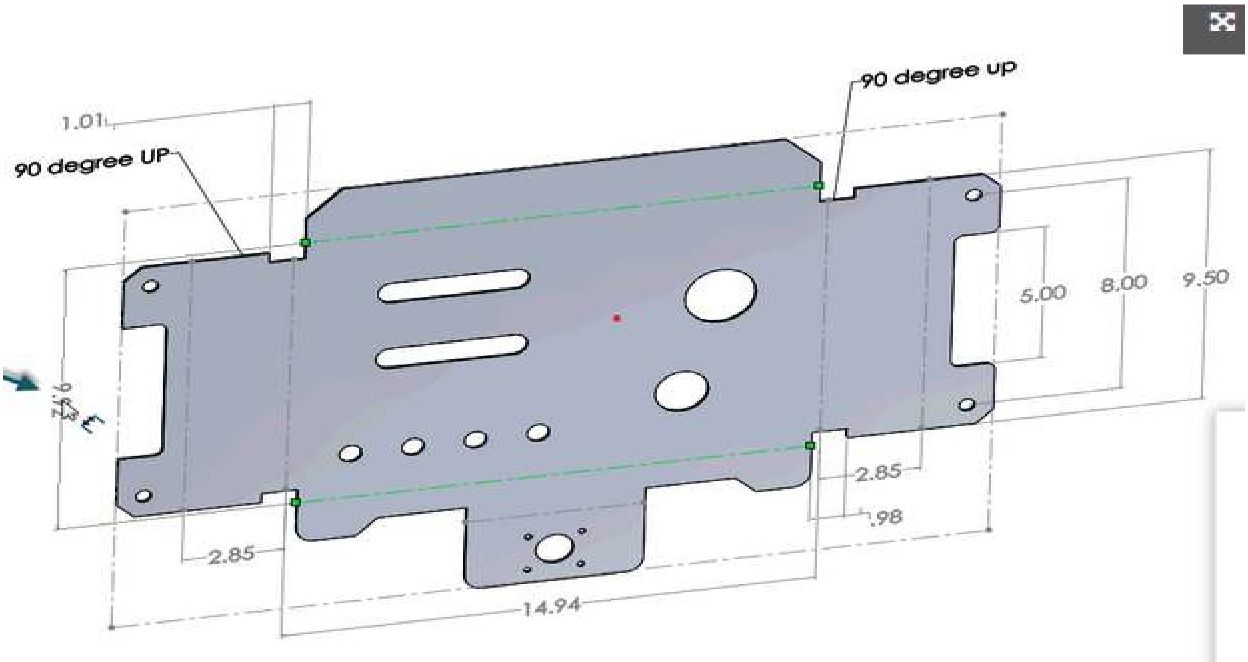
# MECHANICS LEVEL – II

# Based on March 2022 Curriculum

# Version 1




MODULE TITLE: **Preparing drawings for fabricated sheet metal products**

MODULE CODE: **IND MCS2 M02 0322**

NOMINAL DURATION: **70 Hours**

**Prepared by: Ministry of Labor and Skill**

**Aug, 2022**

**Addis Ababa, Ethiopia**

**Table of Content**

## Acknowledgment

**Ministry of Labor and Skills** wish to extend thanks and appreciation to the many representatives of TVT instructors and respective industry experts who donated their time and expertise to the development of this Teaching, Training and Learning Materials (TTLM).

## Acronym

**TVET – Technical vocational Education Training**

## Introduction to the Module

In mechanics filed ; the **Preparing drawings for fabricated sheet metal products** is provides a sound basic knowledge skills, and attitudes required to apply standard preparing drawing and interpretation, transferring the drawings to sheet metal development and fabrication process associated with a range of drawing instrument standard ,specification and equipment at the metal engineering workplace of manufacturing detailed drawing fabricated sheet metal products.This module is designed to meet the industry requirement under the **mechanics** occupational standard, particularly for the unit of competency: **Preparing drawings for fabricated sheet metal products**

**This module covers the units**

- interpret specifications
- fabrication techniques
- Prepare detail drawing
- store drawings Document

**Learning Objective of the Module**

- interpret required product specifications
- Identify fabricated techniques  sheet metal products
- Perform detail drawing
- Perform drawing document and store

