JSS MAHAVIDYAPEETHA
JSS SCIENCE & TECHNOLOGY UNIVERSITY
(JSSS&TU)
FORMERLY SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING
MYSURU-570006

DEPARTMENT OF MECHANICAL ENGINEERING

Foundry and Forging Laboratory Manual
III Semester B.E. Mechanical Engineering

USN :_____

Name:_____

Roll No: _____ **Sem** _____ **Sec** _____

Course Name _____

Course Code _____

DEPARTMENT OF MECHANICAL ENGINEERING

VISION OF THE DEPARTMENT

Department of mechanical engineering is committed to prepare graduates, post graduates and research scholars by providing them the best outcome based teaching-learning experience and scholarship enriched with professional ethics.

MISSION OF THE DEPARTMENT

M-1: Prepare globally acceptable graduates, post graduates and research scholars for their lifelong learning in Mechanical Engineering, Maintenance Engineering and Engineering Management.

M-2: Develop futuristic perspective in Research towards Science, Mechanical Engineering Maintenance Engineering and Engineering Management.

M-3: Establish collaborations with Industrial and Research organizations to form strategic and meaningful partnerships.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1 Apply modern tools and skills in design and manufacturing to solve real world problems.

PSO2 Apply managerial concepts and principles of management and drive global economic growth.

PSO3 Apply thermal, fluid and materials fundamental knowledge and solve problem concerning environmental issues.

PROGRAM EDUCATIONAL OBJECTIVES (PEOS)

PEO1: To apply industrial manufacturing design system tools and necessary skills in the field of mechanical engineering in solving problems of the society.

PEO2: To apply principles of management and managerial concepts to enhance global economic growth.

PEO3: To apply thermal, fluid and materials engineering concepts in solving problems concerning environmental pollution and fossil fuel depletion and work towards alternatives.

PROGRAM OUTCOMES (POS)

PO1 **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2 **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3 **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4 **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5 **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6 **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7 **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8 **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9 **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10 **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11 **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12 **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

FOUNDRY AND FORGING LABORATORY

Subject Code	:ME37L	No. of Credits	: 0 – 0-1.5
No. of Practical Hours / Week	: 03	Exam Hours	:03
Total No. of Lecture/Practical Hours	: 48	Exam Marks	:50

COURSE OBJECTIVE:

1. **To provide students with the knowledge and necessary skills to perform sand testing and preparation ofmoulds.**

2. **To provide students with the knowledge and necessary skills to perform metal forging operations and sheet metalwork.**

COURSE CONTENT

UNIT-1

Testing of Moulding sand and Core sand

Preparation of sand specimen's and conduction of the following tests:
1. Compression, Shear and Tensile tests on Universal Sand TestingMachine.
2. Permeabilitytest
3. Core hardness &Mould hardnesstests.
4. Sieve Analysis to find Grain Fineness number of BaseSand
5. Clay content determinations in BaseSand

Foundry Practice

Use of foundry tools and equipment. Preparation of moulds using two moulding boxes using patterns or without patterns. (Split pattern, Match plate pattern and Core boxes). Preparation of one casting (Aluminum or cast iron-Demonstrationonly)

24 Hours

UNIT-2

Forging Operations:

1. Calculation of length of the raw material required to do themodel.
2. Preparing minimum three forged models involving upsetting, drawing and bending operations.
3. Out of these three models, at least one model is to be prepared by using PowerHammer.

Sheet Metal Work:

Preparation of four models involving development of surfaces of regular solids, transition pieces and trays

24 Hours

COURSE OUTCOMES

Upon completion of this course, students should be able to:

CO1   **Demonstrate the knowledge and necessary skills to perform sand testing and preparation of moulds.**

CO2   **Demonstrate the knowledge and necessary skills to perform metal forging operation and sheet metal work.**

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Department of Mechanical Engineering

<u>LABORATORY SAFETY PRECAUTIONS</u>

1. Laboratory uniform, shoes & safety glasses are compulsory in thelab.

2. Do not touch anything with which you are not completely familiar. Carelessness may not only break the valuable equipment in the lab but may also cause serious injury to you and others in thelab.

3. Please follow instructions precisely as instructed by your supervisor. Do not start the experiment unless your setup is verified & approved by yoursupervisor.

4. Do not leave the experiments unattended while inprogress.

5. Do not crowd around the equipment's& run inside thelaboratory.

6. During experiments material may fail and disperse, please wear safety glasses andmaintain a safe distance from theexperiment.

7. If any part of the equipment fails while being used, report it immediately to your supervisor. Never try to fix the problem yourself because you could further damage the equipment and harm yourself and others in thelab.

8. Keep the work area clear of all materials except those needed for your work and cleanup after yourwork.

<u>'Instructions to the Candidates'</u>

1. Students should come with thorough preparation for the experiment to beconducted.

2. Students will not be permitted to attend the laboratory unless they bring the practical record fully completed in all respects pertaining to the experiment conducted in the previousclass.

3. Experiment should be started only after the staff-in-charge has checked the experimental setup.

4. All the calculations should be made in the observation book. Specimen calculations for one set of readings have to be shown in the practicalrecord.

5. Wherever graphs are to be drawn, A-4 size graphs only should be used and the same should be firmly attached to the practicalrecord.

6. Practical record should be neatlymaintained.

7. They should obtain the signature of the staff-in-charge in the observation book after completing eachexperiment.

8. Theory regarding each experiment should be written in the practical record before procedure in your ownwords.

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Department of Mechanical Engineering

<u>CONTENTS</u>

UNIT - 1

TESTING OF MOULD SAND AND CORE SAND

PROPERTIES OF MOULDING SAND

Good moulding sand must possess the following properties. The properties are determined by the amount of clay, moisture content and by the shape and size of the silica grain in the sand.

PERMEABILITY:

It is the ability of sand to allow the gasses to escape from the mould.

COHESIVENESS OR STRENGTH:

This is the ability of sand particles to stick together. Insufficient strength may lead to a collapse in the mould or its partial destruction during conveying turning over orclosing.

ADHESIVENESS:

The sand particles must be capable of adhering to another body, i.e, they should cling to the sides of the moulding boxes.

PLASTICITY:

It is the property to retain it shape when the pressure of the pattern is removed.

REFRACTORINESS:

The sand must be capable of withstanding the high temperature of the molten metal without fusing.

BINDING:

Binder allows sand to flow to take up pattern shape.

CHEMICAL RESISTIVITY:

Moulding sand should not chemically react or combine with molten metal so that it can be used again and again.

FLOWBILITY:

It is the ability of sand to take up the desired shape.

SAND TESTING EXPERIMENTS

Periodic test is necessary to determine the essential qualities of foundry sand.

The most important tests to be conducted for any foundry sand are as follows.

1. Compression, shear and tensile strength test on universal sand testingmachine.

Purpose:

  i) Moulding sand must have good strength otherwise it may lead to collapse ofmould.

  ii) It must be retained when the molten metal enters the mould (bond strength)

  iii) To retain its shape when the patter is removed and movement of themould.

2. **Permeabilitytest.**
   It is the property of moulding sand which allows gases to pass through easily in the mould.

3. **Core and mould hardnesstest.**
   The hardness test is useful to find out the moulds surface uniformly.

4. **Sieve analysis to find the grain fineness number of basesand.**
   To find the average grain fineness number for the selection of fine, medium, and course sand.

5. **Clay content determination in basesand.**
   It is to find the % of the clay content in the base sand.

ExperimentNo.1   **Date:**

COMPRESSION STRENGTH TEST FOR MOULDING SAND

AIM: To find the green compression strength of the given specimen at different percentage of clay and moisture

Materials used: Base sand, clay, water,

Apparatus used: Sand Ramming machine (Rammer) with specimen tube with base, stripper, universal sand testing machine with Compression shackles, weighing pan, measuring jar, steel scale, Electronic weighing scale.

Theory:

1. Periodic tests are necessary to check the quality of foundry sand and compression strength test is one amongthem.
2. The constituents of moulding sand are silica sand, clay, water and other specialadditives.
3. Clay imparts the necessary bonding strength to the moulding sand when it is mixed with water etc.bentonite.
4. Compression test determines the bonding or adhesiveness power of various bonding materials in greensand.
5. The green compressive strength of foundry sand is the maximum compression strength a mixture is capable of developing when it is in mostcondition.

Procedure:

1. Conduct the experiment in twoparts:
   - a) Vary the clay content keeping the water contentconstant
   - b) Vary the water content keeping the clay contentconstant
2. Take weighed proportions of sand and clay and dry mix themtogether
    in a Muller for 3minutes.
3. Adjust the weight of the sand to get standardspecimen
4. Remove the standard specimen by the stripper and place it between shackles which are fixed in the sand testingmachine.
5. Rotate the handle of the testing machine to actuate the ram. Thus, hydraulic pressure is applied continuously till the specimenraptures.
6. Read the compression strength from the gauge and record thesame.
7. Conduct the experiment for the above said two cases and tabulate theresult.

Result and discussion

Plot the graphs with compression strength on y-axis & percentage clay on x-axis and the other with compression strength on y-axis v/s percentage water on x-axis.

Discuss the result with respect to the variation of percentage of clay on compression strength and percentage of water on compression strength.

TABULAR COLUMN

VARYING THE % OF CLAY

Sl. No.	Percentage of sand	Percentage of clay	Percentage of water	Compression Strength gm/cm^2
1				
2				
3				

VARYING THE % OF WATER

Sl. No.	Percentage of sand	Percentage of clay	Percentage of water	Compression Strength gm/cm^2
1				
2				
3				

Fig 1.1 Universal Strength Machine
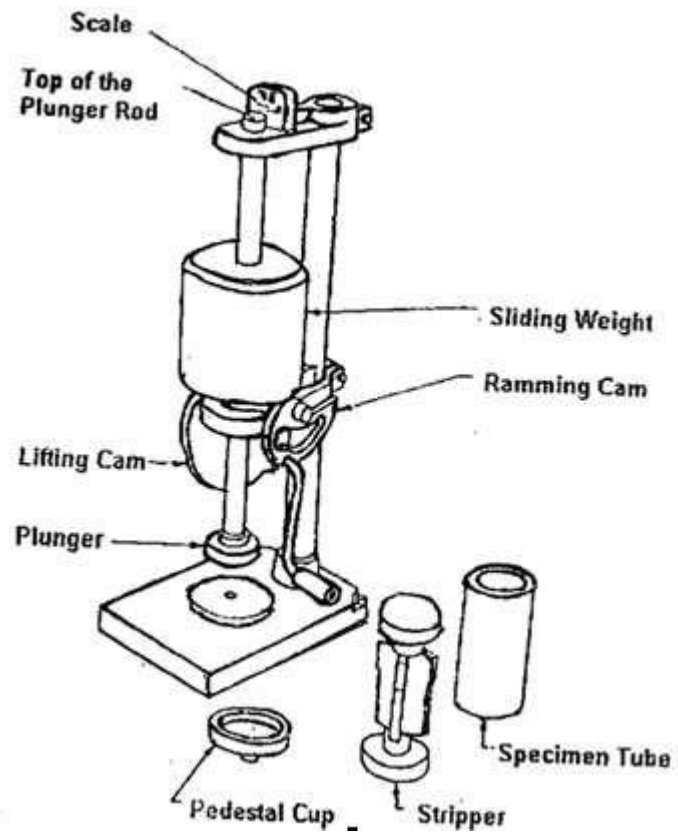
Fig 1.2 Sand Rammer

Date…………….   **Signature of theFaculty**

SHEAR STRENGTH TEST FOR MOULDING SAND

AIM: To determine the green shear strength of the given specimen for different percentages of clay and moisture.

Materials used: Base sand, clay, water.

Apparatus used: Sand ramming machine (rammer), universal sand testing machine with attachments, weighing pan.

Theory:

1. Shear strength is the ability of sand particles to resist the shear stress and to stick together.
2. Insufficient Shear strength may lead to the collapsing of sand in the mould or its partial destruction during handling. The mould and core may also be damaged during flow of molten metal in the mouldcavity.
3. The moulding sand must possess sufficient strength to permit the mould to be formed to the desired shape and to retain the shape even after the hot metal is poured into the mould cavity.
4. In shearing, the rupture occurs parallel to the axis of thespecimen.

Procedure:

1. Conduct the experiment in twoparts:

    a) Vary the clay content keeping the water contentconstant
    b) Vary the water content keeping the clay contentconstant
2. Take weighed amount of foundry sand (mixture of sand, clay & water asspecified).

3. Transfer the sand mixture into the tube and ram it with the help of a sand rammerthrice.

4. Fix the shackles to the universal sand testingmachine.

5. Remove the specimen from the tube with the help of a stripper and load it into the universal sand testingmachine.

6. Apply the hydraulic pressure by rotating the handle of the universal sand testing machine continuously until the specimenruptures.

7. Read the shear strength directly from the scale and tabulate thereadings.

TABULAR COLUMN

VARYING THE % OF CLAY

Sl. No.	Percentage of sand	Percentage of clay	Percentage of water	Compression Strength gm/cm^2
1				
2				
3				

VARYING THE % OF WATER

Sl. No.	Percentage of sand	Percentage of clay	Percentage of water	Compression Strength gm/cm^2
1				
2				
3				

Graphs:

a) Shear strength (Y-axis) V/s Percentage of clay(X-axis).
b) Shear strength (Y-axis) V/s Percentage of water(X-axis).

Results and Discussions:

The Graphs above reveal:

a) With the increase in the percentage of water the shear strength of the specimen……………………………….

b) With the increase in the percentage of clay the shear strength of thespecimen…………………………….

Shear Strength Attachment
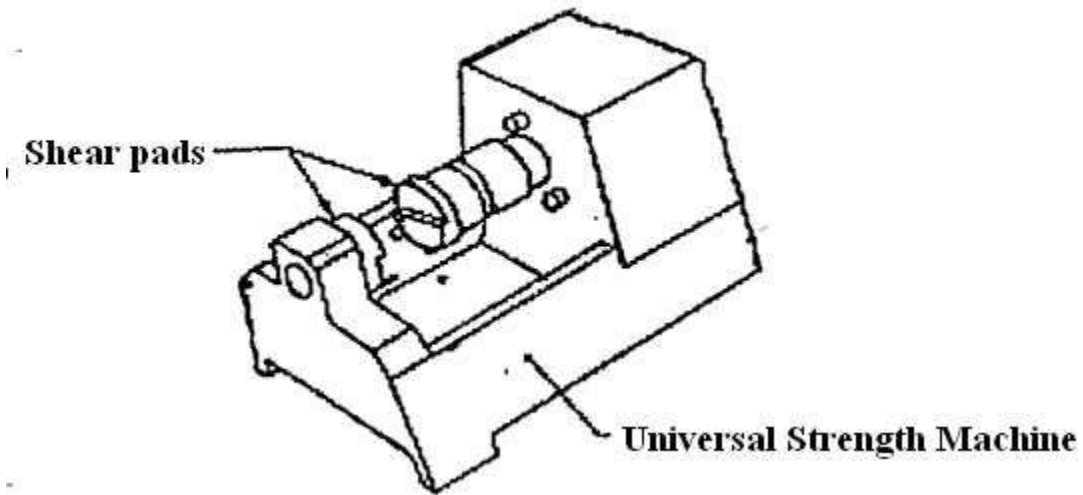
Fig. 2.1 Shear Strength Attachment

Date……………. **Signature of theFaculty**

TENSILE STRENGTH TEST OF CORE SAND

AIM: To determine the tensile strength of sand using two types of binders Viz. core oil binder and sodium silicate binder.

Materials used: Base sand, core oil, sodium silicate.

Apparatus used: universal sand testing machine, Split core box, Sand rammer, oven, tension shackles.

Theory:

1. A core is compacted sand mass of a knownshape.

2. When a hallow casting (to have a hole – through or bind) is required, a core is used in the mould or when a complex contour is required a mould is created out of cores. This core has to be properly seated in the mould on formed impressions in the sand. To form these impressions extra projections called core points are added on the pattern surface at proper places.

3. Core boxes are used for making cores. They are either made single or in two parts. Their classification is generally according to the shape of the core or the method of making the core.

4. Split core box is very widely used and is made in two parts, which can be joined together by means of dowels to form the complete cavity for making thecore.

5. The purpose of adding binder to the moulding sand is to impart strength and cohesiveness to the sand to enable it to retain its shape after the core has beenrammed.

6. Binders usedcanbe   a) Organic: ex. Dextrin, Coreoil

                               b) Inorganic: ex. Sodium silicate, Bentonite

7. Classification ofbinders:

   a. Baking type: Binding action is realized in the sandafter baking the sand mixture in anoven.

b. Gassing type: Binding action is obtained in the sand after passing a known gas through the sand mixture.

Ex. CO_2 gas passed through a mixture of sand and sodium silicate.

8. Core oil is used as binder that hardens with the addition of heat. The sand and binder are mixed and backed at a temperature of $250^O – 300^O$ C and binding action takes place within fewhours.
9. Sodium silicate is a self-setting binder and no external heat is required for the binding action which takes place at room temperature when CO_2 gas ispassed.
10. Duringcastingthecoreisplacedinsidethemouldandthemoltenmetalispouredinto the cavity. As the molten metal begins to cool, it begins to contract on the inner radius as well as the outer radius. Due to the contraction of the inner radius the core sand will be pulled outwards causing a tensile load around the core. Hence knowledge of tensile strength of core sand is important.

Procedure:

1. Conduct the experiment in twoparts.

a. Using core oil as binderand

b. Using sodium silicate asbinder.

2. Take proper proportions of base sand and binder then mix them togetherthoroughly.

3. Assembly the core box and fill the mixture intoit.

4. Place the core box under sand rammer and ram the sandthrice.

5. Using a wooden piece tap the core box gently from sides. Remove the core box leavingthe rammed core on a flat metal plate

6. Bake the specimen (which is on a plate) for about 30 minutes at a temperature of $150^O –$ 200° C in an oven. (When the binder is core oil)

7. If the binder is sodium silicate, pass CO_2 gas for 5 secs. The core hardens instantly and the core can be directlyused.

8. Fix the tension shackles on to the sand testing machine, and place the hardened specimen

in theshackles.

9. Apply the load gradually by turning the hand wheel of the testing machine. Note down the readings when the specimen breaks.

10. Repeat the procedure for the different percentage of binder and tabulate thereadings.

TABULAR COLUMN

Sl. No.	Percentage of sand	Percentage of Sodium Silicate or core oil	Tensile strengthN/m^2	
1				
2				
3				
4				
5				
6				

Result and discussion:

Plot the graph of tensile strength on y-axis and binder on x-axis. Discuss the effect of variation of binder content on tensile strength.

Figures to be drawn:

1) Split core box for tensile specimen(Fig. 3.1)

2) Tensile stress on core(Fig. 3.2 a and Fig.3.2 b)

3) Dimensions of standard tensile specimen(Fig.3.3)

4) Tensile test shackles(Fig. 3.4)

Fig. 3.3 Dimensions of standard tensile

Fig. 3.1 Split core box (Tension)
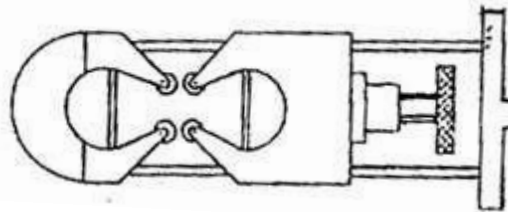
Fig. 3.4 Tensile test shackles
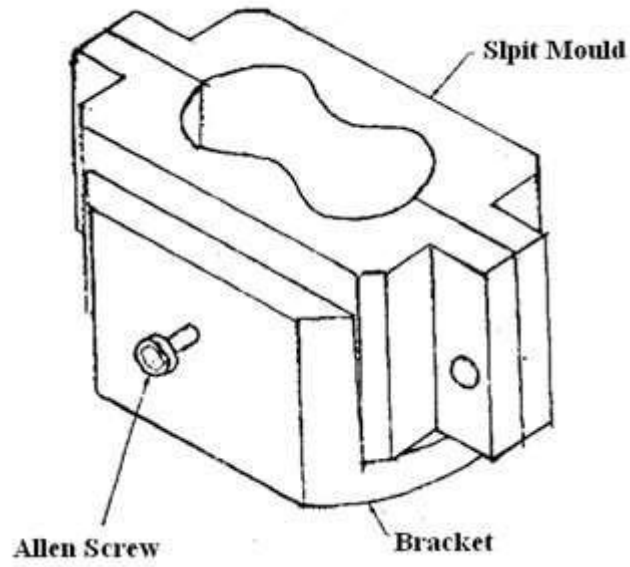
Fig. 3.2 a: Tensile Core Box
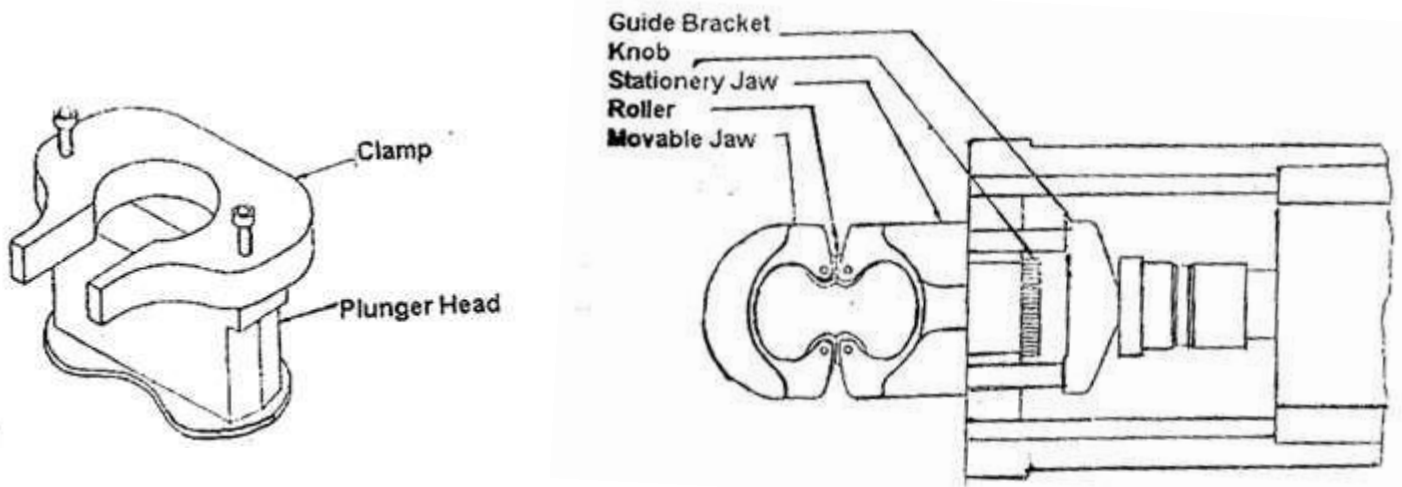
Fig. 3.2 b: Tensile strength attachment

Date…………….   **Signature of theFaculty**

ExperimentNo.4   **Date:**

PERMEABILITY TEST

AIM: To find the effect of water content, clay content on green permeability of foundry sand.

