up , their functions, design principles and materials used
    - Basic building block of circuit on which experiment set-up is based
    - Design of experiment
5. **<u>THEORY:-</u>** Materials are composed of crystals or grains of various sizes. The grain sizes are specified by ASTM (American society for testing of materials) numbers such as ASTM 1, ASTM 2 --------- and ASTM 12.The grain size affect various properties of materials. ASTM grain sizes can be determined by different methods. We are determining it by comparison method.
6. **Methodology of experiment :**

i) Take a thoroughly polished and etched specimen and view it through a microscope.

ii) Observe the type of microstructure which is visible

iii) Compare it with the microstructure chart after that note the no. of grains per square inch.

7. **Observation table**

No. of grains observed per sq. inch N= _________ grains/inch^2.

ASTM no. n=______.

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8. Calculation and graph preparation

- Formula used

  No. of grains observed from chart =N

  Now $N=2^{(n-1)}$

  Where n is ASTM number of grain size

  $n=(\log N/\log 2)+1$

9. Discussion of result

The grain size no. is ASTM _______.

10. Application of experiment result used

i) Material testing
ii) Microstructure

11. Remarks

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EXPERIMENT NO. 12

1. **Name of the Experiment:** Heat Treatment experiment
2. **Objective of the experiment** To compare the hardness before & after Heat Treatment experiment
3. **Instrument used:** Electrically heated temperature controlled muffle furnace, bucket, job holding tong, mild steel/C.I specimen, Universal testing machine, and microscope.
4. **Experimental Knowledge**
   - Function of the instruments used
   - Design principle of the instruments used
   - Calibration method of instruments used
   - Detailed hardware of the experimental set-up
   - Main element of set up , their functions, design principles and materials used
   - Basic building block of circuit on which experiment set-up is based
   - Design of experiment
   - **THEORY:** Properties of metals and alloys can be changed by heat treatment processes such as tempering, annealing, normalizing and hardening. In tempering the steel is heated up to about 400 °C and slowly cooled, in annealing it is heated up to about 700 °C and slowly cooled, in normalizing it is heated between 800 °C to 1000 °C and slowly cooled but in hardening it is heated up to 800 °C and suddenly cooled.

5. **Methodology of experiment :**

i) First determine the hardness of a given specimen at room temperature and note the value of BHN,

ii) After that conduct hardening of the specimen by quenching,

iii) Heat the specimen about 800 °C to 1000 °C, maintain it at this temperature for about ten minutes,

iv) Now take it out of the furnace and suddenly dip it in the cooling bucket this is quench hardening process during which marten site will form. When the job cools take it into Universal Testing machine to determine BHN.

6. **Observation table**
   1. Calculation of BHN before heat treatment process

Load (P)= ______________ Kg

Dia of spherical ball(D)= ________________ mm

Dia of impression (d)= ________________ mm

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Brinell hardness number (BHN)= ________

2. Calculation of BHN after heat treatment process

Heating temperature =______________ °C

Quenching medium is water at room temperature

Load (P) = ______________ Kg

Dia of spherical ball(D) = ______________ mm

Dia of impression (d) = ______________ mm

Brinell hardness number (BHN) = ______________

7. Calculation and graph preparation

Brinell Hardness No .can be calculated by the following.

$$BHN = \frac{\text{Load on ball (in kgf)}}{\text{Area of a ball impression in mm}^2}$$

$$= \frac{2P}{\pi D (D- \sqrt{D^2 - d^2})}$$

Where P = Load in kgf

D = Diameter of the spherical ball in mm.

d = Diameter of the impression in mm.

8. Discussion of result

The effect of quench hardening is to increase the hardness from ________ to _______. The load applied varies from 500 kg to 3000 kg according to the material being tested .The lower values of the load are used in the testing of softer metals and alloys like brass while other values are used for testing of harder materials like steel, steel alloys and cast iron .The magnitude of BHN is indicative of the relative hardness of the material . The higher this no .the harder the material.

9. Application of experiment result used

i) Material testing

ii) Die preparation

10. Remarks

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EXPERIMENT NO. 13

1. **Name of the Experiment:** Comparative study of microstructures
2. **Objective of the experiment:** Comparative study of microstructures of different given specimens (mild steel, aluminium, brass, copper etc.).
3. **Instrument used** Microscope, properly polished and etched specimen, an air drier to dry the specimen.
4. **Experimental Knowledge**
    - Function of the instruments used
    - Design principle of the instruments used
    - Calibration method of instruments used
    - Detailed hardware of the experimental set-up
    - Main element of set up , their functions, design principles and materials used
    - Basic building block of circuit on which experiment set-up is based
    - Design of experiment
5. **THEORY: -** Levels of material structure may be both macro and micro, where as the macrostructure can be seen with a naked eye or with an optical microscope of low magnification, the microstructures can be observed with high magnification metallurgical microscopes. In this experiment we shall visualize the microstructure of the material. The difference in microstructures is due to the presence of carbon in different forms viz. ferrite, cementite, pearlite ,ludeburite etc

OPTICAL COMBINATION

Huygenian Eyepieces : 10 x & 15 x paired

Achromatic Objectives : 5 x, 10 x , 20 x & 40 x

Magnification chart: Binocular Head Magnification 1x

HUYGENIAN EYEPIECE	ACHROMATIC OBJECTIVES			
	5x	10x	20x	40x
10x	50x	100x	200x	400x
15x	75x	150x	300x	600x

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6. Methodology of experiment :

i) Remove the objective plastic cover from the objective turrect of the microscope and screw up all the objectives in anti clockwise direction while standing in front of the microscope tube.

ii) Remove the eyepiece tube caps from the microscope and insert the one pair of eye pieces

iii) Remove the metallurgical lamp cap from the microscope tube on left side fixed with a screw and insert the metallurgical lamp for the examination of opaque sample and screw it again. Plug in the cord of lamp of the transformers socket and the transformers cord to the mains socket

iv) Place the metallurgical sample which is to be tested on the mechanical stage platform for x & y movement and make it in the axis of objective and eye piece.

v) Switch on the transformer keeping the 10x objective in the alignment and the iris diaphragm of the lamp be full open , turn the beam splitter clock wise or anti clock wise as the case may be with the help of a knob with a small leaver situated just above the objectives turrect in the front side of the microscope to get the maximum circular light beam on the object . Although the knob is satisfactorily adjusted.

vi) Adjust the binocular arm to approximately the eye pupil distance .This is done by bringing the mark on the right side arm to the respective graduation on the plate found between the binocular arm .Adjust the left hand eye piece with the number of dioptress required by the left adjustment of the binocular device system to Superimpose the two images viewed through the binocular eye piece. The binocular device may be rotated around the vertical axis of the microscope.

vii) Focus the image using coarse motion only by applying torque to the knob.

viii) After a coarse focusing by the coarse motion system finish it up using the fine movement system .The right hand index marked on the one side knob for the micrometric adjustment will set at sides intervals.

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ix) The sample is firstly investigated the low magnification objectives (10x) & brought then in to the optical axis of the next objective required using the revolving head of Objective.

x) Focusing after each change of the objective is done by using the fine movement.

xi) For small and transparent sample use bottom light system instead of metallurgical Lamp light.

7. Observation table

There is no observation table we see the microstructure of the material and Compare it with a standard chart.

8. Calculation and graph preparation

9. Discussion of result

The microstructure of the material compares it with a standard chart.

10. Application of experiment result used

i) Material testing
ii) Microstructure

11. Remarks

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