**Module Instruction**

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the "LAP test" giver at the end of each unit and
5. Read the identified reference book for Examples and exercise

## Unit one   Access and interpret specifications

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- sheet metal product specifications
- sheet metal products fabricated techniques
- organizational and industry standards

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Classify sheet metal products fabricated techniques
- Interpret sheet metal product specifications
- Identify organizational and industry standards

## 1.1 sheet metal product specifications

**A sheet metal symmetrical development** is defined as a stretch out of an object on a flat sheet metal surface. To obtain a pattern of a given body, we need to cut it along one, two or more of its edges so that it can be stretched on a flat surface. The concept of pattern development plays a vital role **in sheet metal work**. A wide variety of packing materials are also prepared from carton using the concept of pattern development.

**Work requirements**

Since sheet metals are expensive, it is important that students make practice using hard paper (Classer). After they have grasped the basic knowledge of pattern development they move on to actual sheet metal process. So this course is divided in to two major parts: ***Pattern practice using hard paper*** and ***actual work using sheet metal***.

The first part can be held in a standard drawing room where students draw the given pattern on hard paper, then cut-off the pattern, make the necessary forming and finally join the edge using a paper glue (UHU).

The importance of this part is tremendous.

1. Hard paper is easily manageable than sheet metal
2. Sheet metal Wastage is minimized

So patternpracticeusinghardpaper is basically a technical drawing except the cutting, forming and joining process involved. All drawing instruments needed for technical drawing are employed. For this reason drawing instruments and their function is revised in this learning material.

### 1.1.1Carrying out development using appropriate tools and equipment

**Introduction**

As stated above students usually start pattern development using hard paper. We draw a pattern on a hard paper, then we cut it off, make the necessary forming and finally we join the edge using a paper glue(UHU). So this part of the lesson is just a technical drawing except all those cutting, forming and joining processes. Therefore, students must make a review of the instruments we use in technical drawing and how we can use them.

**Identifying drawing instruments**

The common instruments that we use in technical drawing are discussed below.

**Drawing Board** - drawing work is carried out by fixing the drawing sheet on the drawing board. The drawing board is made of soft wood or plastic. There is perfectly straight projecting edge on one side of the board known as working edge, which is useful when T-square is used in the drawing.

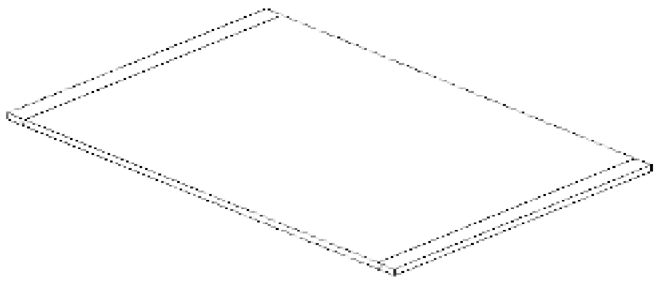


Figure 1.1 Drawing bored

**T-Square** - is composed of a long strip, called the blade, fastened rigidly at right angles to a shorter piece called the head. The upper edge of the blade and the inner edge of the head are working edges and must be straight. T-square is used to draw horizontal lines.

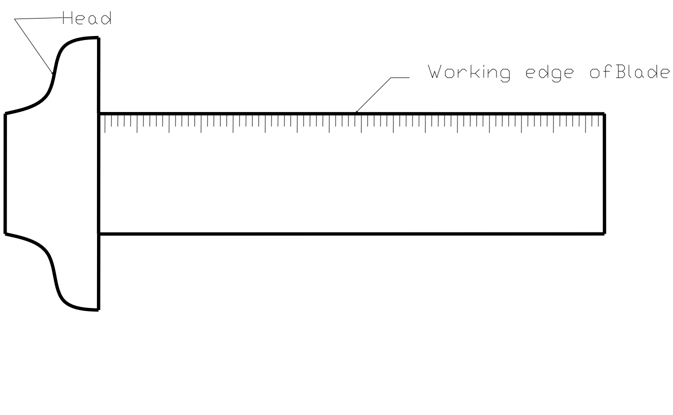
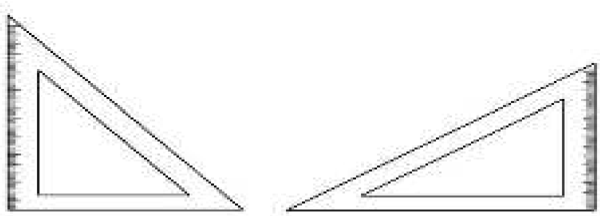



***Figure 1.2 T-Square***

***Set squares*** - The setsquares commonly employed in technical drawing are 45$^{o}$ and 30- 60 triangles.

.