Materials used: Base sand, clay and water.

Apparatus used: Sand rammer, Permeability meter, Electronic weighing scale, stripper, stop watch, measuring jar, specimen tube, specimen tube cup.

Theory:

1. Molten metals always contain certain amount of dissolved gases, which are evolved when the metal startsfreezing.

2. When molten metal comes in contact with moist sand, generates steam or watervapour.

3. Gases and water vapour are released in the mould cavity by the molten metal and sand. If they do not find opportunity to escape completely through the mould, they will get entrapped and form gas holes or pores in the casting. The sand must therefore be sufficiently porous to allow the gases and water vapour to escape out. This property of sand is referred to aspermeability.

4. Permeability is one of the most important properties affecting the characteristic of moulds which depends upon the grain size, grain shape, grain distribution, binder content, moisture level and degree ofcompactness.

5. Permeability is a physical property of the physical sand mixture, which allows gases to pass through iteasily.

6. The AFS (American Foundry Men Society) definition of permeability is "the number obtained by passing 2000cc of air through a standard specimen under a pressure of 10 gm/cm^2 for a given time inminutes".

7. The permeability number P_N can be found out by theequation

$$P_N = \frac{(VH)}{(PAT)}$$

Where

V = Volume of air passing through the specimen, 2000cc

H = Height of the specimen = 50.8 mm (standard value)

P = Pressure as read from the manometer in gm/cm^2

A = Area of the specimen = $\pi d^2/4$

Where d = 50.8 mm (standard value)

T= time in minutes for 2000 cc of air passed through the sand specimen.

Experimental setup details:

Permeability meter has a cylindrical water tank in which an air tank is floating. By properly opening the valve, air from the air tank can be made to flow through the sand specimen and a back pressure is setup. The pressure of this air is obtained with the water manometer. The meter also contains the chart, which directly gives the P_N depending on pressure.

Procedure:

1. Conduct the experiment in two parts. In the first case vary water percent keeping clay percent constant. In the second case vary clay percent and keep water percentconstant.

2. Take weighed proportions of sand dry mix them together for 3 minutes. Then add required proportions of water and wet mix for another 2 minutes, to get a homogeneous and mixture. Take the total weight of the mixture between 150-200 grams. The correct weight has to be determined by trial and errormethod.

3. Fill the sand mixture into the specimen tube and ram thrice using sand rammer. Use the tolerance limit provided at the top end of the rammer for checking the specimen size. If the top end of the rammer is within the tolerance limit, the correct specimen is obtained. If it lies below the limit, increase the weight of sand mixture and prepare a new specimen. The specimen conforming to within limits represent the standard specimenrequired.

4. Now the prepared standard specimen is having a dia.50.8mm and height50.8mm.

5. Place the standard specimen along with the tube in the inverted position on the rubber seal or on the mercury cup (specimen in the top position in the manometerreading).

6. Operate the valve and start the stop watch simultaneously. When the zero mark on the inverted jar just touches the top of water tank, note down the manometerreading.

7. Note down the time required to pass 2000cc of air through the specimen. Calculate the permeability number by using the formulagiven.

Direct scale reading:

The permeability can also be determined by making use of the graduated marker provided near the manometer.

Procedure to be followed:

- Coincide the graduations on the transparent scale with the meniscus of themanometer liquid.
- Note the reading of thescale.
- This reading represents the permeability number of thesand.

TABULAR COLUMN

Varying the percentage of Clay and keeping percentage of Water constant. Indicate percentage of Clay (No. of arms = 3)

Sl. No.	Percentage of Clay	Pressure gm/cm^2	Time in min.	P_N	
				Indicated	Calculated
1					
2					
3					

Varying the percentage of water and keeping percentage of Clay constant. Indicate percentage of Water (No. of arms = 3)

Sl. No.	Percentage of water	Pressure gm/cm^2	Time in min.	P_N	
				Indicated	Calculated
1					
2					
3					

Draw graph:

Permeability number v/s % Clay

Permeability number v/s % water

Discuss the effect of water and clay on Permeability
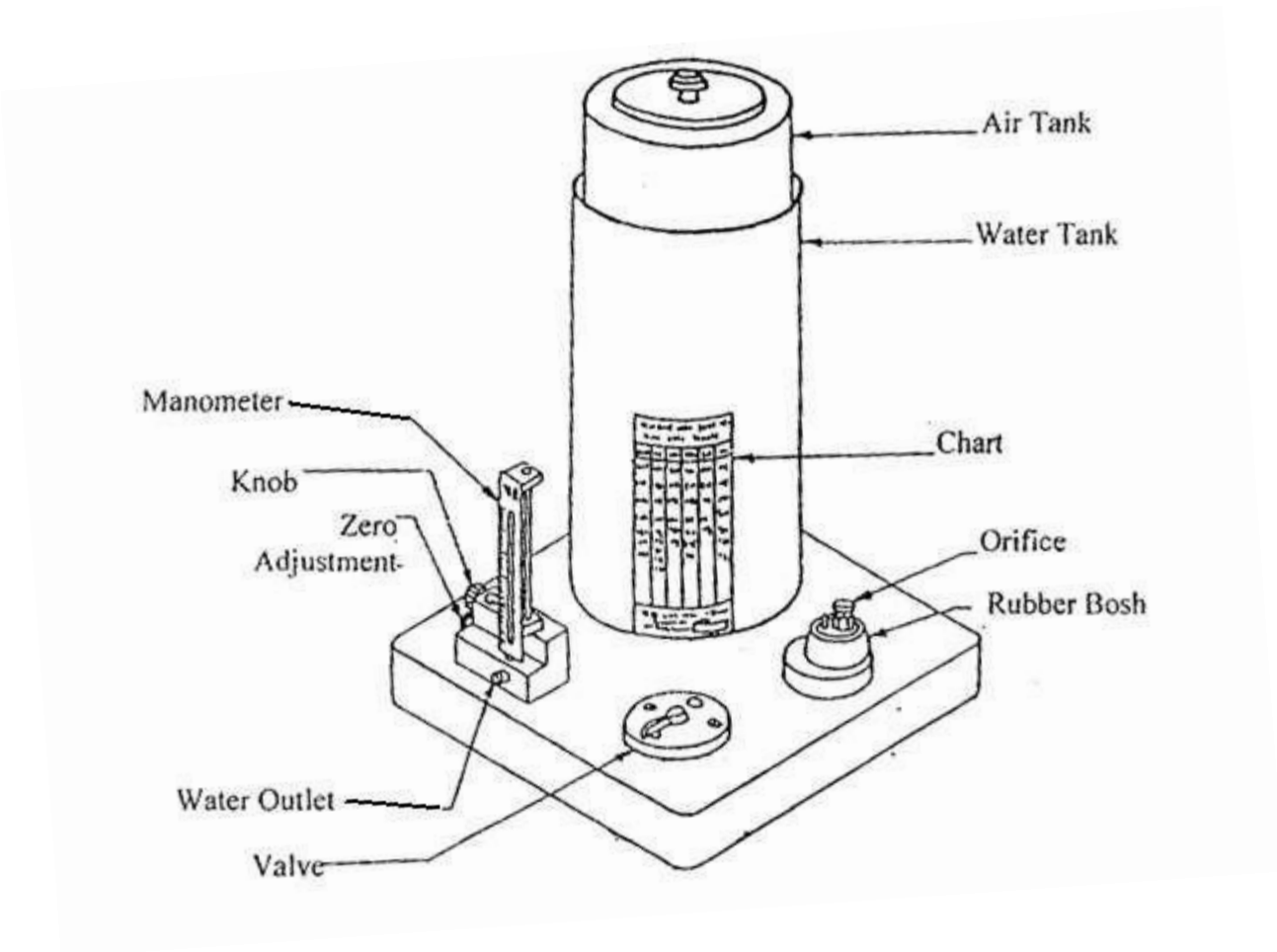
Fig. 4.1 Permeability Meter

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CORE HARDNESS AND MOULD HARDNESS TEST

Mould and core hardness can be found out by the hardness – tester which is based on the same principle as Brinell hardness tester. A steel ball of 50 mm diameter weighing 237 gm is pressed on the mould surface. The depth of penetration of steel ball will give the hardness of mould surface on the direct reading dial. This hardness test is useful in finding out the moulduniformity

The following are the moulding hardness numbers for

Moulding sand (1 number = 1/100 mm)

Soft rammed moulds = 100
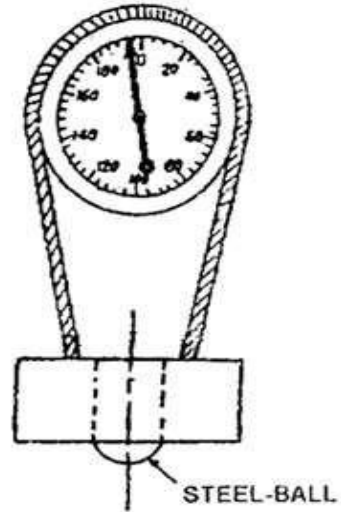
Medium rammed moulds =125   Fig. 5.1 Mould Hardness Tester

Hard rammed mould = 175

Tabular column for Core Hardness Test

Sl. No.	% of Sand	% of sodium silicate	Core Hardness Number
1			
2			
3			

Tabular column for Mould Hardness Test

Sl. No.	% of Sand	% of Water	Mould hardness Number
1			
2			
3			

Date…………….   **Signature of theFaculty**

<u>SIEVE ANALYSIS TO FIND GRAIN FINENESS NUMBER OF BASE SAND</u>

AIM: To find the distribution of sand grains using a set of sieves and to find the average grain fineness number.

Materials used: Base sand- Silica sand.

Apparatus used: Electronic weighing scale, stop watch, sieve shaker.

Theory:

1. The base sand is a mixture of grains having a variety of shapes suchas

   a) Round   b) sub-angularc)angular

       d)compoundedgrains.Base sand is relatively free from any binder

   oradditives.

2. Depending on the average size of the grains, the sand can be grouped into: a)Fine

   b) Medium and c) Coarse grains.

3. The shape and size of grains has a large influence on the permeability of sand mix as well as on the bondingaction.

4. The shape and size of grains determine the possibility of its application in various types of foundrypractice.

   > Ex: Fine grain sand results in good surface, on the casting but gases cannot escape out of the mould made from it. Coarse grain sand allows gases to escape out easily but the casting surface will be very rough. Hence grain size should select appropriately.

5. The given size of sand grains is designated by a number called grain fineness number that indicates the average size of grains in themixture.

6. The size is determined by passing the sand through sieves having specified apparatus which are measured inmicrons.

7. The sieve number designates the pore size through which the sand grains, may pass through it or retained init.

8. Average grains fineness number can be found out by theequation

$$GFN = Q/P$$

Where Q = sum of product of percentage sand retained in sieves and Corresponding multiplier.

P = sum of percentage of sand retained in sieves.

Procedure:

1. Take 50 gm or100 gm of dry sand and place in the top sieve of a series and close thelid.

2. Place the whole assembly of sieves on the vibratory sieve shaker and clampit.

3. Switch on the motor and allow the sieve assembly to vibrate for 5 minutes. Then switch off themotor.

4. Collect the sand particles retained in each of the sieve separately and weigh in Electronic weighing scale and enter into the tabular column. Calculate the percentage weight retained by each of the sieves. Multiply this value with the multiplier for eachsieve.

(Calculate the average GFN using the formula as shown below.)

Tabular Column:

Total weight of sand taken = 100g.

Sl. No.	(a) Sieve No. in microns	(b) Weight in grams		(c) % Retained	(d) Multiplying factor	(e) Product $\Sigma e = c \times d$
		Empty Sieve W_1	Sieve with sand W_2			
1	1700				5	
2	850				10	
3	600				20	
4	425				30	
5	300				40	
6	212				50	
7	150				70	
8	106				100	
9	75				140	
10	53				200	
11	Sieve pan				300	
				$P = \Sigma c$		$Q = \Sigma e$

$$\% \text{ Retained } C = \frac{\text{Weight of sand in each sieve}}{\text{Total weight of sand}} \times 100$$

Calculation: AFS grain number = Q (sum) / P (total)

Results; The average grain fineness number is =

Graph: Percentage of sand retained v/s sieve number

Knob
Clamping patti
Side flexible bar
Set of sieve
Spring
Bumper
Toggle switch
Indicator lamp
Panel
Timer
Levelling knob
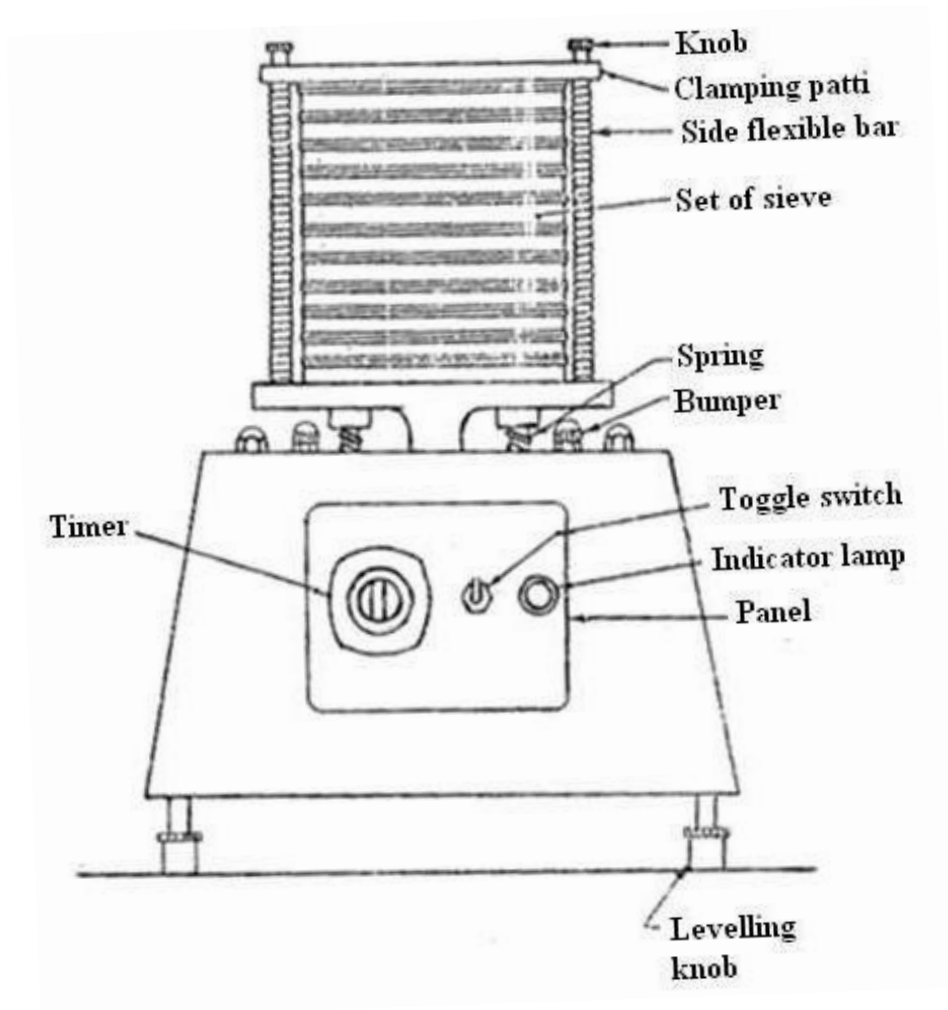
Fig. 6.1 Sieve Shaker

Date…………….   **Signature of theFaculty**

CLAY CONTENT TEST

AIM: To determine the percentage of clay present in base sand.

Materials used: Base sand, 5 % NaoH solution and water.

Apparatus used: Wash bottle, measuring jar, mechanical stirrer and siphon tube.

Theory:

1. Clay can be those particles having less than 20 microns size. Moulding sand contains 2 to 50 percent of clay. When mixed with water it imparts, binding strength andplasticity.
2. Clay consists of two ingredients a) Fine silt and b) True clay. Fine silt as no binding power where as true clay imparts the necessary boundary strength to the moulding sand; thereby the mould does not lose its shape afterramming.
3. Clay also can define as those particles which when mixed with water, agitated and then made to settled, fails to settle down at the rate of1"/mm.
4. The particles of clay are plate like from and have a very large surface area compared to its thickness and therefore have a very high affinity to absorbmoisture.
5. Clay is the main constituent in a moulding sand and mixture other than sand grains. Clay imparts binding action to the sand and hence thestrength.
6. Clay is of mineral origin available in plenty on earth. It is made of alumina silicate. The types of clay are a) montmorillonite b) Kaolinite and c) Illite the first type is generally referred to asBentonite.

Clay is the main constituent in a moulding sand mixture other than sand grain. Clay help impart binding action to the sand and hence strength to the sand.

Procedure:

1. Take 100g of base sand in a wash bottle and add 475ml of distilled water and 25ml of

   NaOH solution toit.

2. Using the mechanical stirrer, stir the mixture for about 5 minutes add distilled water to make up the level to 6"height. Stir the mixture again for 2 minutes. Now allow the content of the bottle to settledown.

3. Siphon out 5" level of unclean water using a standardsiphon.

4. Add distilled water again up to 6" height and stir the content again. Allow the mixture to settle down for5minutes.

5. Siphon out 5" level of water from the bottom of thebottle

Repeat the above procedure for 3-4times till the water becomes clear in the wash bottle.

6. Transfer the wet sand from the bottle in to a tray and dry in it in an oven at 110 $^{\circ}$ C toremove moisture. Note down the dry sand weight accurately. Using the calculations find percentage of clay.

Calculations

Weight of sand W1= 100 gm

Weight of dried sand W2 = ----------- gm

% of clay= $\dfrac{(W1-W2)X100}{100}$

Results and discussion:

The % of clay is -----------------%

Discuss whether the % of Water is present is high or low and whether this % is enough to act as binder in the sand.

Glass Jar
Fan
Toggle Switch
Timer
Indicator Lamp
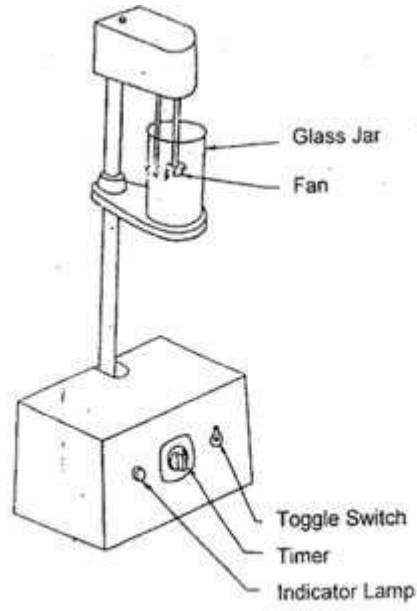
Fig 7.1 Clay Washer

Date…………….   **Signature of theFaculty**

UNIT - 1

FOUNDRY

FOUNDRY

Introduction:

Foundry is a process of shaping the metal components in their molten stage. It is the also called as metal casting the shape and size of the metal casting is obtained depends on the shape and size of the cavity produced in sand mould by using wooden/ metalpattern.

Practical application

1. Casting is the cheapest and most direct way of producing the shape of thecomponent
2. Casting is best suited to work where components required is in lowquantity.
3. Complicated shapes having internal openings and complex section variation can be produced quickly and cheaply by casting since liquid metal can flow into any form/ shape. Example: 1. Outer casing of all automobileengines.

        2. Electric motorhousing

        3. Bench vice, Irrigation pumpsetc.

4. Heavy equipment such as machine beds of lathe, milling machine, shaping, drilling plaining machine etc. can becast/easily

5. Casting is best suited for composite components

    Example.1: steel screw threads in zinc diecasting

    All conductors into slot in iron armature for electric motor.

Steps in foundry process

    The Foundry process involves three steps.

  (a) Making the requiredpattern
  (b) Moulding process to produce the cavity in sand usingpattern.
  (c) Pouring the molten metal into the cavity to getcasting.

Classification of foundries;

- Steel foundry
- C.Ifoundry
- Light alloyfoundry
- Brass foundry
- Shell mouldingfoundry
- Die casting foundry (using permanent metal or dies for high volume of low and pressure die)

Pattern:

A pattern is normally a wooden/ metal model or thermosetting plastic which is facsimile of the cast product to be made, there are many types of pattern and are either one piece, two piece or three piece, split pattern, loose piece pattern, Gated and match plate pattern etc.

Pattern size: Actual casting size +shrinkage allowance +shake allowance +finish allowance

1. Shrinkage allowance: The liquid metal shrinks during solidification and it contraction to its room temperature, so that the pattern must be made larger then the casting to provide for total contraction.

2. Finishing allowance: The casting is to be machined at some points then the casting should be provided with excess metal formachining.

Types of foundry sand

1. **Natural sand**: Sand containing the silica grains and clay bond as found. It varies in grain size and clay content. Collected from naturalrecourses.
2. **Synthetic sand**: It is an artificial sand obtained by mixing relatively clay free sand, binder (water and bentonite). It is better moulding sand as its properties can be easilycontrolled.
3. **Facing sand**: It is the fine grade sand used against the face of the pattern and finally governs the surface finish of thecasting.
4. **Parting sand**: It is fine dry sand + brick dust used to preserve the joint face between the cope and thedrag.

NaturalGreensand=   sand+   clay+   moisture

(10to15%)   (7 to9%)

SyntheticGreensand=   sand+   clay+   moisture

(5to7%)   (4 to8%)

5. **Green sand**: moulding is the most common mouldingprocess

6. **Dry sand mould:** Dry sand mould refer to a mould which isartificiallydried   beforethe molten metal is poured intoit.
   Dry sand moulds are costly, stronger, used for complicated castings, i.e. avoid casting defects, casting gets smoother surface.

Moulding methods:

- **Bench moulding:** In this method the moulding is carried out on convenient bench and moulds are relativelysmall.
- **Floor moulding:** In this method the moulding is carried out in medium and large moulds are carried out on thefloor.
- **Plate moulding:** For large quantity production and for very heavy casting two plates may be used withpattern.
- **Pit moulding:** In this method the moulding is carried out in the pits and generally very large moulds aremade.
- **Machine moulding:** A machine is used to prepare moulds of small and medium. This method is faster and gives uniformmoulding.