45$^0$ Setsquare 30- 60 Setsquare

Figure 1.3 set square

**Compass** - is used for drawing circles and arcs of different radii. It consists of two legs hinged with each other. A pin is fitted in one of the legs; other end has a detachable pencil.

**Figure 1.4 compass**

**Divider** - the dividers consist of two legs hinged at the upper end and have steel points at both the lower ends. The dividers, as the name implies, are used for dividing distances into a number of equal parts. They are also used for transferring distances or for setting off a series of equal distances.

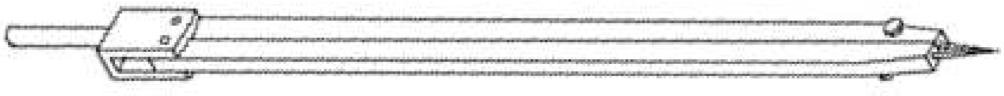


**Figure 1.5 divider**

**Protractor** - is used for measuring or setting of angles other than those obtained with the set square.

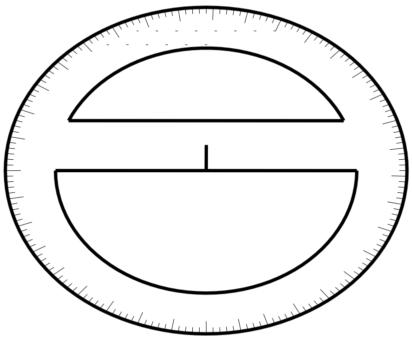


**Figure 1.6 protractor**

**French Curve** (Irregular Curves) - is required to draw mechanical curves other than circle or circular arcs. Many different forms and sizes of curves are manufactured. French curves are composed largely of successive segments of the geometric curves, such as ellipse, parabola, hyperbola, and involutes.

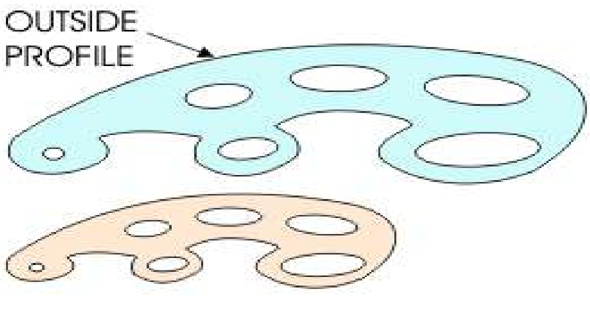



**Figure 1.7 French curve**

**Eraser** – erasers are available in many different degrees of hardness and abrasiveness. A good quality soft pencil eraser is recommended for erasing light and undesirable lines.