CORE AND CORE MAKING

CORES: Cores are sand blocks they are used to make hollow portion in a casting. It is placed in a mould so that when molten metal is poured into the mould. This apart of mould will remain vacant i.e. the molten metal will not fill this part of the mould. So, when the mould is broken and the castings removed a hollow portion will result in the casting.

Core sand= Moulding sand+ binders (ABC core oil) or sodium silicate

Core making: Cores are made separately in a core box made of wood or metal.
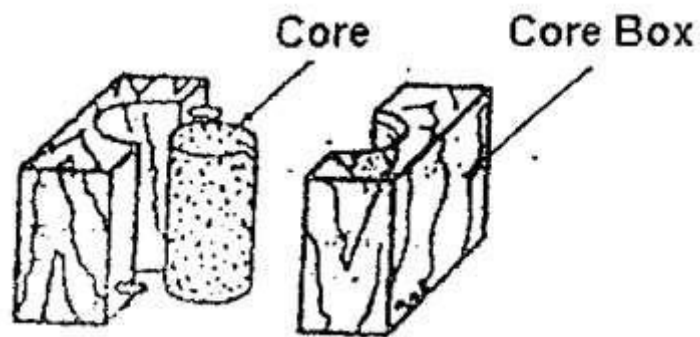
Fig. 8.1 Core making

Core binders

1. Water soluble binders (2 to 4% byweight)

2. Oil binders (1-3% byweight)

3. Pitch and resin binders (1-35 byweight)

 The sand is treated with binder to achieve cohesion

Core Baking

The core is baked (hardened) by heating at 150C depends on core size in oven.

This hardening of the core helps to handle and to place the core in the mould.

The core is supported in the mould by projection known as core prints.
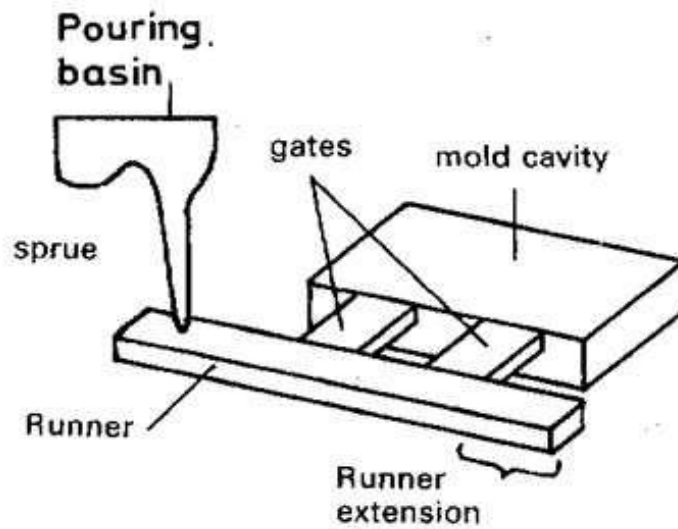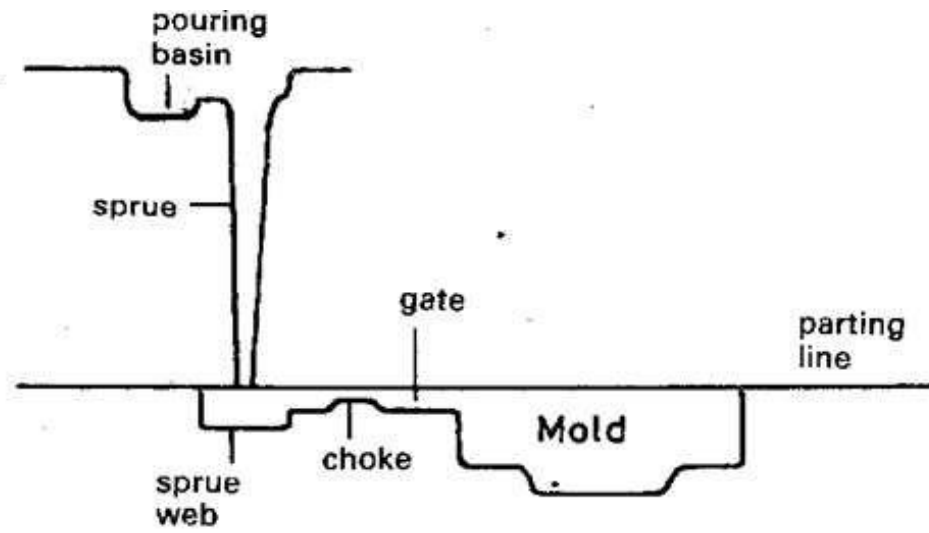
Fig. 8.2 Nomenclature of a Mould

English trowels

Long heart trowel

Broad heart trowel

Taper trowel

Heart and square trowel
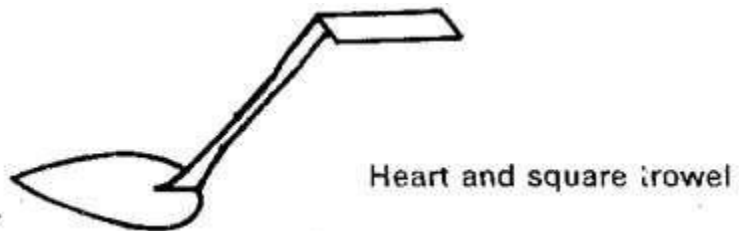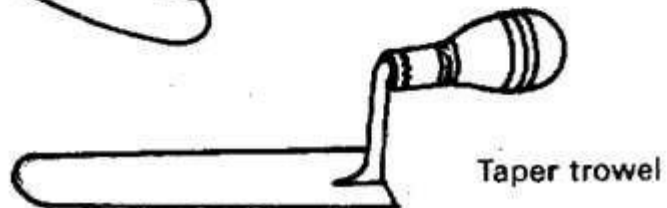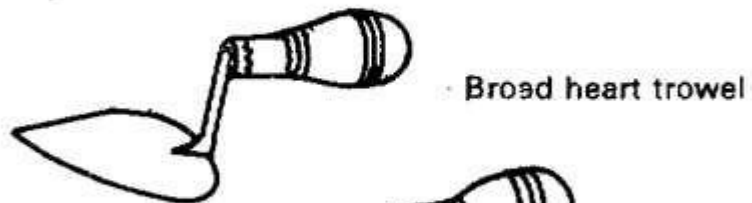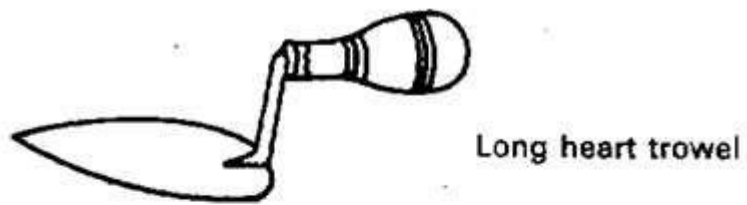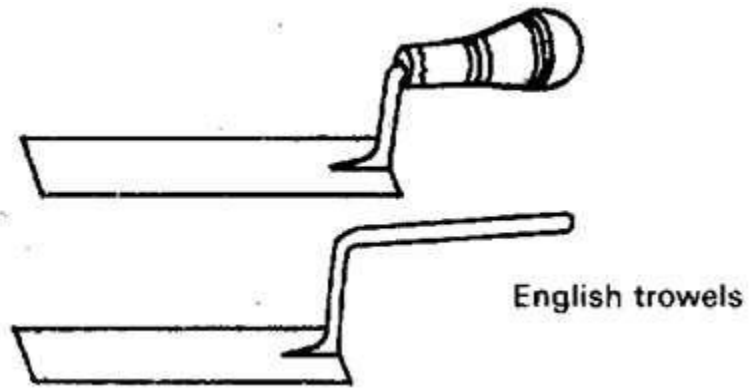
Flange bed
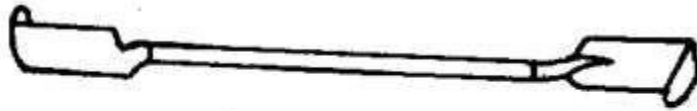
Boss tool

scoth cleaner

straight bead

English cleaner

girdar tool
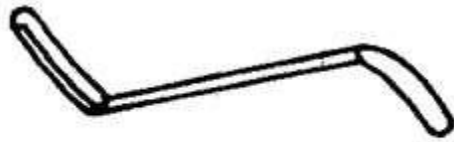
fluted bead
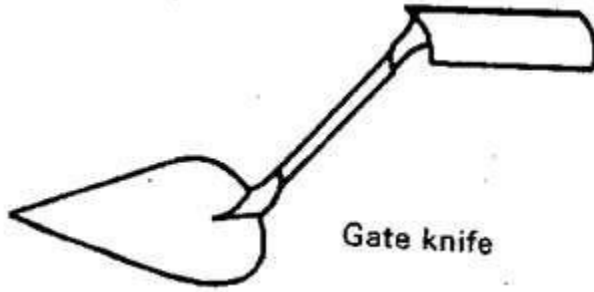
Gate knife

. Spoon tool

Safe edge heart and upset
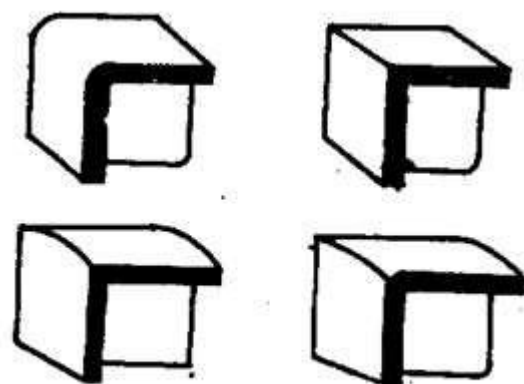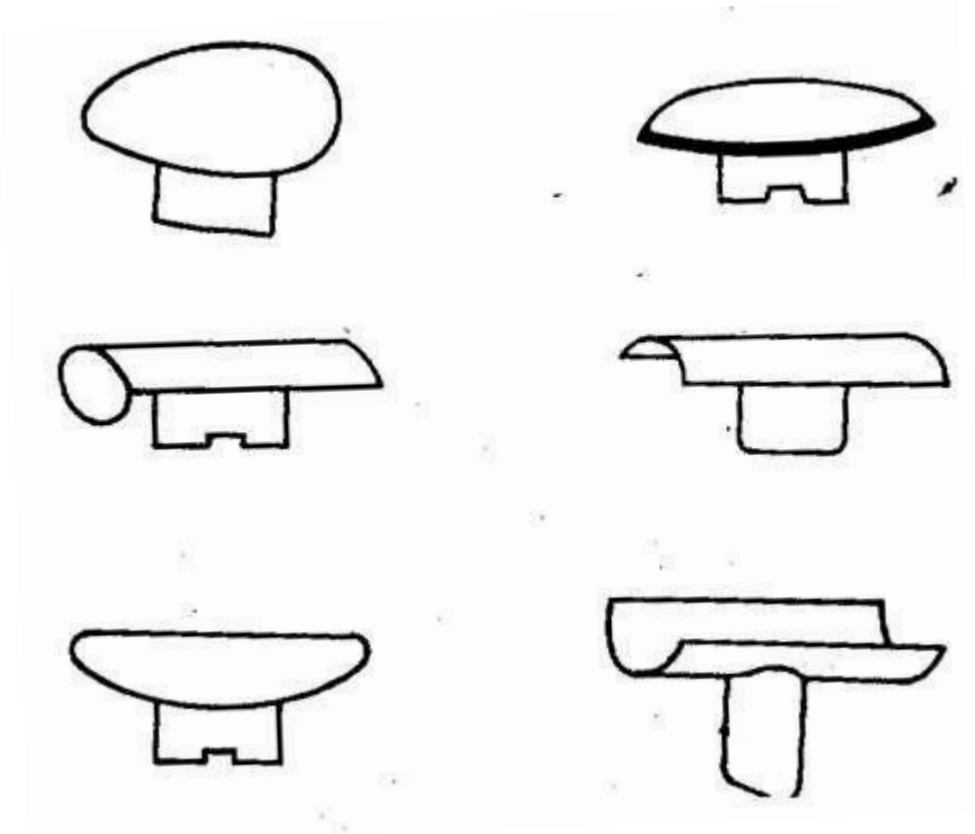
Smoothers

Bellows

Selected centre line
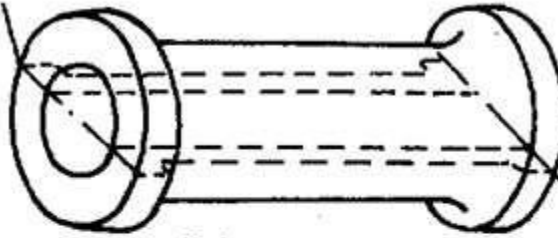
finished component

Locating dowels

Core prints each end

Rapping rod holes
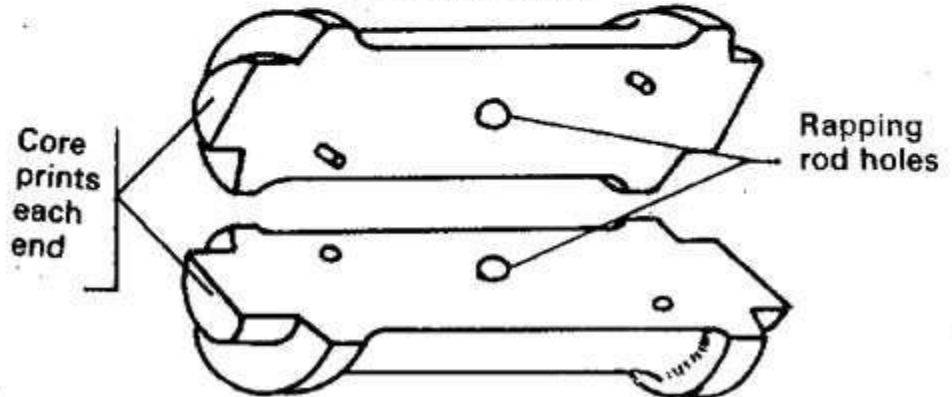
Two halves of pattern

Lower half of moulding box (drag)   green sand

bottom half of pattern
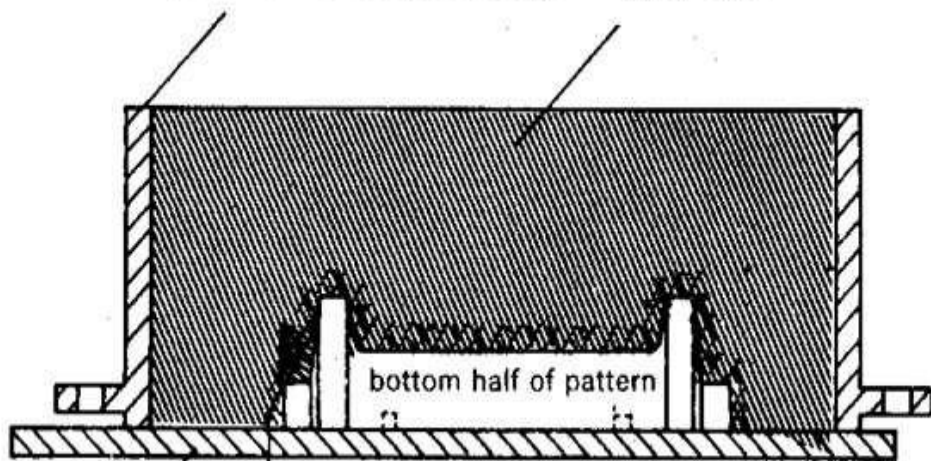
turnover board   facing sand

SECTION A-A
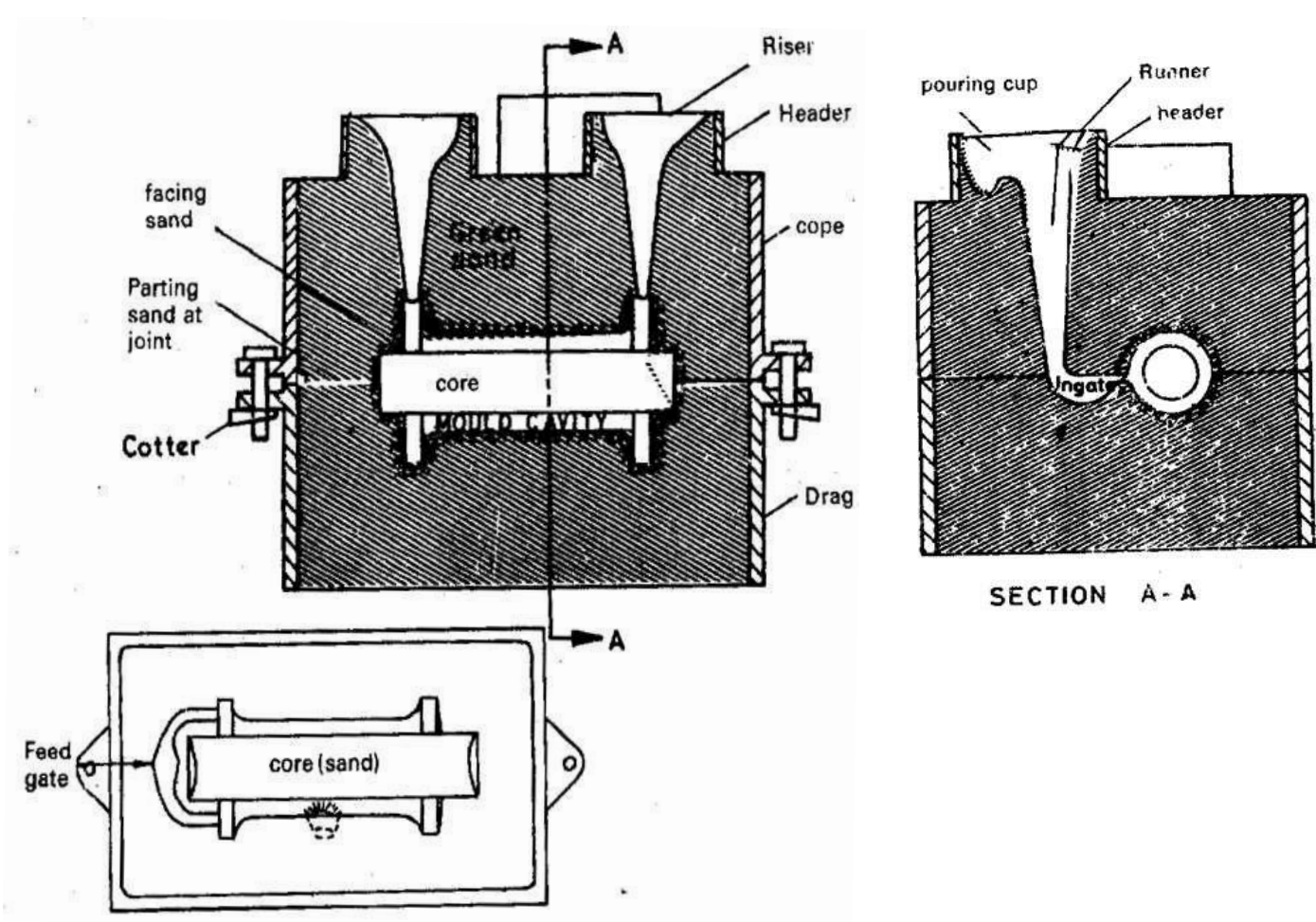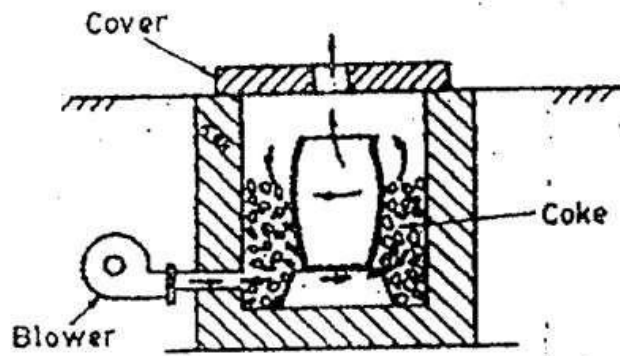
(a) Coke fired
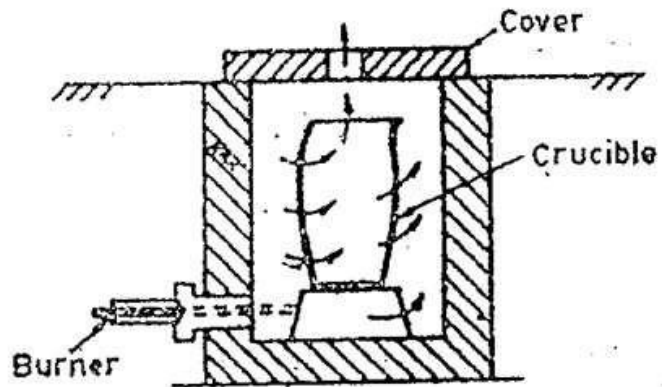
(b) Oil/Gas fired
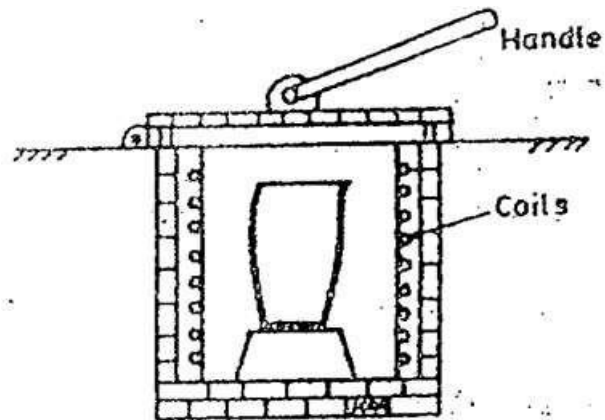
(c) Resistance type

Pin Type Furnaces

Trowels: These are used for working up into a square corner.

Taper trowel: It is more useful for working along the curved edges of a pattern. trowels are measured by the length and width of the blade.

Slicks: Used for repairing and slicking small surfaces. They are named according to the shape of the blade and measured at the widest part of the blade.

Lifters and Cleaners: They are used to clean & finish the bottom and sides of deep narrow openings.

Gate Knife: is for cutting the channel from the mould to the bottom of the runner or riser.

Spoon tool: is convenient for cutting the pouring basin.

Corner Slicks: are, as the shape implies, for finishing off fillets and corners of moulds.

Draw Spike: is a spike for knocking into the wooden pattern in order to withdraw it.

Draw Screw: is for the same purpose as the draw spike; the end is threaded to screw into the rapping plate.

Swap: is a soft – pointed brush for moistening the edges of the mould before lifting the pattern. The angle at which it is held will decide the area to be covered. Care must be taken not to get the sand too damp.

Bellows: are used for blowing out loose sand from the completed mould; they must be used gently; too vigorous use will damage the mould.

Working steps in making the sand casting:

- Place the pattern on the turn overboard.

- Place the drag around the pattern with upside and sprinkle the parting sand at thebottom.

- Fill the Moulding sand over the pattern pack, Ram, Jolt &squeeze.

- Level the bottom drag surface by leveler& turn over thedrag.

- Sprinkle the parting sand, place the cope on the drag to suit the dragslot.

- Select the in and out gate in the drag, Place the spruepins.

- Fill the moulding sand around the sprue pins pack, Ram, Jolt and Squeeze & level the surface.

- Make vent holes on both the boxes with the help of ventwire.

- Remove the sprue pin & Separate cope fromdrag.

- Remove the pattern carefully with the help of draw pin, Cut gate ways to flow the molten metal.

- From the funnel shape on runner & riser, Hole to pour the molten metal on the top of the copebox.

- Join the two boxes with clamps, Now the mould is ready to pour the moltenmetal.

Solid Pattern

Calculation for solid Pattern
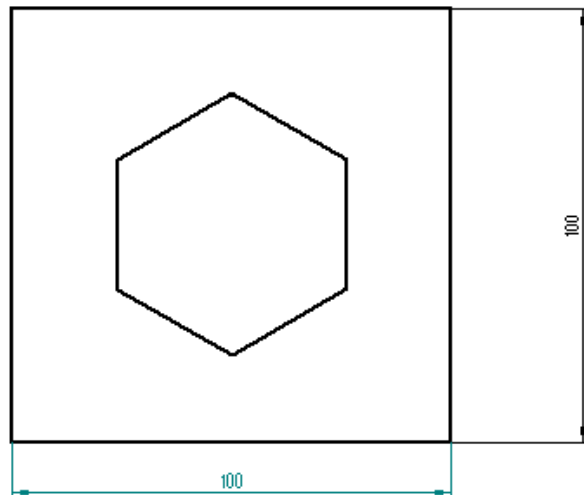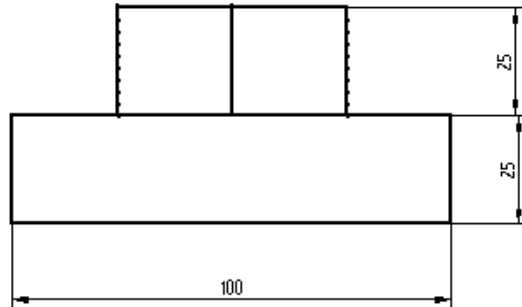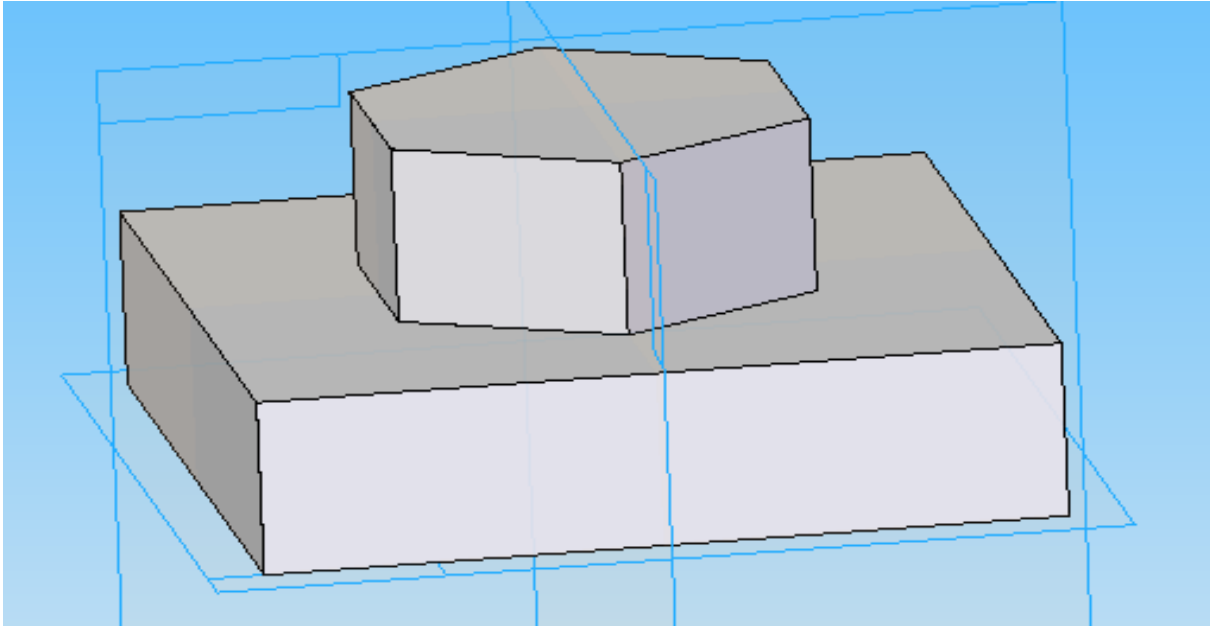
M= Mass of the Product

M_1=Mass of the Hexagonal prism

M_2= Mass of the Square

M_1=Volume x Densitya=30mm=3cm

=2.6 x a^2 x hxρ   h=25mm=2.5cm

=2.6 x 3^2 x 2.5x2.70 $ρ = 2.70$ gm/cm^3

=157.95gms

M_2=Volume x Density   l=100mm=10cm

=l x bxh   b=100mm=10cm

=10 x 10 x 2.5x2.70 $ρ = 2.70$gm/cm^3

=675gmsh=25mm=2.5cm

M=m1+m2

  =832.95gms

Add 30% Extra=249.89

=832.95+249.89

=1082.83gms

Date…………….   **Signature of theFaculty**

Hand Cutting
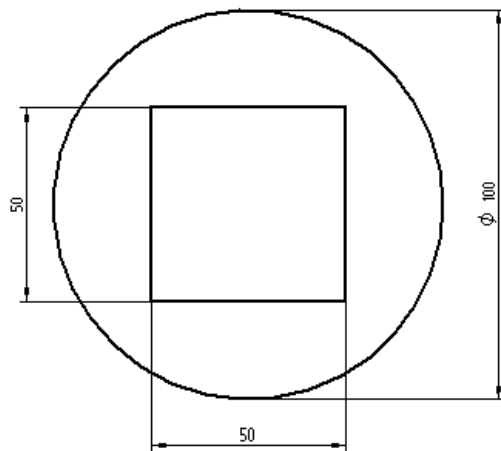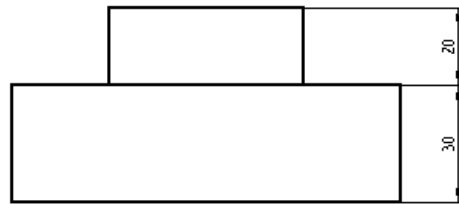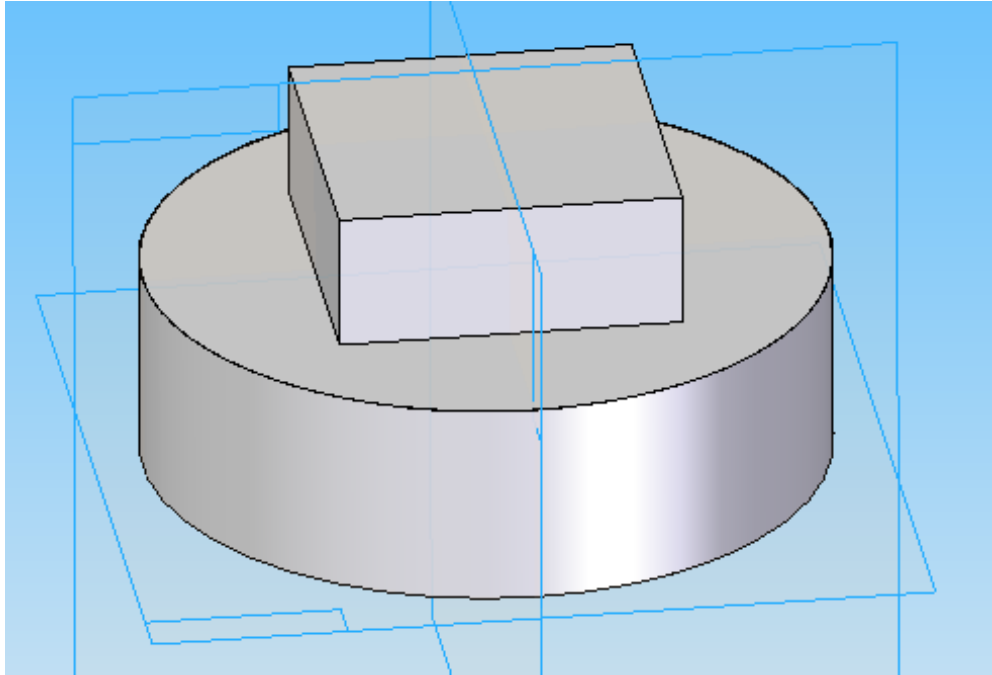
Calculation for Hand Cutting

M= Mass of the Product

m1=Mass of the Cylinder

m2= Mass of the Square

m1=Volume x Density   d=100mm=10cm

m1=A x Lρ L=30mm=3cm

$\quad = \pi d^2/4$ x Lρ ρ = 2.70 gm/cm^3

$\quad$=636.17gms

m2=Volume x Density   l=20mm=2cm

$\quad$=l x bxh   b=50mm=5cm

$\quad$=2 x 5 x 5x2.70 ρ = 2.70gm/cm^3

$\quad$=135gmsh=50mm=5cm

M=m1+m2

$\quad$=771.17gms

Add 30% Extra=231.35

=771.17+231.35

=1002.52gms

Date…………….   **Signature of theFaculty**

Self-Cored Pattern
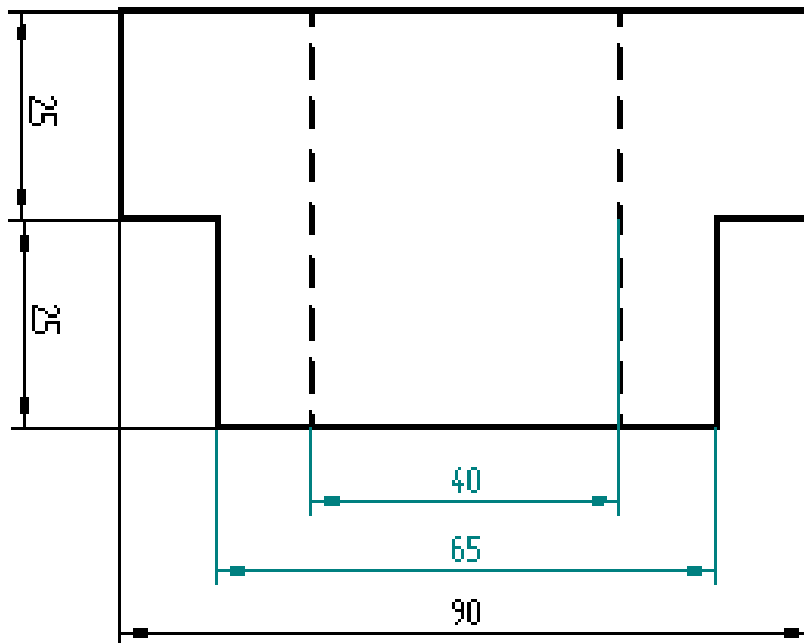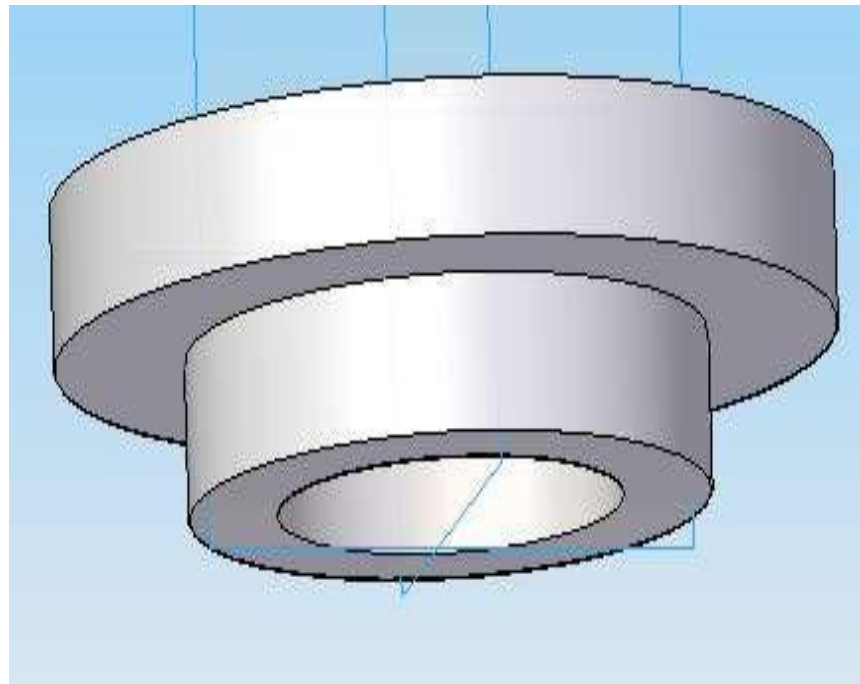
Calculation for Self-Cored Pattern

M= Mass of the Product

m1=Mass of the Cylinder (a)

m2= Mass of the Cylinder (b)

m3= Mass of the Cylinder (c)

m1=Volume x Density   d=90mm=9cm

$$m1=A \times L \times \rho$$

L=25mm=2.5cm

$= \pi d^2/4 \times L \times \rho$ $\rho = 2.70 \ gm/cm^3$

=432.59gms

m2=Volume x Density   d=65mm=6.5cm

m2=A x Lx ρ L=5mm=2.5cm

$= \pi d^2/4 \times L \times \rho$ $\rho = 2.70 \ gm/cm^3$

=225.64gms

m3 =Volume x Density   d=40mm=4cm

m3 =A x Lρ L=50mm=5cm

$= \pi d^2/4 \times L \times \rho$ $\rho = 2.70 \ gm/cm^3$

=170.90gms

M=m1+m2-m3

=487.29gms

Add 30% Extra=146.18

=487.29+146.18

=633.47gms

Date…………….   **Signature of theFaculty**

Stepped Cone Pulley with Core Print
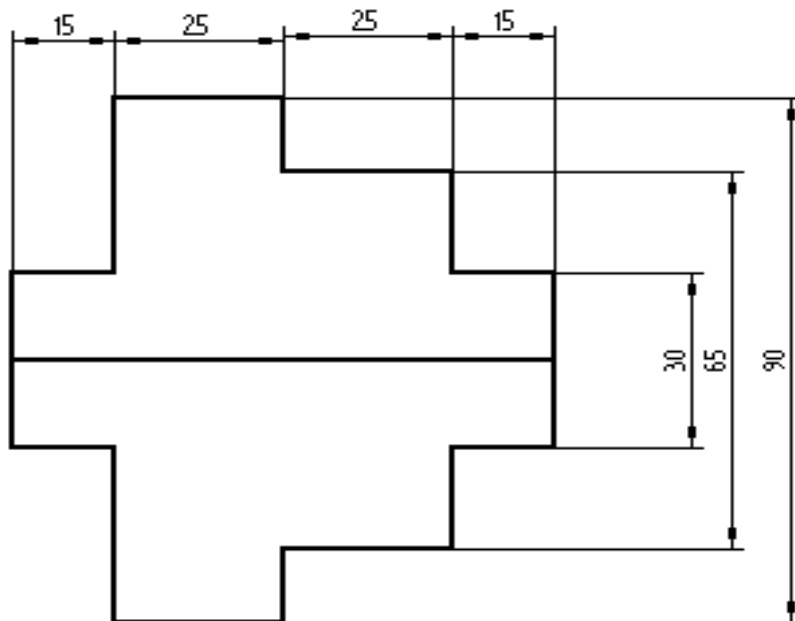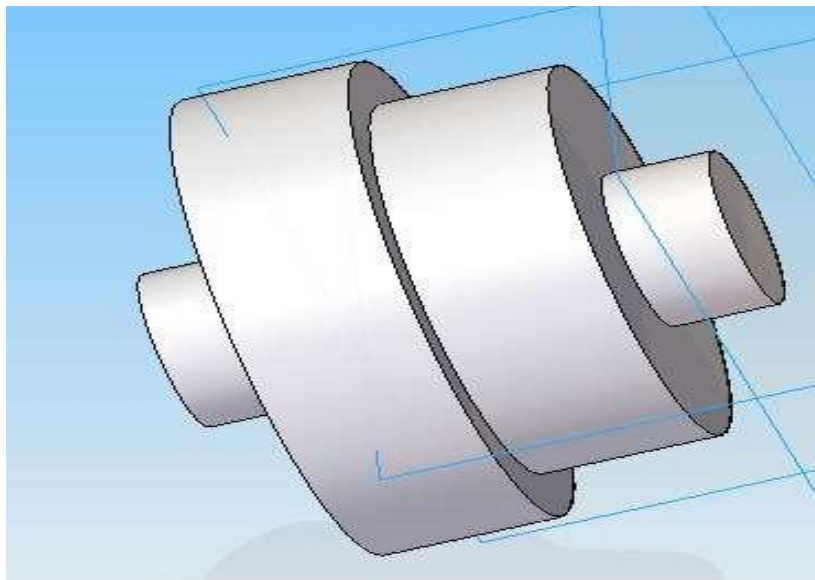
Date…………….   **Signature of theFaculty**

Split Pattern with Two Halves
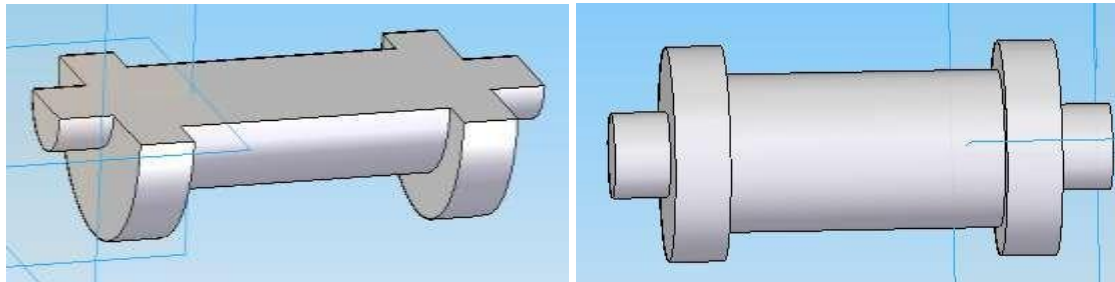
Estimation of Material Costs

In this chapter the material cost means the direct material cost. The frequently used materials are: Aluminum, Copper, Gunmetal, Brass, Iron, Tin, Magnesium, Mild steel, Alloy steel & Lead etc.

The generalized procedure to calculate the Material Cost:

1. Observe the component drawings, break up the drawing into simple parts as per convenience.

2. Using formulae calculate area & Volume of each part. Scrap should be taken into accountwhilecalculating thevolume.

3. Add the Volume of all theparts.

4. Multiply the component volume & density ofmaterial. It will be weight ofthe component. Density X Volume =Weight.

5. Multiply the weight of the component with the cost of material per unitweight.

The following table gives the densities of various materials:

No.	Material	DensityG m/cc	No.	Material	DensityG m/cc
1	Aluminum Cast	2.70	2.	Al-wrought	2.681
3.	Cast Iron	7.209	4.	Wrought- Iron	7.707
5.	Steel	7.868	6.	Mild Steel	7.2
7.	Brass-Cast	8.109	8.	Brass-Wire	8.382
9.	Bronze	8.7	10.	Gun Metal	8.735

11.	Zinc-Cast	6.872	12.	Zinc Sheet	7.209
13.	Copper	8.622	14.	Gold	19.316
15.	Lead	11.368	16.	Tin	7.418

Solved Examples: Stepped Pulley:

Q. No 1. A Cast-Iron Step cone pulley is shown in the following Figure. The Density of the C.I. is 7.209 gm/cc, Material Cost is Rs.20/ kg. Calculate the mass and materialcost.

Solutions:
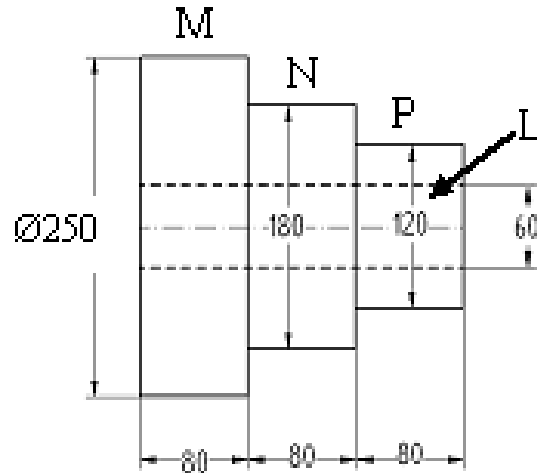
Let L, M, N, P are the different parts of the fig shown.