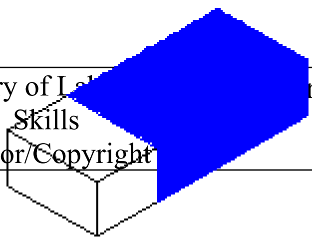


**Figure 1.8 Eraser**

**Dusting Brush** – is useful for removing eraser crumbles from the drawing.

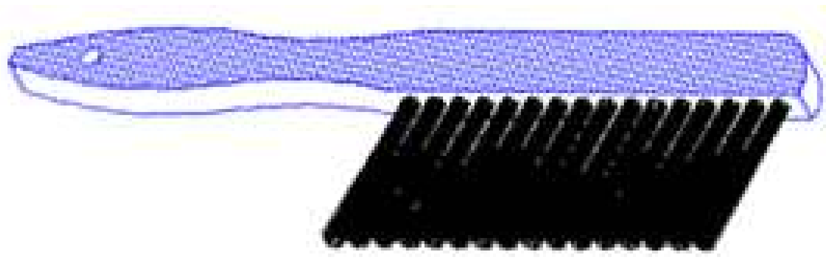


**Figure 1.9** Dusting brush

## 1.1.2 Datum points

A datum point refers to a reference point from which you start a drawing. So the main thing you need to understand here is that you can't start a drawing from anywhere you like. If you do so you will find down the road that your drawing goes out of paper boundary or work piece boundary. Such problems usually arise in triangulation method. The concept behind a datum point is that you should always know the size of your paper (work piece) and the size of a figure you are going to draw. Then you have to start your drawing from some suitable place so that it properly fits in to the paper (work piece). Specially during examinations such kind of error will nullify your result because you may not get enough time to start the work from scratch once again.

## 1.1.3 Template material

The Need for Templates

There are several reasons for the use of templates or patterns in the sheet metal and plate fabrication industries. For example:

1. To avoid repetitive measuring and marking-off of the dimensions, where a number of identical parts or articles are required. Marking-off large numbers of exactly the same type from a template or pattern is a much quicker method and a great deal more accurate than measuring and marking each part individually.

2. To avoid unnecessary wastage of material. Very often, when marking a full-size layout directly on to a sheet or plate, from information given on a drawing, it is almost impossible to anticipate exactly where to begin in order that the complete layout can be economically accommodated. Consequently, large-size layouts tackled in this manner generally result in an extravagant waste of material.

### Materials Used for Templates

Table 1 gives details of the materials used for templates together with some of their applications.

In the making of templates considerable use is made of timber: it is easy to drill and cut to shape, relatively light in weight, and fabrication instructions can be pencilled on it. Suitable wooden battens of various convenient widths and usually 10 mm or 12 mm thickness are cut to represent the steel members outlined on the template floor. These battens are then laid on the appropriate lines on the floor together with the paper or hardboard patterns representing gusset plates and cleat angle connections. All are temporarily nailed to the floor in their exact positions to represent the particular steel structure. The centers of holes required for making the connections to be bolted or riveted are marked on the assembled templates, which are then removed from the floor to be drilled and have the necessary fabrication instructions marked on them. After being drilled, and the information for the guidance of the fabricators having been marked on them, the whole assembly is replaced in the correct position on the template floor and checked for accuracy. They are then carefully stored until required on the workshop floor.

| **Material** | **Applications** |
|---|---|
| Template paper | Outlines for small bent shapes, such as brackets, small pipe bends and beveled cleats may be set out on template paper. Used for developing patterns for sheet metal work. |
| Hardboard | Templates for gusset plates to be produced in small quantities. |
| Timber | Used in considerable quantities for steel-work templates. Easy to drill and cut to shape. Whitewood timber strips (battens) up to 153mm wide and 12.7mm thickness are |

| | |
|---|---|
| | used to represent steel members. Plywood used for making templates for use with oxy-fuel gas profiling machines. |
| Sheet metal | Used for making patterns for repetition sheet metal components. Templates for checking purposes. Steel, 3.2mm thick is used for profiling templates on oxy-fuel gas profiling machines fitted with a magnetic spindle head. |
| Steel plate | Light steel plate fitted with drilling bushes is used as templates for batch drilling of large gusset plates. |

Table. 1. 1Material Used for Templates

**Template Making**

Large fabrication workshops are often provided with an area reserved for template making, known as the 'template shop' or 'loft'. Such shops are usually situated above the normal shop floor level, but those situated at ground level are fitted with an overhead runway and lifting tackles to handle steel plates for the making of steel templates.

A template shop should be well glazed to ensure good lighting during daylight hours, and provided with adequate artificial lighting for use in the darker hours. Specialist template makers are employed in the template shop to produce accurate templates for use in the various fabrication shops by the croppers, smiths, benders, platters and welders when cutting, marking for drilling, punching, forming and welding the steel parts. Skilled template makers must possess a sound knowledge of the principles of plane geometry and be able to apply workshop calculations. They must be able to interpret detailed drawings and also have the ability to use carpenter's tools. Much of the machinery used in a template shop is of the type normally used for woodworking, such as a circular saw, fret-saw, planning machine and woodworker's drilling machine. It also includes a cardboard shearing machine to cut the special template paper.