Total Length of the Fig.=80+80+80 = 240 mm

Now calculate the volume of Each Part:

a) Volumeofholei.e.,Part"L"

$V_L = \pi/4 \times d^2 \times 1 = \pi/4 \times 60^2 \times 240 = 678584 mm^3 = 678.584 cm^3$

b) Volume of part "M"

$V_M = \pi/4 \times d^2 \times 1 = \pi/4 \times 250^2 \times 80 = 3926990 mm^3 = 3926.99 cm^3$

c) Volume of part "N"

$V_N = \pi/4 \times d^2 \times 1 = \pi/4(180)^2 \times 80 = 2035752 mm^3 = 2035.72 cm^3$

d) Volume of part "P"

$V = \pi/4 \times d^2 \times 1 = \pi/4 \times 120^2 \times 80 = 904778.68 mm^3 = 904.778 cm^3$

The volume of the part = (b + c + d) − a

$$= (3926.99 + 2035.72 + 904.778) - 678.584 = 6188.904 \ cm^3$$

Total mass of the part = Volume of the part X Density of the CI Material

$$= 6188.904 \ X \ 7.209 = 44615.809 \ \text{gm.} = 44.615 \ \text{kg}$$
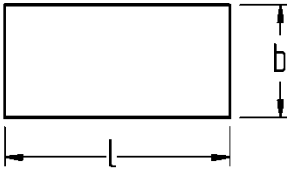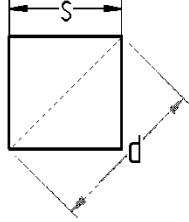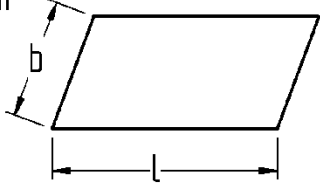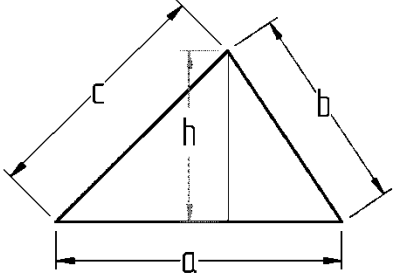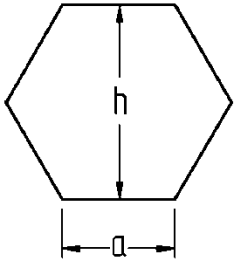
Assume the cost of CI = Rs. 75/-

Cost of the Material Required = Weight X Cost

$$= 44. \ 615 \ X \ \text{Rs.} \ 75 = \text{Rs.} \ 3346.125$$

ESTIMATION

Some of the important formulae regarding Planes and Solids are given below

1 Rectangle		l = length of rectangle b= breath of rectangle ∴ Area = l x b, Perimeter = 2 x (l x b)
2 Square		S = length of each side of square d = length of diagonal ∴ Area $= S^2 or \frac{d^2}{2}$, Perimeter = 4S
3 Parallelogram		l = length of one side of parallelogram b = length of another side h = height of parallelogram ∴ Area = l x h, Perimeter = 2(l + b)
4 Triangle		h = height of A from BC Area = $\frac{1}{2}$ x a x h = $\frac{1}{2}$ x base x $\perp^r$ height Perimeter = a + b + c = 2s
5 Hexagon		a = length of each side; h = height Area = $\frac{3\sqrt{3}}{2} x a^2$ Perimeter = 6a, h = $\sqrt{3}a$

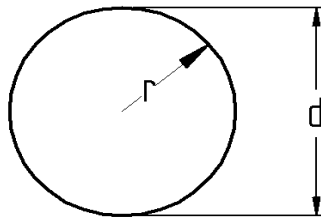| 6 Any Regular Polygon	Let n = no of sides; a = length of each side Perimeter = n x a Area = $\frac{1}{2}$ x perimeter x inner radius
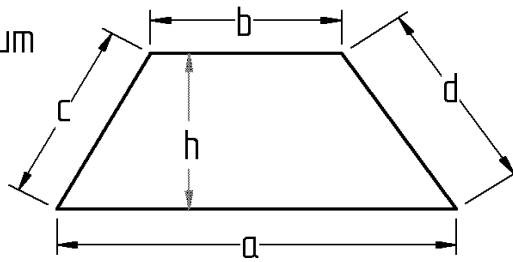
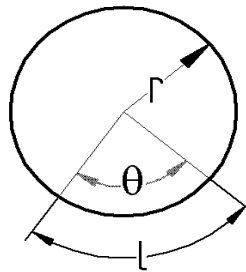| 7 Trapezium	a, b, c, d are the lengths, h = distance between parallel sides Area = $\left(\dfrac{a+b}{2}\right)h$ perimeter = a + b + c + d

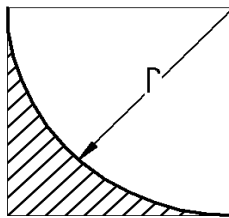| 8 Circle	r= radius, d = dia Area = $\dfrac{\pi d^2}{4} = \pi r^2$ Perimeter = $\pi d = 2\pi r$

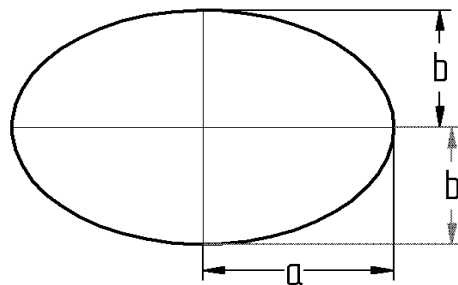| 9 Sector	r = radius, θ = angle in radius, l = length of arc, l = r xθ, Area = $\dfrac{\theta}{2\pi} x \pi r^2 = \dfrac{\theta r^2}{2}$

10 Fillet	Area of fillet = $r^2 - \dfrac{\pi}{4} = r^2 - \left(1 - \dfrac{\pi}{4}\right) = 0.215r^2$

11 Ellipse	a = Semi major axis b = Semi minor axis area = π x a b Perimeter = π (a + b)

UNIT - 2

FORGING

FORGING

Introduction:

Forging is a process of shaping the metal components in cold or hot condition by the application of impact or pressure but the primary difference between various forging methods is the rate which the energy is applied to the work piece.

Practical Application:

Forging is generally used for those components which require high strength and resistance to shock or vibration sudden impact of load and uniform properties

Example: Automobiles

                              (1) Chassis of allvehicles

                              (2) Front and Rearaxel

                              (3) Wheeldrums

                              (4) Springblades

                              (5) Rockerarm

                              (6) Gearshifter

                              (7) Connecting rodetc.

          Railways   (1) Railwaywheels

                              (2) Railway tracks

          General   D. E.Spanners

                              (2) RingSpanner

                              (3) Wrenches

                              (4) CuttingPliers

                              (5) Hammersetc.

FORGING METHODS

    (1) Handforging

    (2) Dropforging

    (3) Pressforging

    (4) Rollforging

Hand forging: Hand forging is made by heating the metal until it is plastic state in an open hearth furnace and there by hammering is done on anvil by smith/sledge hammer with use of open face dies to get the desired shape and size by judgment of an individual.

Drop forging: In this process of forming the desired shape by placing a heated bar or billet on the lower half of the forging die and hammering the top half of the die into the metal by means of a power hammer by repeated blows the impact of which compel the plastic metal to conform the shape of the die. This method is used to produce large number of small and medium sized forging of similar parts.

Press forging: In this process the heated billet is squeezed between die. The pressure is applied by the forging press which completes the operation in a single stroke. Large forging are generally shaped by thin method.

Roll forging: Rolling involves the passing of a heated bar between revolving rolls that contains an impression of the required shape. It is used to reduce short thick section to long slender pieces.

FORGING operations;

  (1) Drawingdown

  (2) Upsetting

  (3) Punching

  (4) Bending

  (5) Welding

  (6) Cutting

Drawing down:

The operation of spreading or thinning action and is accomplished by striking the work piece with flat dies. Due to impact of die on metal its thickness is reduced and length is increased
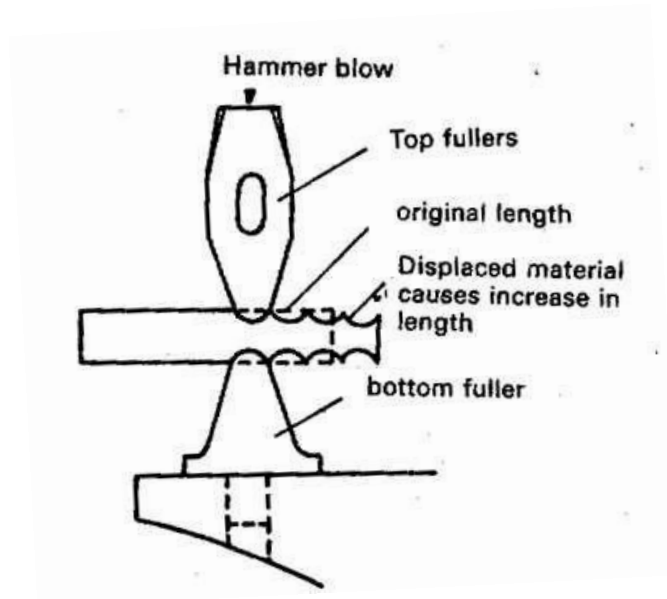
Fullers: are blunt hosed chisel and are used to reduce the thickness of hot metal. They may be held with hand fitted with a rod handle. Bottom fullers may be inserted in the square hole of the anvil.
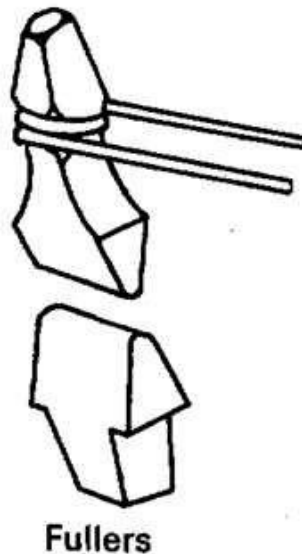
Fullers

Flatters: this is used to flatten and smoothen metal flatters are used under a sledge hammer to flatten the metal particularly after its thickness has been reduced using fullers.

Flatter

Hammer blow
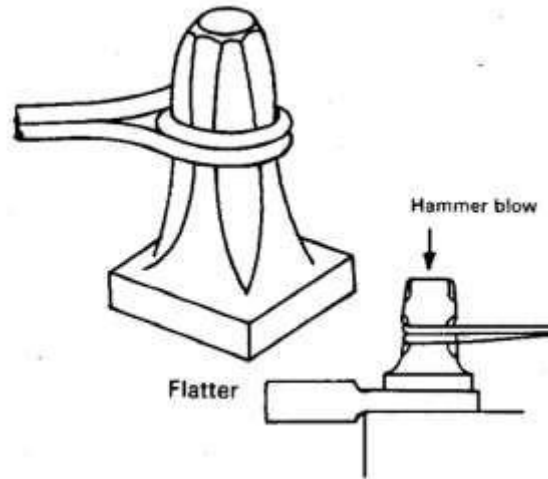
Upsetting: This is just opposite to drawing and involves increasing of the cross-sectional area usually by pressing or hammering in the direction parallel to the original ingot axis. Only the part to be upset is heated to forging temper and the bar or work is then struck at the end, usually between the hammer and the axis as shown in figure.

Punching: It is the process of producing hole generally cylindrical by using a hot punch over a cylindrical die.

Drifting: It is the opening out of holes previously punched.

Bending: It is one of the most important processes of forging and isveryfrequently   used.

Bends may be classified a sharp cornered bends or more gradualbends.

The operation is performed by hammering the metal over the edge of the anvil or over a block of metal held in vice.
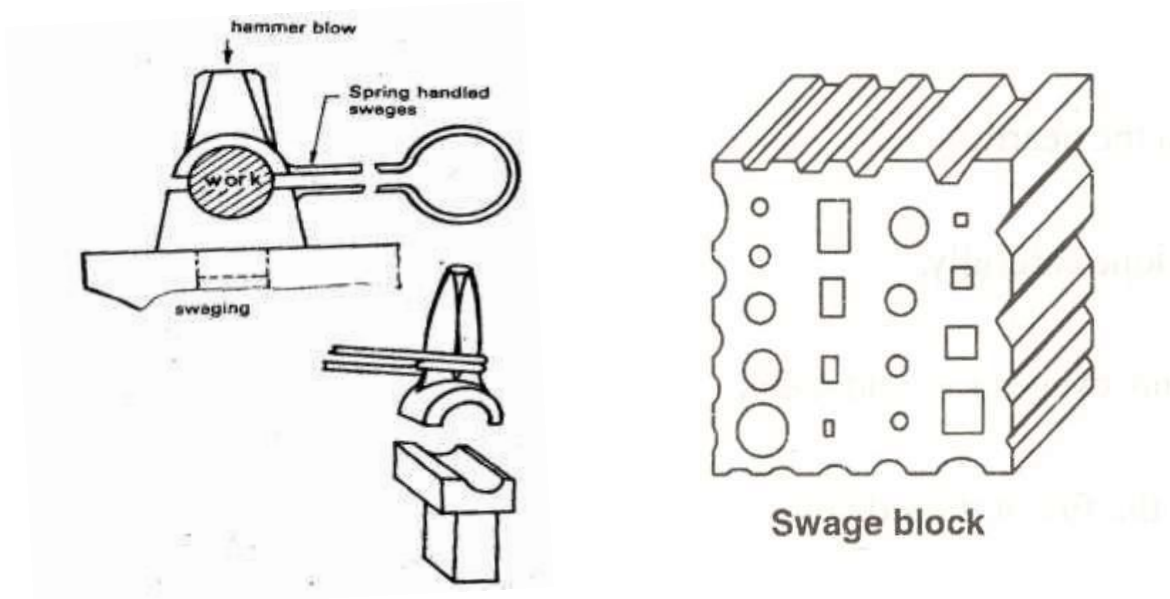

Rod Bends

Flat Sheet Bend
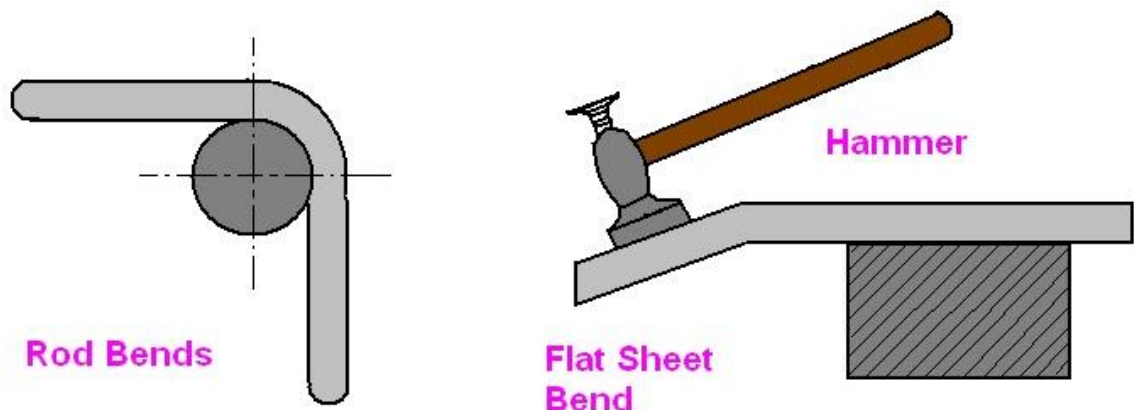
Hammer

When the metal is bending by hammering, the outer and inner surface does not remain same. The inside surface is shortened while the outer surface is stretched which causes bulging of the side at the inner surface and a radius on the outer surface of a sharp corner is required an additional metal is required at the place where the bend occur in order to permit stretching of metal at outer surface.

Welding: Metal like wrought iron and steel are welded by pressing or hammering together surface after they have been raised to the correct welding temperature at 1350°C when the metal is white not. The operation of such a type of welding is performed in forge shop. And hence is also called forge welding.

Cutting: In order to perform a rapid cutting operation by chiseling, the metal is heated in black smith fire to a temperature of 850-900°C and then hammer blows are directed on the chiselhead. If the thickness of metal to be cut is more than two notched or grooves are made 180°apart.

Swaging: it is a process of finishing a round or hexagonal section of bar between a pair of swages of the appropriate size. These may be separate tools for top and bottom or these may be held to gather by a long spring handle as shown in figure.
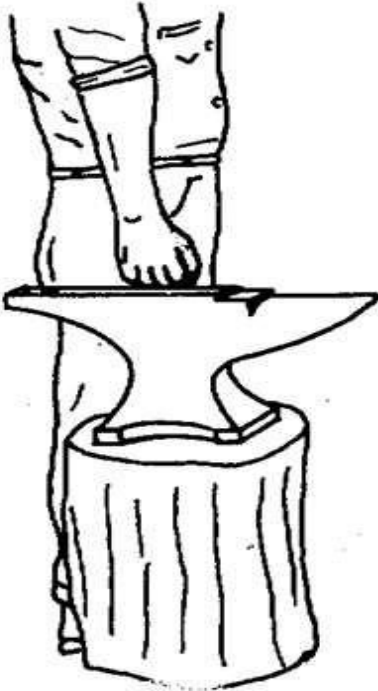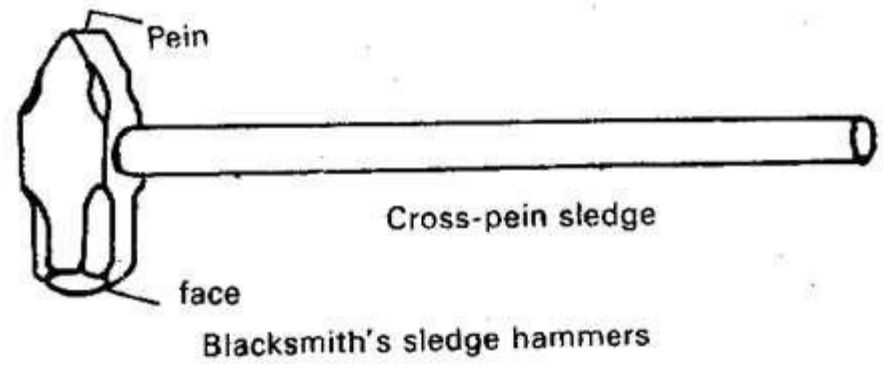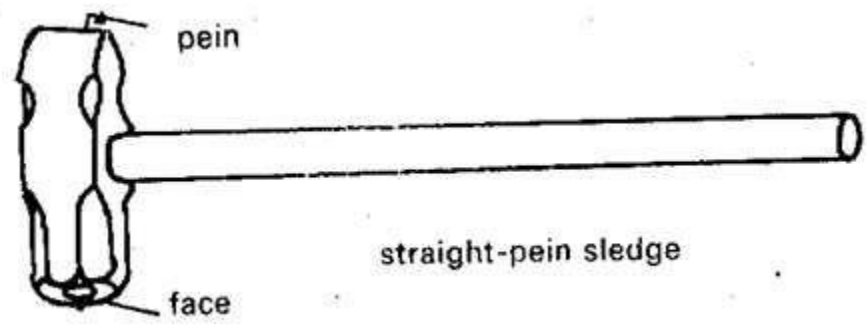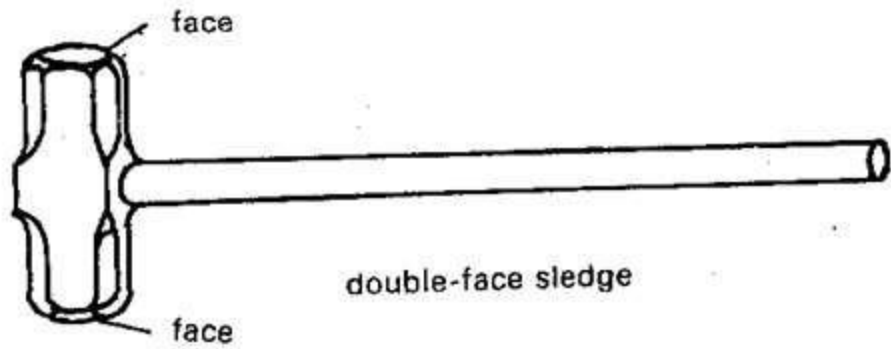

Swages

TOOLS & EQUIPMENTS REQUIRED FOR FORGING.

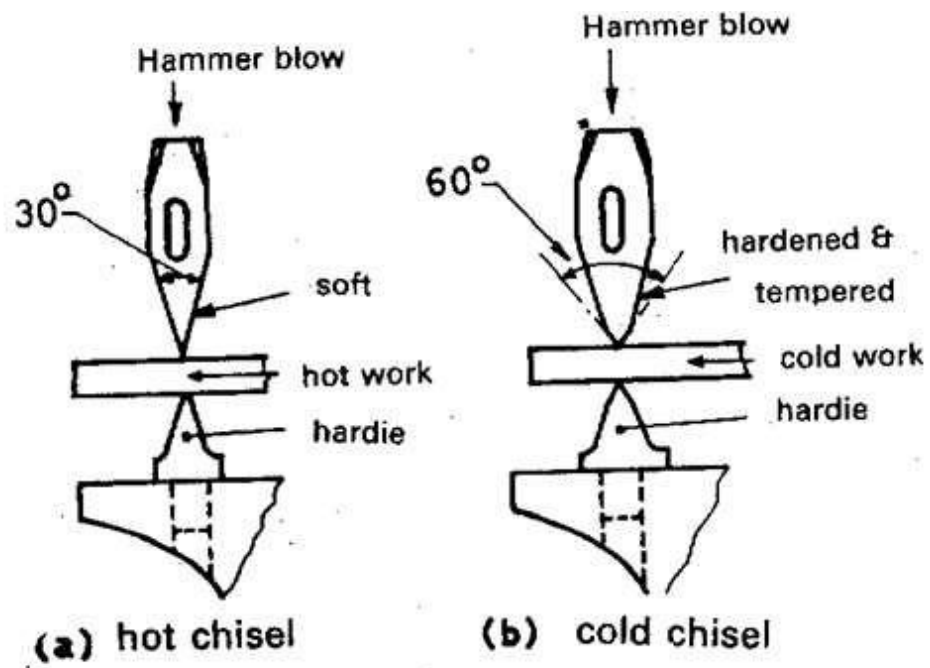A SMITH'S ANVIL

face

double-face sledge

face

pein

straight-pein sledge

face

Pein

Cross-pein sledge

face

Blacksmith's sledge hammers

Hammer blow

Hammer blow

30°

60°

hardened &
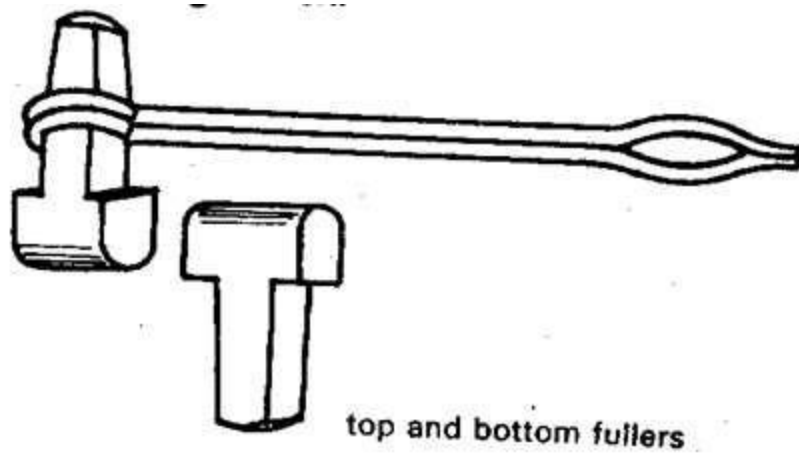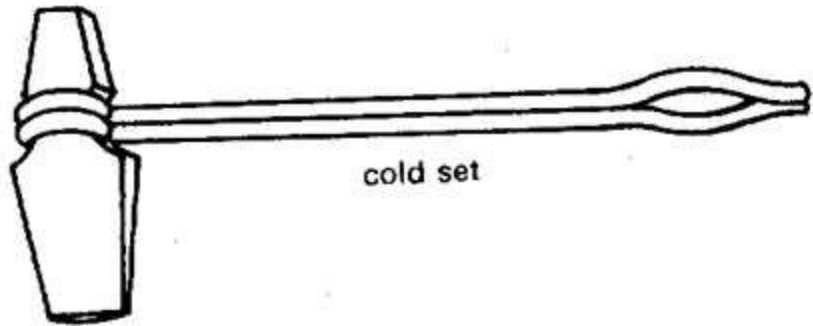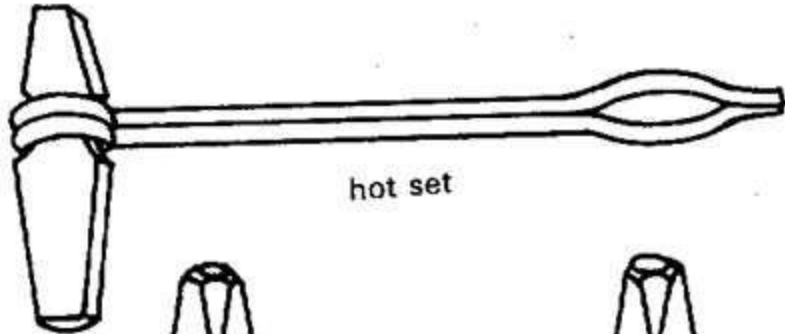tempered

soft

cold work

hot work

hardie

hardie

(a) hot chisel
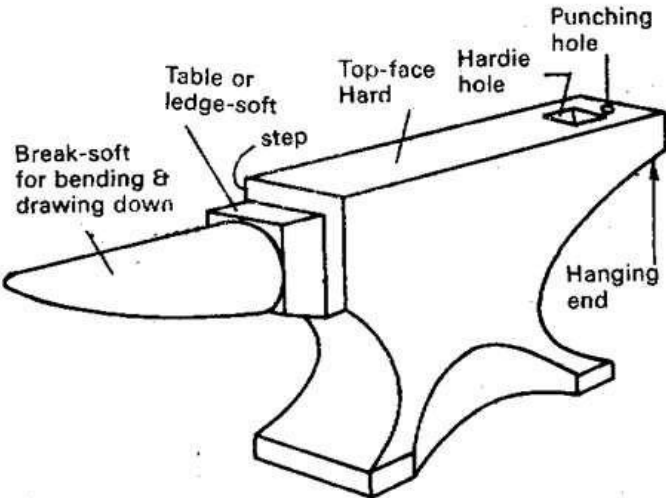
(b) cold chisel

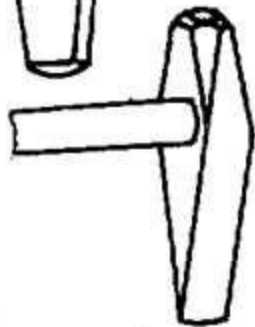Use of chisels in forging
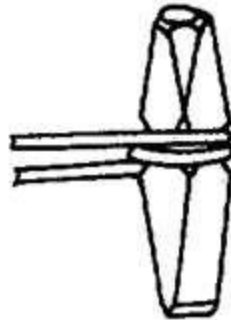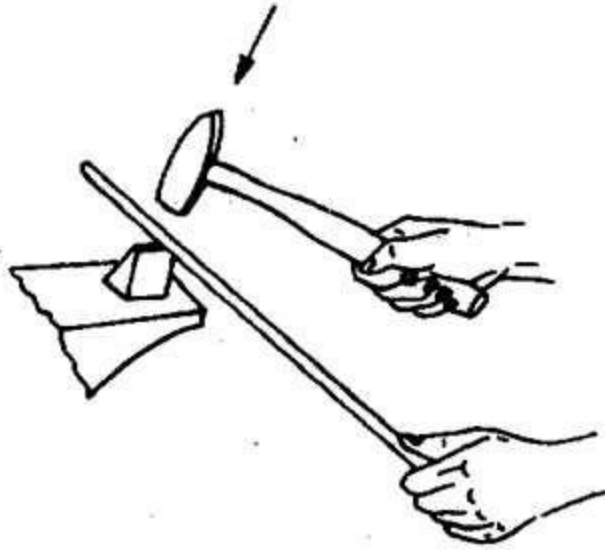
top and bottom fullers

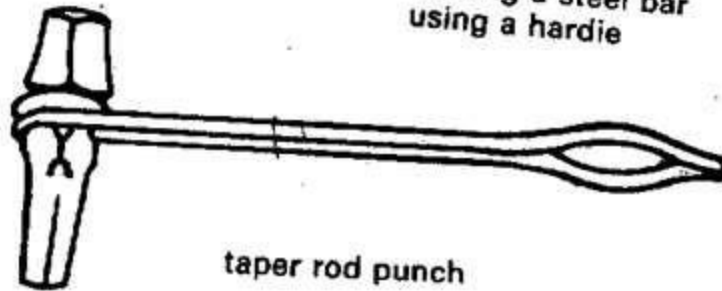cold set

hot set

Hot set with
wooden handle

cold set with
steel rod handle

hardie

Cutting a steel bar
using a hardie

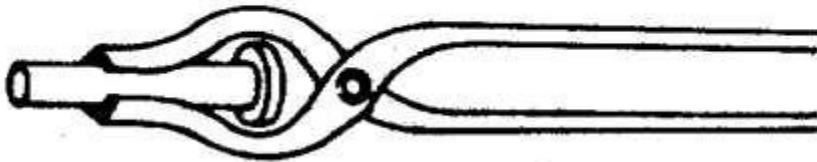taper rod punch

top and bottom swages
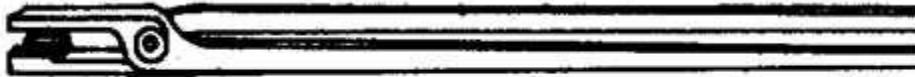
Flat mouth

Open mouth
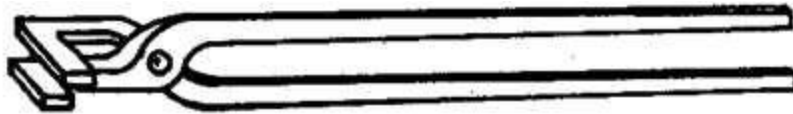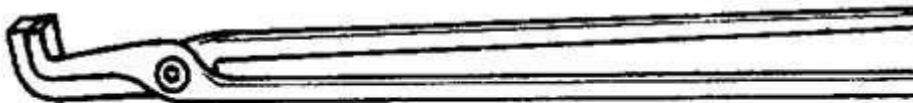
Chisel or bolt

close mouth

hollowbit

Double hollow bit

Square mouth

side mouth

Band saw

Anvil: It is used as a mount for pairs of tools between which the work is forged by hammer blows. The main body of the anvil is made of mild steel with a hardened top face welded on. The beak is soft and with an increasing diameter of cross section. Beak is useful for producing bends of different radii. The ledge between the beak and the anvil face is soft and can be used as a base for cutting operation with hot chisels.

Sledge hammer: It is a very heavy hammer with a long handle. It may weigh from 4 to 16 kg. These are used for heavy work. The length of the handle increases with the weight.

Chisel: It is fitted with a long handle. The chisel is held on the work and struck with a hammer.

Cold chisel: It is used for cutting cold metal.

Hot chisel: It is used for cutting hot metal.

Hardie: This is a chisel fitted in to a hole in the anvil with its cutting edge at the top. There is usually one for hot and another for cold use.

Swages: These are used in pairs to shape hot metal. They are supplied in pairs, top and bottom.

Fullers: These are blunt nosed chisels and are used to reduce the thickness of hot metal. They may be held with hand or fitted with a rod handle. Bottom fullers may be inserted in the square hole of the anvil. For occasional use, fullers can be improvised from round mild steelbar.

Flatter: This is used to flatten and smooth the metal. It is used under a sledge hammer to flatten and smoothen the metal, particularly after its thickness has been reduced using fullers.

Tongs: These are used to hold hot metal pieces. Various shapes of blacksmith's tongs are available.

Types of Tongs:

Single pick up tong: It is used to pick up either flat work or round work.

Curved lip tong: This is also called as chisel or bolt tong. It is used to hold round work.

Straight lip tong: It is also called as flat-jawed or flat mouth tong. It is used to hold flat work.

Double hollow bit: It is used to pick up either flat work or round work.

WORKING STEPS IN MAKING THE FORGING JOB

1) Calculate the final length of the model to be forged of the given round rod of 12mmdiameter.

2) Place the given round rod in the Hearth furnace in suitableplace.

3) Switch on the blower and set the temperature range up to 900-1000^{0}C in control panel.

4) The job is heated to red hottemperature.

5) Place the heated job in between open-faced Bottom & Top Die, which is set on Anvil.

6) Draw down the heated work piece to calculated length with the help of hammer, tong &flatter.

7) The process is carried approximately until the circular rod is transformed into desired shape and with desireddimensions.

8) The work piece is re-heated to carry out bendingoperation.

9) Bending is carried out on Leg vice as perdimensions.

10) With the help of flatter, open faced dies finish the work piece to the final dimension and surface finish, cool the specimen by dipping inwater.

Date…………….   **Signature of theFaculty**

SQUARE SECTION PRISM
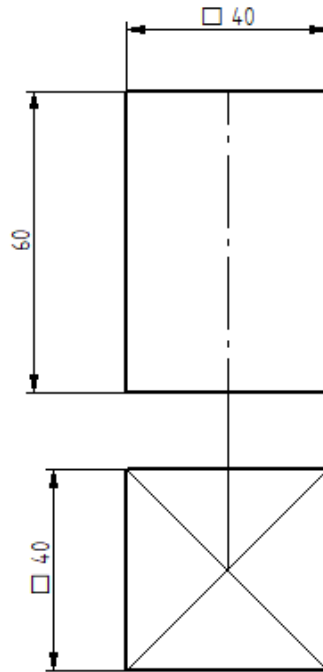
Calculation   of length of the raw material required to do the component

M_f= Mass of the finished product

M_f of Square Prism = Volume x Density   a=40 mm=4.0 cm

$$M_f = a^2 \text{ x } L \text{x} \rho$$ ρ =7.85 gm/cm^3

                                        L=60mm=6.0 cm

M_r =Mass of the raw material MS round

M_r = Volume x Density   L =?

        M_r = A x Lx ρ d=16mm=1.6cm

$753.6 = \pi d^2/4 \text{ x } L \text{x} \rho$ ρ =7.85 gm/cm^3

L=

Add extra 10 % forging allowance =

Total=

Date…………….   **Signature of theFaculty**

SQUARE SECTIONNAIL
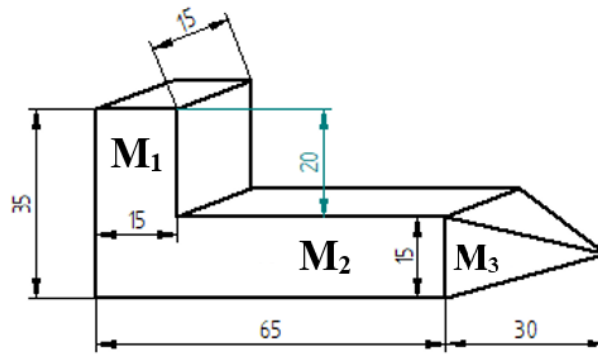
Calculation of length of the raw material required to do the component

M= Mass of the finished product

M_1= square prism = volumex density   L=15mm=1.5cm

            = L x BxH x ρ   B=15mm=1.5cm

                                  H=20mm=2.0cm

                                  $ρ =7.85$gm/cm^3

M_2= square prism = volumex density   L=50mm=5.0cm

            = L x BxH x ρ   B=15mm=1.5cm

            =   H=15mm=1.5cm

            = $ρ =7.85$gm/cm^3

M_3=Square Pyramid = 1/3 x A^2xH   A=15mm=1.5cm

              =   H=30mm=3cm

            $ρ =7.85$gm/cm^3

        $M=M_1+M_2+M_3 =$

=

M = Mass of the raw material MS round

L=?

Mass = Volumex Density

d=16mm=1.6cm

$$= \pi d^2/4 \times L \times \rho =$$

$\rho = 7.85 \text{gm/cm}^3$
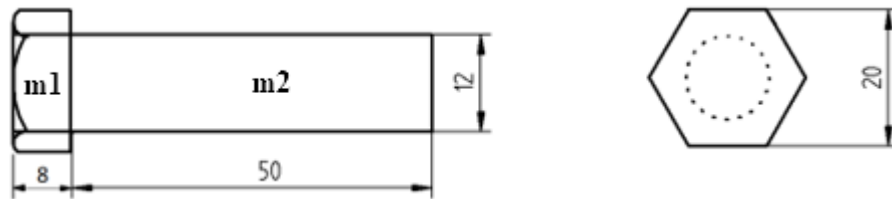
L=

Add extra 10 % forging allowance =

=

Total =

Date…………….   **Signature of theFaculty**

HEXAGONAL BOLT

Calculation of length of the raw material required to do the component

M= Mass of the finished product

m1= Hexagon prism =Aρ= $6ah+3\sqrt{3}\,a^{2}*\rho$ a=12mm=1.2cm
=   h=8mm=0.8cm

= ρ =7.85gm/cm^3

m2= Round = $\pi d^2/4$ x Lx ρ d=12mm=1.2cm

         =   L=50mm=5cm

         =ρ =7.2gm/cm^3

M=m1+m2=

         =

M = Mass of the raw materialMS Roundd=16 mm=1.6 cm

= $\pi d^2/4$ x Lx ρ = L=?

L=4.30cmρ =7.85 gm/cm^3

Add extra 10 % forging allowance =

  =

                    Total=

Date…………….   **Signature of theFaculty**

SHEET METAL

Metal in the form of sheet is called 'sheet metal'. Sheet metal work involves, working with metallic sheets using various tools to make components/articles such as office trays, funnel, box, cans, chimney air ducts and to fabricate boiler shells, pipe joints, storage tanks etc. Sheets up to3mm thickness are called 'sheet metal' and above 3 mm thickness, they are called 'plate'.

Practical Applications:

Many industries like automobile, aircraft, ship building, packing, air conditioning, ventilatingsystem, fabrication of funnels, hoppers, bins, paint tins, trays, oil tins, buckets, storage tank, chimney boilers, involves sheet metal fabrication.

Methods of Developments:

1. **Parallel line method of development**: The surfaces of right prisms, cylinders, cubes, Rectangular Trays & Similar objects.
2. **Radial line method of development**: The lateral surfaces of right pyramids and cones may be developed by this method.
3. **Triangulation method of development**: The surfaces are made of a No of Triangular strips laid out in their true size. Ex. Square to round Rectangular to square etc.
4. **Approximate Method of development**: This method is used to draw the development of a sphere etc.

Common metal sheets used in sheet metal Work are:

1. B.P or H R Sheet (Black Plain sheet or Hot Rolled sheet)
2. C R plain sheet (Cold Rolled sheet) – 0.1-0.3 % of Carbon
3. Galvanized plain sheet (Galvanizing Zinc)
4. Aluminum sheet
5. Copper sheet
6. Tin Sheet
7. Stainless steel sheet – (Alloy steel it contains 18% Chromium, 8%, Nickel, less than 1% carbon rest is iron)

Gauge number corresponding to the thickness of sheet or wire diameter.

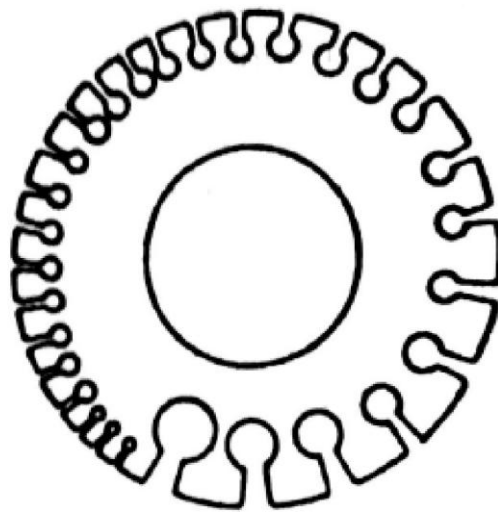| l. No	Gauge No	Thickness of sheet or diameter of wire in mm
1	10 G	3.25
2	12 G	2.64
3	14 G	2.03
4	16 G	1.63
5	18 G	1.22
6	20 G	0.91
7	22 G	0.71
8	24 G	0.56
9	26 G	0.46
10	28 G	0.38
11	30 G	0.30

Fig. Standard wire gauge (SWG)

FABRICATING SHEET METAL PARTS

To make a sheet metal object, first the sheet has to be cut to the desired shape. The technique employed to know the shape of the given object, is to unfold all the outer surfaces of the object so as to lie on a plane.

When the complete surface of an object is opened out and laid on a plane, the object is said to be 'developed'. The figure so obtained on the plane is called 'development of the object'. For ex., consider a cylinder with both of its end being open. To fabricate the object, first the surface should be developed. Figure shows the process of laying out the surface of the object on a plane. The figure

so obtained is called the 'development of surface of a cylinder'.

The surface to be developed is first drawn on a paper (or can be drawn directly on the sheet metal itself). Suitable allowance should be provided for joining the end surfaces. The paper is then pasted on the sheet metal. All other processes, namely cutting, bending, folding and joining are done manually with the help of tools. The end surface can be joined either by soldering, riveting, brazing etc.
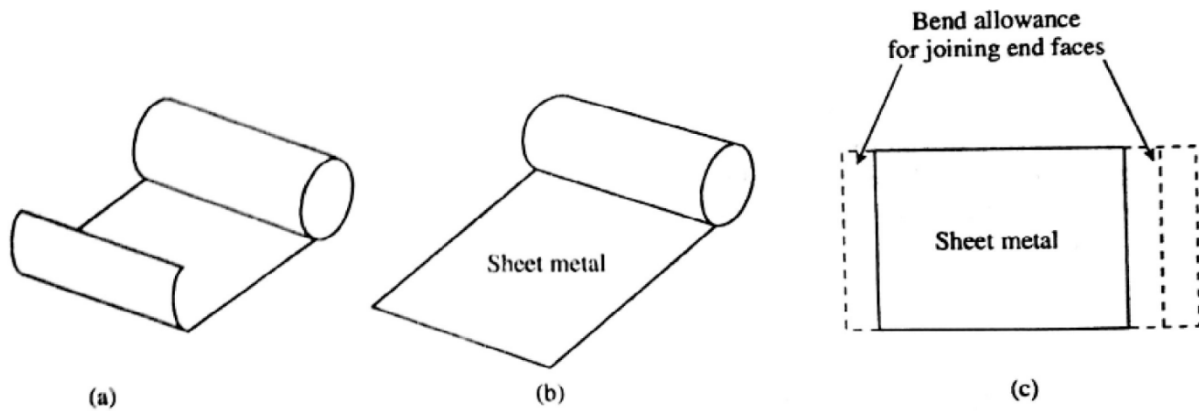

Fig: Development of cylinder

TOOLS USED IN SHEET METAL WORK

The different types of tools used in sheet metal work are explained in below.

Snip

Snips are used to shear or cut the sheet metal to the required shape and size. Different types of snip such as straight snip, bent snip (pipe snip), universal combination snip, heavy snip etc., arc used to depend on the requirements.

Figure shows a straight snip used for cutting sheet metal along a straight line. A bent snip can be used for cutting the metal along a curvature.
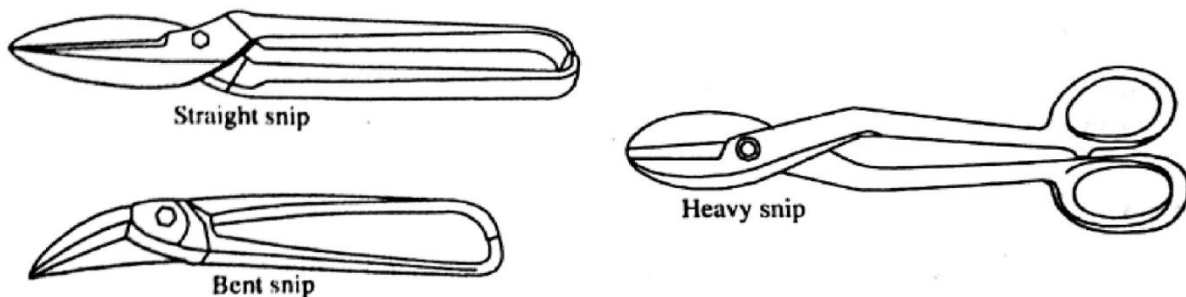

Fig. Different types of snips

Stakes

Stakes are anvils of different shapes on which the sheet metal is placed and formed (bended) to the required shape. Different types of stakes like bick iron stake, round head stake, half-moon stake, horse head stake etc., are used in sheet metal work.

Material: Stakes are made from wrought iron and faced with steel.

Hammer / Mallet:

Hammers used in sheet metal work are made to have round or square heads to suit hammering of the round and corner surfaces respectively. Soft faced (nylon faced) hammers are frequently used in sheet metal work to avoid damage to the metal sheet. A wooden mallet is also used for the same purpose, particularly when light blows are needed. A soft face hammer and a mallet are shown in Figure a and b.
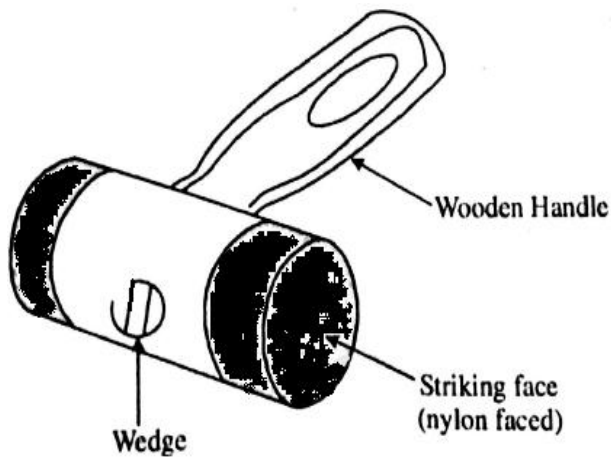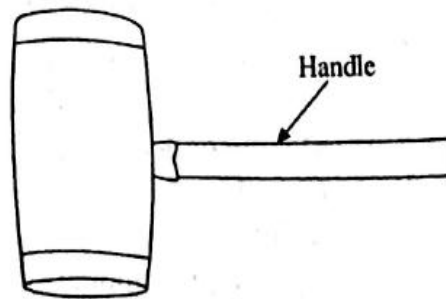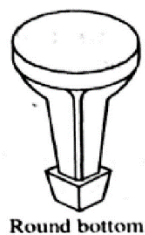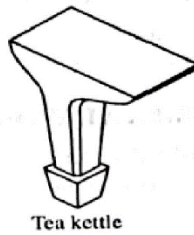
Fig.a : Nylon faced hammer.   Fig.b Mallet
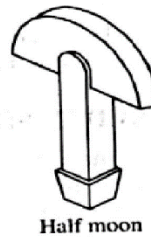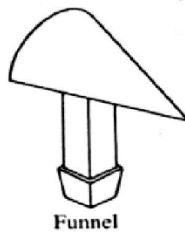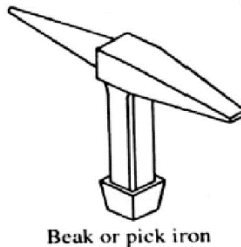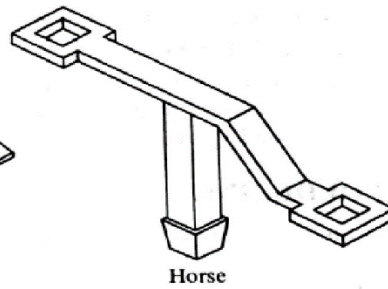
Fig. Different types of stakes

Sheet Metal Operations:

1. **Measuring**: - It is process of measuring length, width and thickness of sheet by using steel scale, standard wire gauge, micrometer etc.

2. **Marking**: - It is a Process of marking the desired shape on a given sheet (G P Sheet 28G) thin punch on line of bending with use of center punch & Ball peen hammer.

3. **Cutting & Shearing**: - It is a Process of Cutting block. The term shearing stands for cutting of sheet metal is by parallel cutting edges moving in opposite direction. This can be done either by hand snip or by means of shearing machine.

4. **Notching**: - It is a Process of removal of excess material from the edge of strip to avoid wrinkling or bulging to obtain correct shape. Straight Notch, Square Notch, V Notch

5. **Bending**: - It is a Process of bent the sheet in one plane.

6. **Piercing and Punching**: - It is a Process in which a pointed bullet shape punch is forced enough to produce a hole on sheet.

7. **Nibbling**: - It is a Process of continuous cutting along a contour which may be a straight line or on irregular profile is known as Nibbling by potable shearing machine.

8. **Hemming:** - It is a Process of folding the edge of sheet to provide stiffness and safety on hand for sheet metal products.

9. **Seaming:** - It is a Process of interlocking of sheet metal products such as drums, can, bucket, funnel etc.

10. **Forming**: - It is a Process of shaping sheet metal objects to give it desire shape and size of the final product by using different shapes of stakes.

11. **Planishing:** - It is a Process of giving good surface finish by rubber, Nylon & wooden mallets.

12. **Swaging**: - It is a Process of marking the sheet into a ridge surface or corrugated. Ex: Rolling shutters, Roof Sheets etc.

13. **Coining**: - Coin, medal and other similar part are produced by using hand press with coining die and punch.

14. **Stamping**: - It is a Process of printing letters and other figures on metal using stamping dies and punch. A, B and 1,2

15. **Riveting**: - It is a Process joining permanent in which the end of the metal pin is pressed over or spread out by hammering operation.

SKETCHES OF SHEET METAL TOOLS

Fine Adjustment   Trammel   Mallet

Standard Wire gauge

Cutting edge

Straight   Bend

Snips

Groover

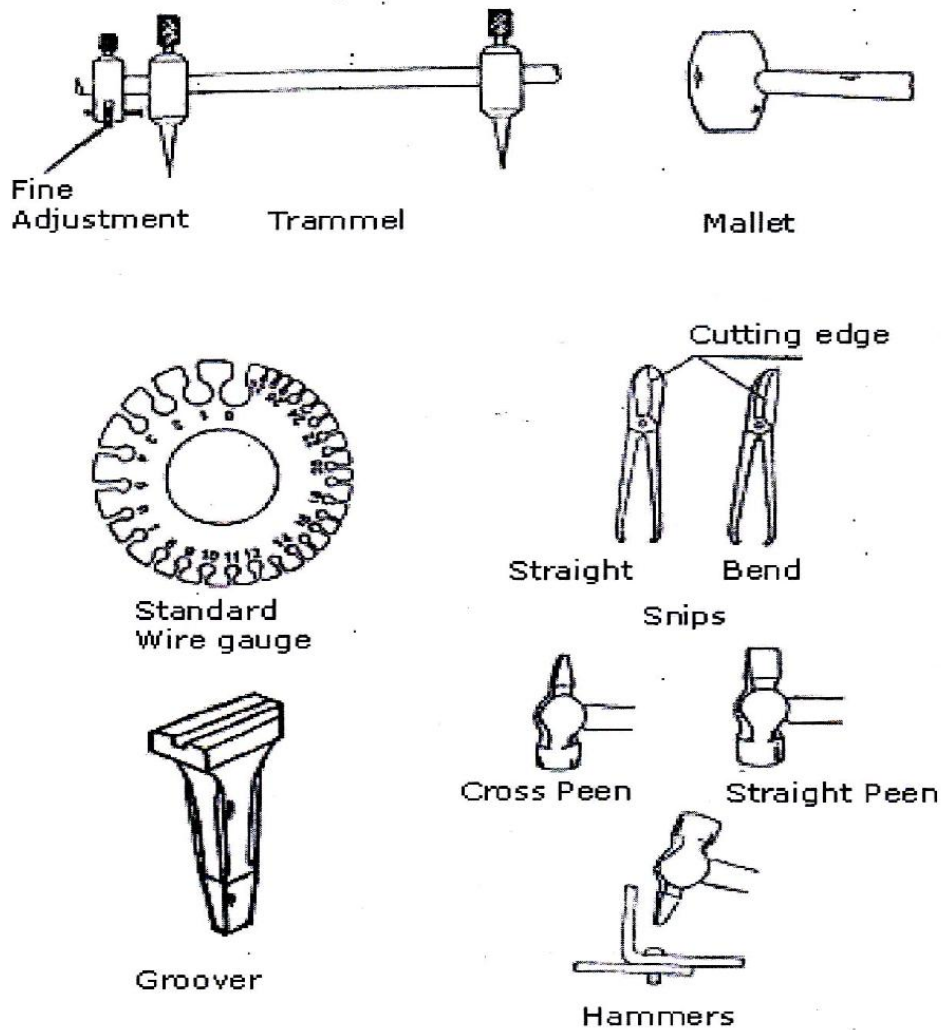Cross Peen   Straight Peen

Hammers

Fig. Sheet Metal Tools

SOLDERING

Soldering is a method of joining similar or dissimilar metals by means of a filler metal whose melting temperature is below 450°C. The filler metal usually called 'solder' is an alloy of tin and lead in various proportions.

The surface of the parts to be joined are first cleaned in order to remove dirt, grease and other oxides. After cleaning, 'flux' is applied at the edge of the parts to be joined. Zinc chloride, Hydrochloric acid and Alcohol-rosin are some of the fluxes used in soldering.

The function of the flux is to wet the surface of the work piece and to permit the molten solder to flow easily into the joint. It also prevents oxides from separating the solder from the surface. The solder is heated by an electric source, usually a soldering iron and molten solder is deposited at the joint. The solder is allowed to cool for some time and then the soldered joint is cleaned to remove any flux residues in order to avoid corrosion.

FLUX

The principal function of the flux is

- To wet the surface of the metal and to permit the molten solder to flow easily into the joint.
- To clean any impurities, present on the surface of the sheet metal to be joined.
- To prevent the formation of oxides during soldering.

The different types of flux used are

- Borax it is the most commonly used flux. It is supplied as a powder mixed with water. It should always be applied as a paste.
- Zinc chloride or Killed spirits although it is commonly used, it causes corrosion.
- Resin type flux or rosin It is non-corrosive but does not have the cleaning properties of zinc chloride
- A mixture of equal amounts of HCI solution and zinc chloride solution.

SOLDERING IRON

Figure shows the soldering iron used for soldering sheet metal joints. The working end of this tool is made of copper, which is a good conductor of heat.

Material for soldering bit Copper (copper bit wets readily and the molten solder clings to the bit easily).
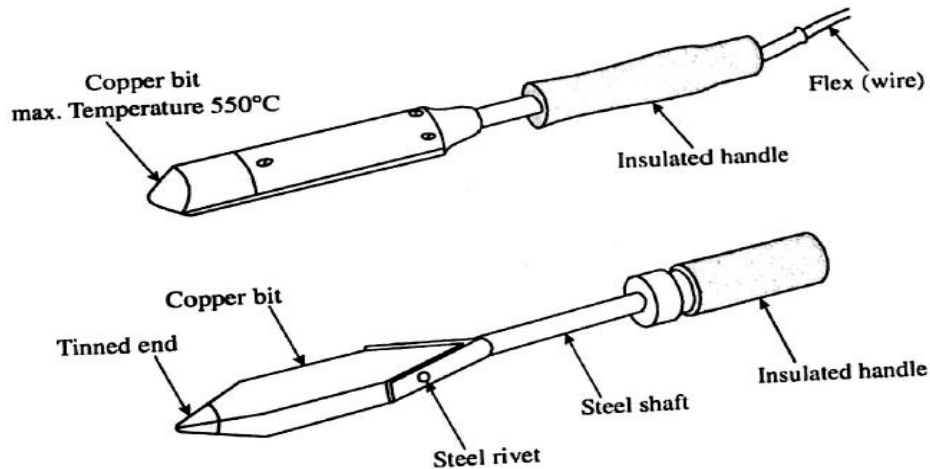
Fig. Soldering iron

SOLDER
A solder is an alloy metal which melts at low temperatures. There are two types of solder.
  (i) Soft solder
- These are alloys of tin and lead. (Lead =37 % and Tin = 63 %).
- The melting range of soft solder is between 150 - 190°C.
- Soft solders are used where the soldered joints are not subjected to heavy loads and high

temperatures.

(ii) Hard solder

- Silver alloyed with lead (lead = 97.5 % and silver = 2.5 %) or silver alloyed with copper and zinc are called hard solder. (Silver = 50 %, copper = 34 % and zinc = 16 %). A soft solder in the form of wire is shown in Figure.
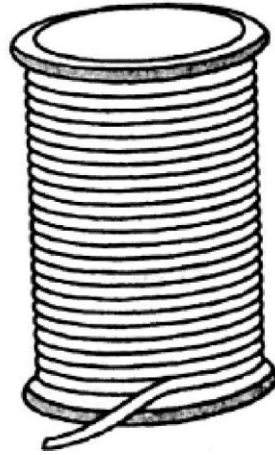
Fig. Solder

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Development of Hexagonal Prism

Development of Hexagonal Prism

All dimensions are in mm
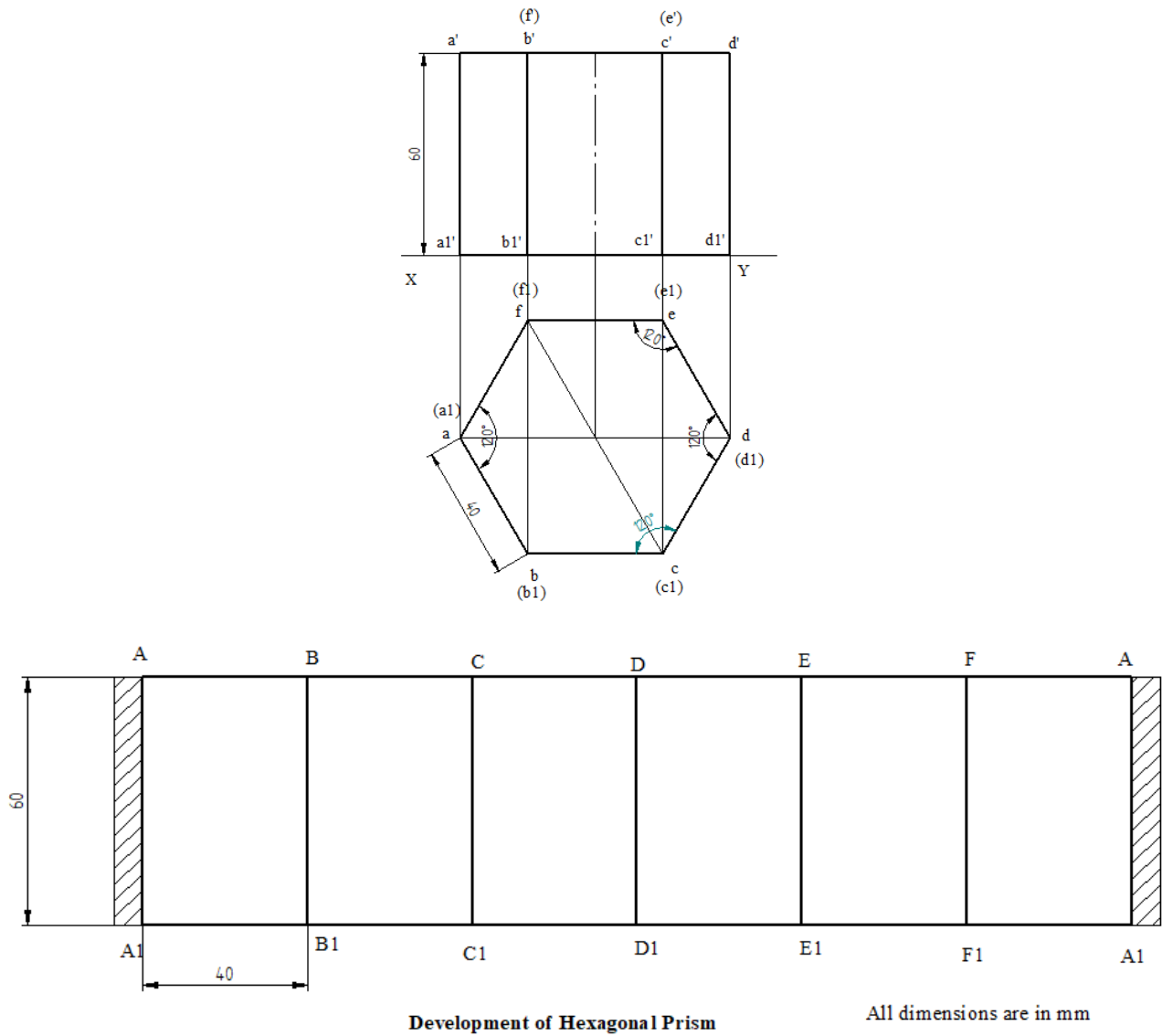
Sequence of operations or procedure for preparing Hexagonal Prism

- Draw the top and front view of the prism of the given dimensions.
- Equal to six sides of the prism 40 X 6 =240 mm.
- Draw a stretch out line A1A1 and mark off the sides of the base along this line i.e. A1B1, B1C1, C1D1 & D1E1, E1F1 and F1A1.
- Erect perpendiculars through these points and mark the edges AA1, B B1, CC1, DD1, EE1, FF1 and AA1 and height of the prism 60mm.
- Add 5mm extra adjacent to AA1 for seam joint.

- Cut the development to shape on lines by using paper cutting scissor.
- Place and fix the development on gives G.P sheet by using sticker.
- Punch two points on each bending line.
- Mark the boundary line by using marking pen.
- Remove the paper development join the two points by scriber or marking pen.
- Shear the boundary lines by hand snip.
- Flatten the sheet by using mallet on flatter.
- Always bend the seaming line first and then the remaining lines to get desired shape.
- Finish the surface keeping on stake to shape.
- Solder the joint.
- Finish the surface finishing and complete the job.

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Experiment No.: 02   Date:
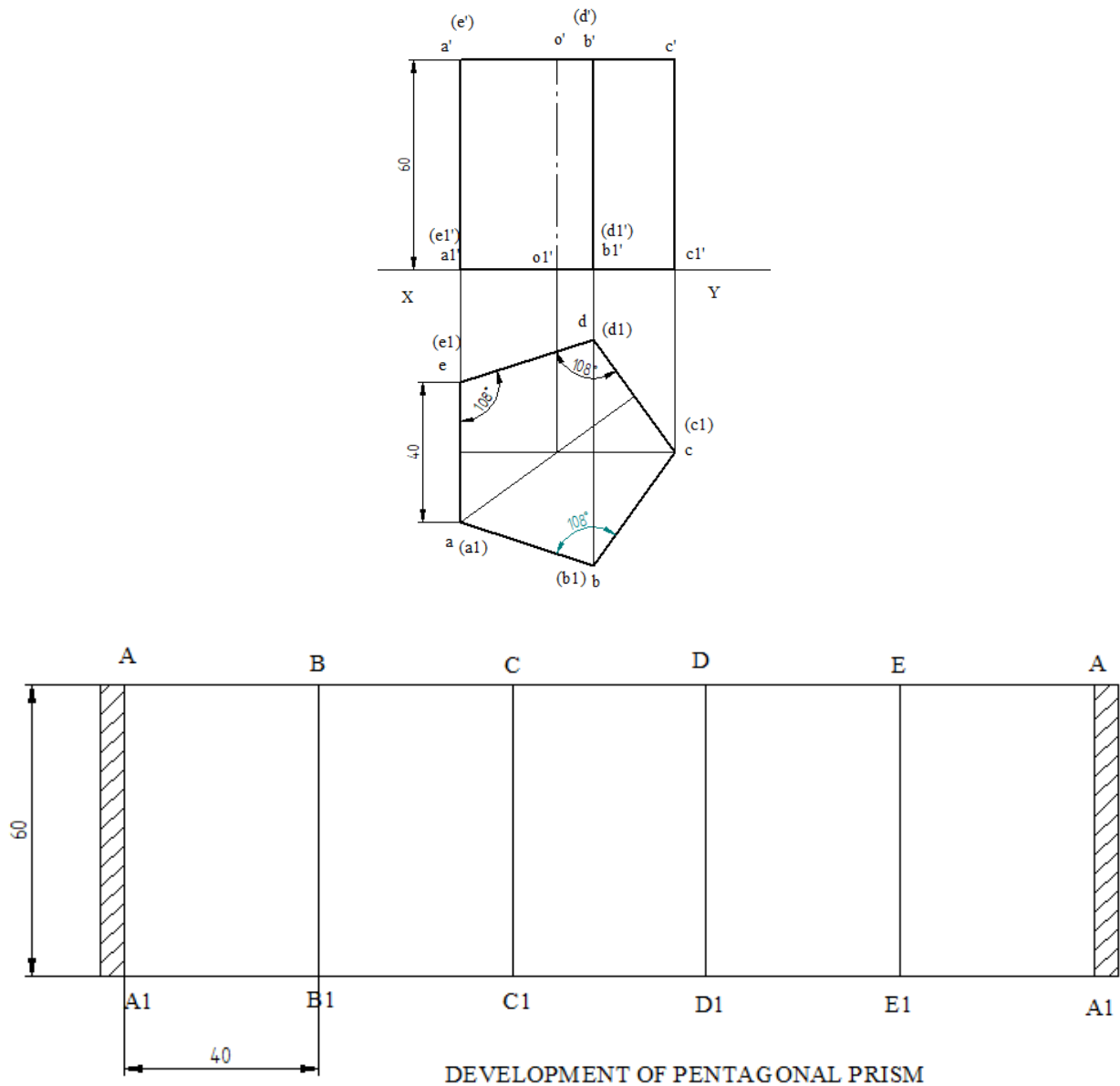
Development of Pentagon Prism

DEVELOPMENT OF PENTAGONAL PRISM

All dimensions are in mm

Sequence of operations or procedure for preparing Pentagonal Prism

- ➢ Draw the Top & Front view of the prism to the given dimensions.
- ➢ Draw a stretch out line A1A1 and mark off the sides of the base along this line i.e. A1B1, B1C1, C1D1 & D1E1 and E1A1.
- ➢ Erect perpendiculars through these points and mark the edges AA1, B B1, CC1, DD1, EE1 and AA1 and height of the prism is 60mm.
- ➢ Add 5mm extra adjacent to AA1 on each side.
- ➢ Cut the development to the shape of the line by using paper cutting scissor
- ➢ Place & fix the development to the given GP sheet by using sticker.
- ➢ Punch the two points on each bending line
- ➢ Mark the boundary line by using marking pen.
- ➢ Remove the paper development; join the two points by scriber or marking pen.
- ➢ Shear the boundary line by hand snip.
- ➢ Flatten the sheet by using mallet on flatter.
- ➢ Always bend the seaming line first and then the remaining lines to get desired shape.
- ➢ Finish the surface keeping the stake to correct shape
- ➢ Solder the joints
- ➢ Finish the surface finishing and complete the job

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Development of Truncated Square Pyramid

DEVELOPMENT

All dimensions are in mm
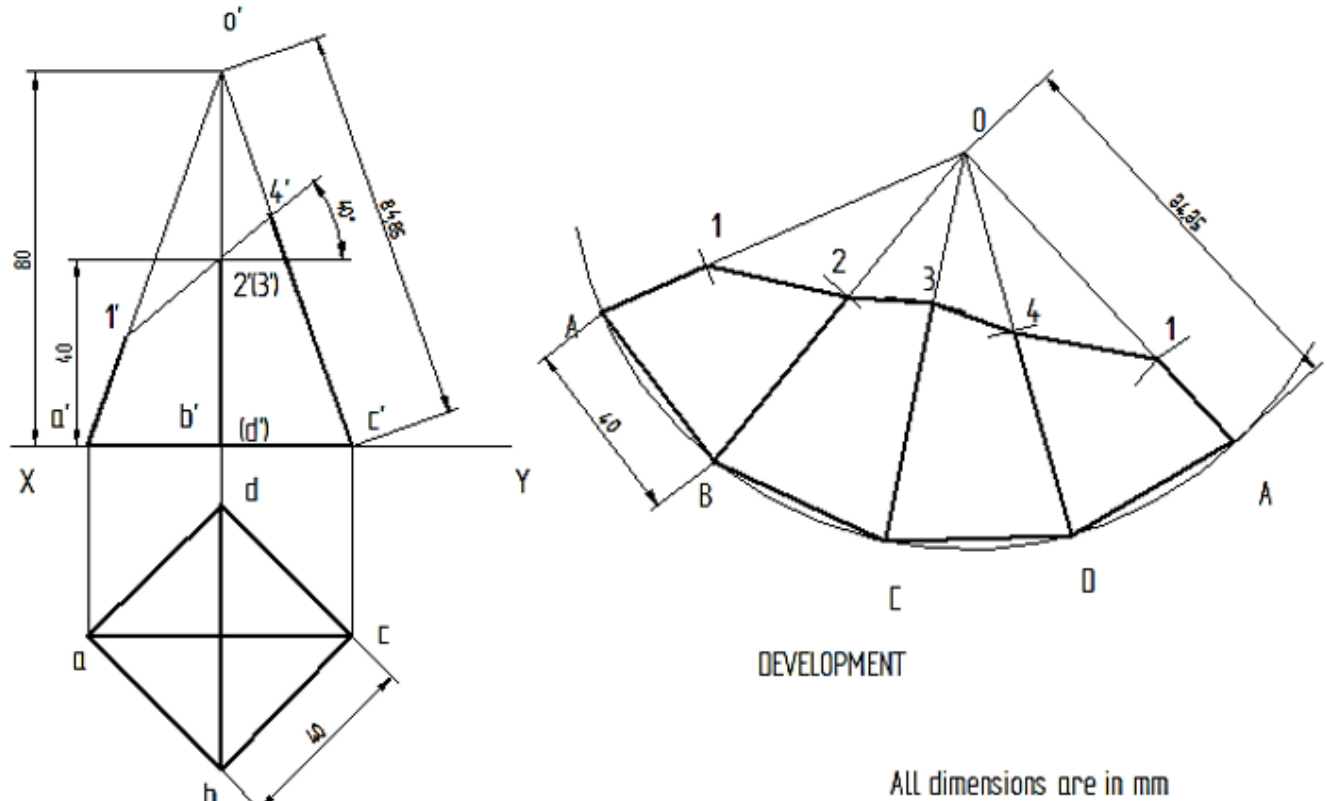
**Sequence of operation to prepare truncated square pyramid.**

- Draw the front view of the Truncated Pyramid as per dimensions.
- Extend the outer slant edges to mark apex 'O''.
- Project and get the top view of the pyramid and O'C is the true length of the slant edge.
- With O' as center and radius O'C' describe an arc.
- Transfer the true length of top face edges 40mm each on the arc AB, BC, CD and DA. Join them with straight line and to Apex 'O'.
- Section points are marked on the development by measuring their true distances from O on the true length of slant edge in front view.
- Join the sections and draw dark lines to set the development of the surface of the remaining portion of the pyramid.
- Set 5mm extra for seam joint.

- Continue the same procedure of marking, bending, forming

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Development of Frustum of Cone

Development

All dimensions are in mm
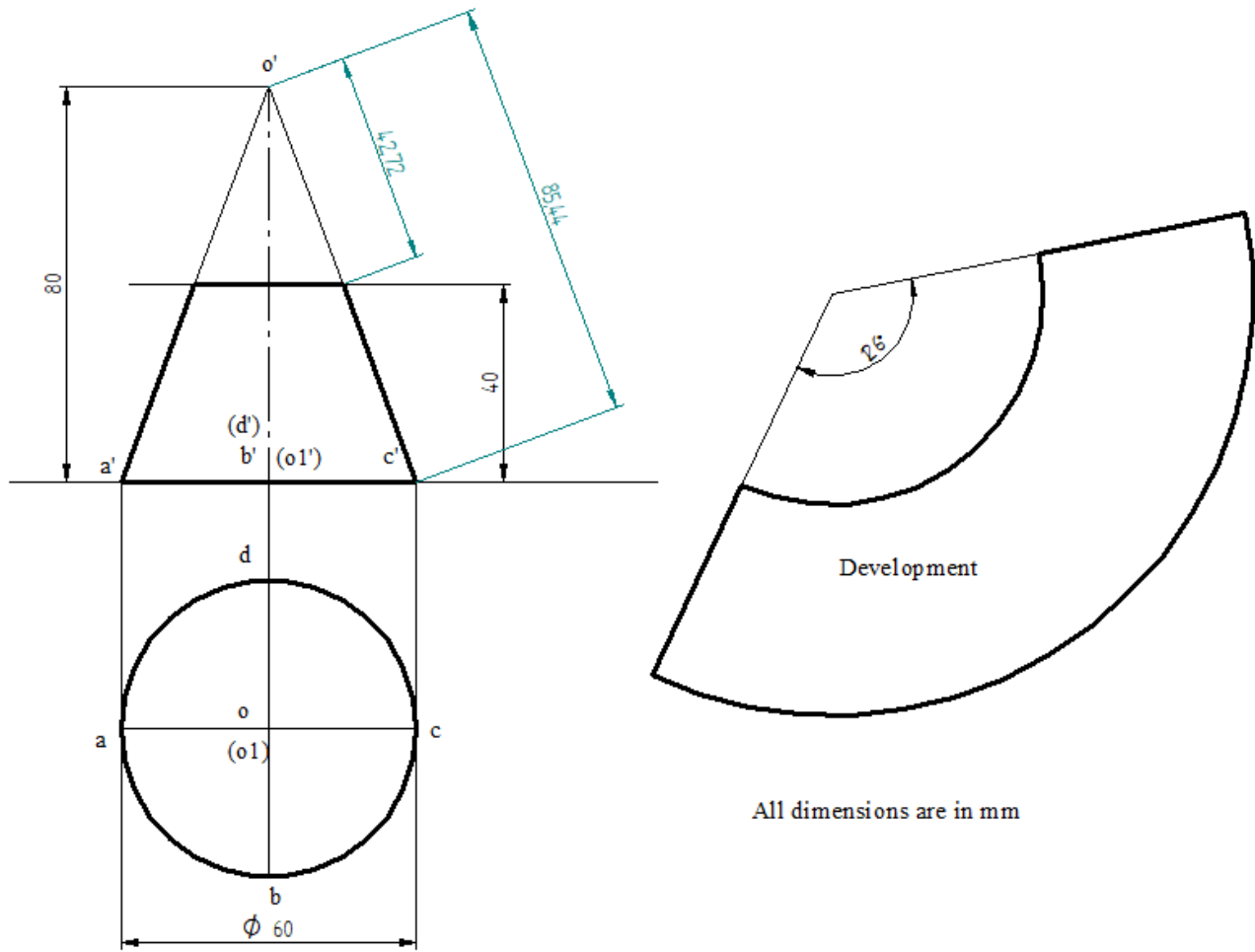
Procedure:

Draw the top view and front view of the right circular cone of base dia. 60mm. A section plane cuts perpendicular to the axis of the cone at 40mm height above the base.
With 'O' as center and radius equal to slant generator length (O'C' or O'A'), draw an arc.

Find =(r/R) x 360° where r= Radius of the base circle of the cone, R=Length of slant generator of the cone and 360° = Angle subtended to cut the arc.

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Development of Funnel

All dimensions are in mm

Development   ①   65

Pi ⋅ d = 94,24

Procedure for preparing a funnel

Draw the top view and front view of the right circular cone of base dia. 60mm. A section plane cuts perpendicular to the axis of the cone at 40mm height above the base.
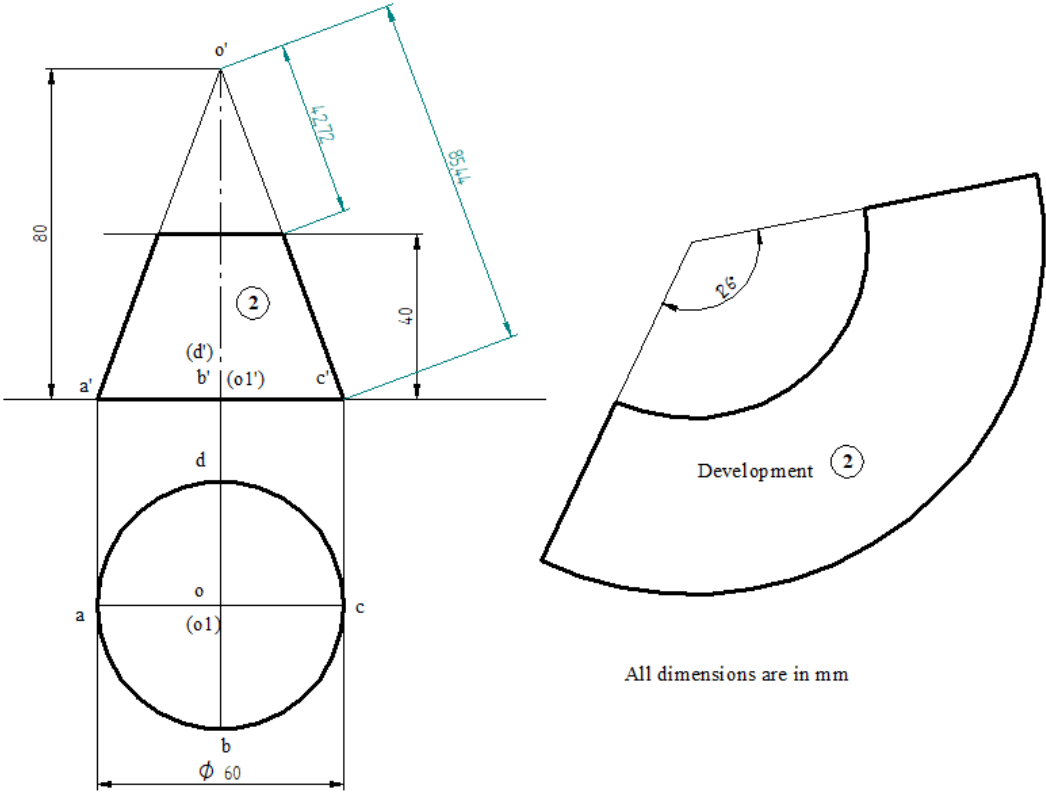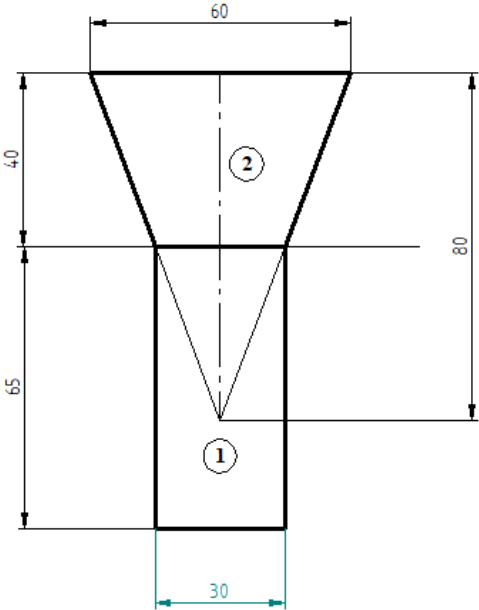With 'O' as center and radius equal to slant generator length (O'C' or O'A'), draw an arc.

Find =(r/R) x 360°where r= Radius of the base circle of the cone, R=Length of slant generator of the cone and 360° = Angle subtended to cut the arc.

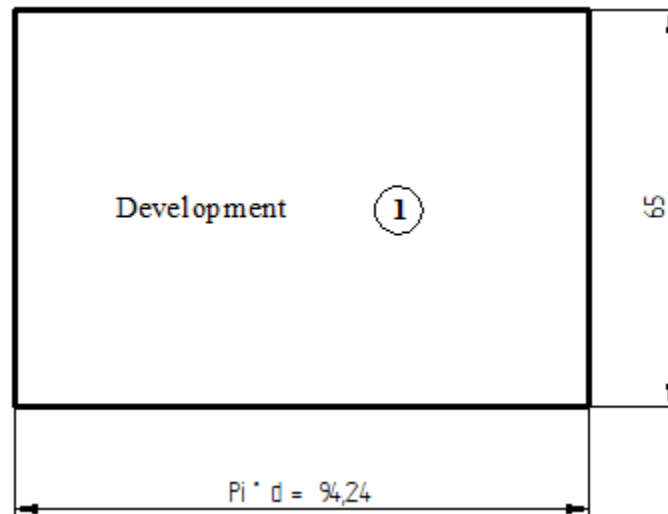- o Draw the top view and front view of the cylinder of base dia. 30mm and bottom of funnel is beveled off completely to 40°.
- o Develop the cylinder of base diameter 30 mm and height 65mm.
- o Circumference =2r, where r =Radius of cylinder
- o Cut the sheet along the line according to shape of the development.
- o Fold 5 mm extra allowance in clockwise and anti-clockwise directions by keeping hacksaw blade thickness and pressed.
- o Remove the hacksaw blade, Bend the main body using the stake and lock the end joint.
- o Solder the two parts with electric soldering.

Date…………….   **Signature of theFaculty**

Development of Rectangular Tray
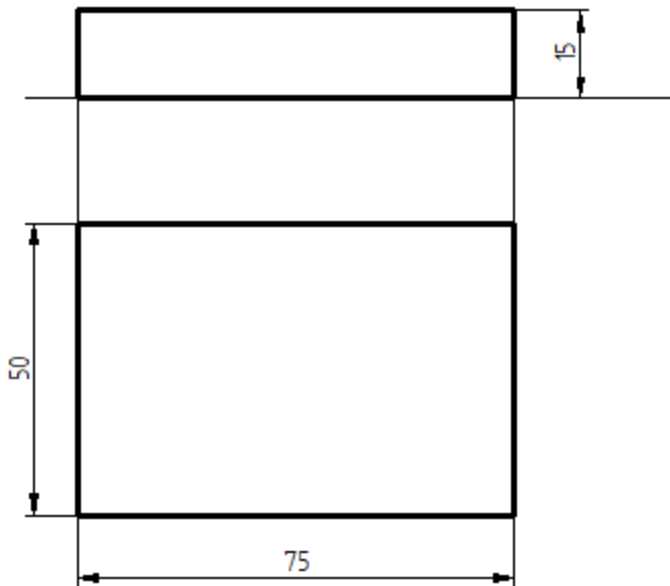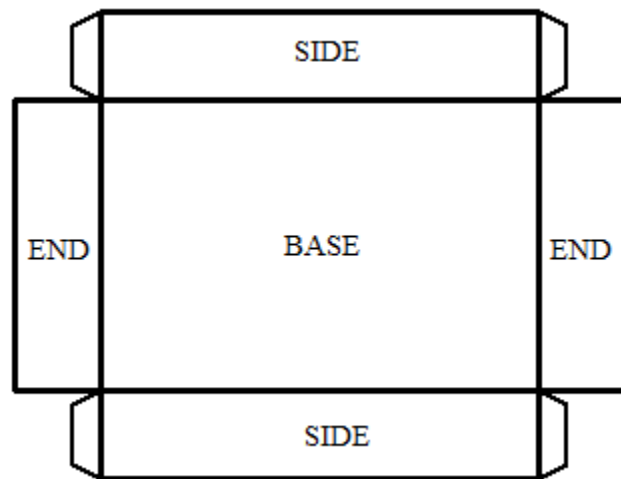
2D Drawing
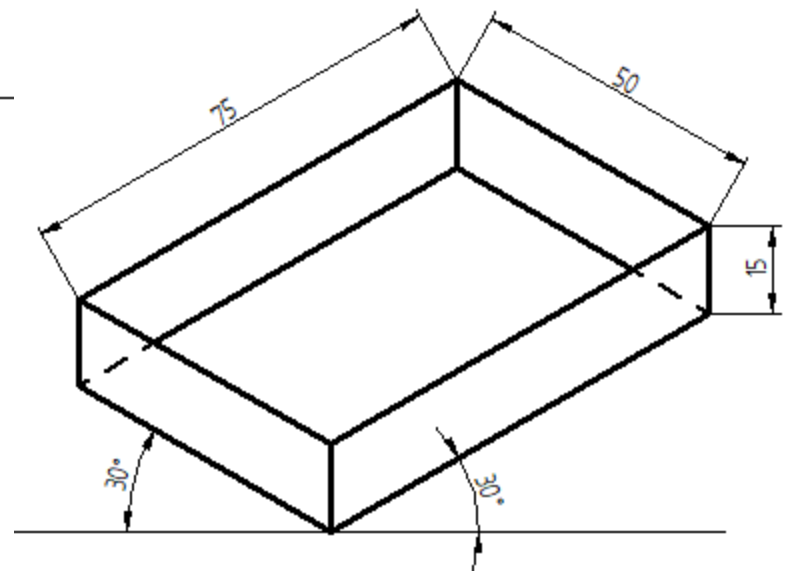
3D Drawing (Isometric)

Development of Rectangular Tray

Sequence of operation or Procedure to prepare Trays in Sheet metal.

- Draw 2D/ 3D sketches as per scale.
- Draw the development considering all lines must be a "True Length"
- Construct the base of the Tray.
- Construct the two sides of the tray.
- Construct the two ends of the tray.

- Set 5mm extra, allowance on side face for joining the corners by seaming.
- Notch the points to prevent bulging on seaming
- Cut the development shape on lines by using paper cutting scissor
- Place and fix the development on given G.P sheet by using Sticker.
- Punch two points on each bending line.
- Mark the boundary line by using Marking Pen.
- Remove the paper development join the two punch points by a scriber or marking pen.
- Shear the boundary lines by hand snip.
- Flattening the sheet by using mallet on flatter.
- Always bend the seaming line first and remaining lines to get the desired shape by forming.
- Finish the surface keeping on stake to shape.
- Solder the joint.
- Finish surface finishing and complete the Tray.

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Viva Questions with answers

1. What is coresand?

   Sand that prepared by mixing a special binder such as core oil with sand, that develop high strength.

2. What are the properties of good mouldingsand?

   ➢ Permeability

   ➢ Cohesiveness or Strength

   ➢ Adhesiveness

   ➢ Plasticity

   ➢ Refractoriness

   ➢ Binding

   ➢ Chemical resistivity

   ➢ Flowability.

3. What is moldingsand?

   Its prepared by using a mixture of base sand, binder, additives and with or without water. The mixture of sand is referred to as moulding sand.

4. What is abinder?

   It is a material, which imparts the necessary binding action to the sand, a binder holdsthe sand   grains together and induces strength and other properties to themoulds

5. What is greensand?

   Containing 5-7% water and 6-10% clay it's the cheapest of sand mix.

6. What ispermeability?

   The ability of sand to allow the gasses to escape from the mould

7. What isclay?

   Its most common binder system used in foundries, it's a product of siliceous rocks, containing hydro silicates of alumina (Al_2O_3).

8. What is the importance of GFN? Explain how GFN affects the properties of sand andcasting.

Grains fineness number Fine grain sand result in good surface, on the casting but gases cannot escape out of the mould made from it. Coarse grain sand allows gases to escape out easily but the casting surface will be very rough. Hence grain size should select appropriately.

9. What are the different types of patterns used infoundry?

- Solid pattern

- Split pattern

- Cope and Drag pattern

- Loose piece pattern

- Gated Pattern

- Match plate pattern

- Follow board pattern

- Skeleton pattern

- Sweep pattern.

10. What are the different methods of preparingmoulds?

- Open mould

- Pit mould

- Loma mould

- Sweep mould

- Core sand mould

- Cement bonded mould

- Plaster mould

- CO_2 Sand mould

- Shell mould.

11. What is a dry sand mould? Why binder isused.

Its refers to sand mould in the dried condition when there is no moisture in the mould, Dextrin is used up to 2% with clay as Binder.

12. What are the different types of furnaces used formelting?

- ➢ Crucible Furnace
- ➢ Coke Fired Furnace
- ➢ Gas or oil-Fired Furnace
- ➢ Resistance Furnace
- ➢ Electric Arc Furnace
- ➢ Induction Furnace
- ➢ Cupola Furnace.

13. What are the different tools used for making moulds in thefoundry?

- ▪ Round Rammer
- ▪ English Trowels
- ▪ English cleaner
- ▪ Spoon tool
- ▪ Smoothers
- ▪ Bellows.

14. What is pattern allowance? Why it isrequired.

Pattern has the same shape as that of the casting but the dimensions will be generally than that of the casting. This extra dimensions or deviations from the required value, given on the pattern are referred to as pattern allowance.

15. Name different allowances given for thepattern.

- ❖ Shrinkage allowances

❖ Draft allowances

❖ Machining allowances

❖ Scale & grinding allowances

❖ Distortion allowances

16. What are the different patterns materials used infoundry?

- Wood

- Metal

- Plastic

- Wax

- Plaster of Paris.

17. What is cope andDrag?

The upper part of mould is cope and lower part of mould is drag.

18. What isfoundry?

Shaping the metal components in their molten stage is known as Foundry.

19. Name different additives used in foundrypractice.

o Cereal husks

o Sea Coal

o pitch

o wood flour

o Silica flour

o Iron oxide

o Dextrin

o Molasses.

20. What iscasting?

Casting is a manufacturingprocess by which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process.

21. Name the different castingprocesses.

❖ Sand Casting

❖ Permanent Mold Casting

❖ Low Pressure Casting

❖ Die Casting (high pressure)

❖ Direct Squeeze Casting

❖ Continuous Casting

❖ Investment Casting

❖ Shell mould casting

❖ Vacuum Casting

❖ Investment (top) and Conventional Castings

❖ Lost Foam Casting

❖ Centrifugal Casting

22. What is aCore?

Core is sand blocks they are used to make hollow portion in a casting.

23. How a core ismade?

Core is made separately in a core box made of wood or metal.

24. What isSprue?

It is taper shaped vertical component in the system. It will help transfer of molten metal

from the pouring cup into the runner.

25. What is Runner andRiser?

It is a long horizontal channel which carries molten metal and distributes it to the ingates or gates. It will ensure proper supply of molten metal to the cavity so that proper filling of the cavity takes place.

Riser is to supply the molten metal to the solidifying casting and eliminate shrinkage cavity and should permit easy escape of air and gases.

26. Name some of the Common castingdefects.

- Porosity/Holes

- Shrinkage cavity

- Inclusions

- Hot Tears

- Scab, Rat tails

- Sand burn-on/sand fusion

- Cold shut

- Core shift/Mould shift

- Fins.

27. What isgating?

Molten metal is conveyed into the mould cavity and the mould gets completely filled up. After solidification, the solid metal represents casting, for conveying the molten metal into the mould cavity components referred to as Gating system.

28. What isforging?

The process of shaping the metal components in cold or hot condition by the application of impact or pressure but the primary difference b/w various forging method is the rate which the energy is applied to the work piece.