Procedures for making template/patterns

**Pattern**

A pattern is a physical representation of a project. Typically this is a full-size drawing of the project. Newsprint (available at art supply stores) is excellent for large drawings. You can easily lay out grid lines on the paper. For smaller scale drawings graph paper (also available from art supply stores) that has 1/8" squares allows you to quickly transfer measurements from a project plan. Draw the pattern using a soft 2B pencil –You can then cut out individual parts of the pattern using a sharp utility knife and a straight edge for the straight sections and a pair of scissors for the curved sections. Use 3M Super 77 Spray Adhesive to attach the patterns onto pieces of poster board. You'll then need to trim the poster board with knife or scissors.

Place the pattern on a piece of stock. Keep in mind that grain running contrary to the curves on your pattern won't enhance the look of the final product, so place the pattern accordingly. If it is a complex pattern you may need to tape it in place. Use a sharp 2B pencil to trace the outline on your stock. Remove the pattern and then use the appropriate tools to shape the part. Remember that with a pattern you can transfer the shape onto your stock, but all of the processes to mill the part will still need to be done manually. The pattern mounted to poster board is fine for a limited number of uses, but it is not very durable and will deteriorate after a while.

**Template**

when you have more parts to make than a simple poster board pattern will allow it is time to make a template. A template is a more robust version of the pattern. To make a template, follow the same steps in drawing the pattern for the part on the graph paper; if your parts are longer than the paper, tape two sheets together. Use spray adhesive to attach the pattern to a piece of ⅛" hardboard and trim away the excess on the band saw. Refine the edges using a sander if necessary, but files are the best tools for fine-tuning a template. You can also use ¼" MDF or Baltic birch plywood for your template. MDF is a little sturdier than hardboard, it can be shaped easily, and its extra width will support a bearing guided router bit. Baltic birch is the ultimate in durable template stock because of its strength and rigidity. When fine-tuning the edge of a template that will be used with a piloted router bit be sure to keep the edge perpendicular to the face of the template.

Template/patterns labeling, identification and storage

On wooden or hardboard templates the necessary information is best marked with an indelible pencil. Colored pencils are also used for marking information. On sheet metal templates, for example, which are to be used for the marking of various diameter holes, it is common practice to mark rings, triangles or squares around the holes required to be of the same diameter with a distinguishing color. On steel templates, whitewash or white paint is often used for marking the information.

Typical information 'written-up' or labeled on templates may be as follows:

1. Job or contract number,
2. Size and thickness of the plate,
3. Steel section and length,
4. Quantity required,
5. Bending or folding instructions,
6. 'This side up', 'left hand' or 'right hand',
7. Drilling requirements,
8. Cutting instructions,
9. Assembly reference mark.

To use for long period of time patterns and templates should be stored in appropriate place

- Store them in moisture free place
- Protect them from corrosion
- Clean properly before storage

### 1.1.4 Review of technical drawing

A technical drawing starts with a simple task like drawing lines at various orientations. This is important since most of the figures that we make in geometric development are composed of different types of lines. As a beginner, therefore, it is a must that we understand how to draw horizontal, vertical and inclined lines.

3.1 Drawing a horizontal line

Drawing a horizontal line is a very simple task in technical drawing. It can be done in two steps as follows.

1. Properly align the edge of the T-square with the edge of the drawing table
2. Use the edge of the T-square to draw the line

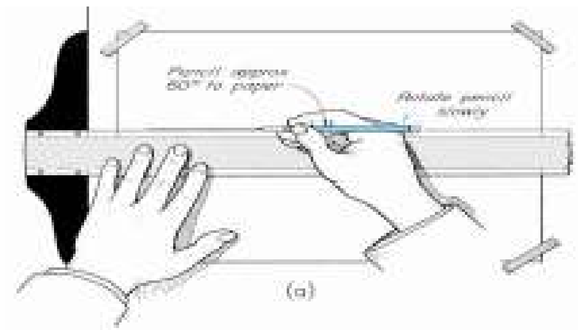


**Fig.1.10** Drawing a horizontal line

**Drawing a vertical line**

A drawing table and a T-square alone is not enough to draw a vertical line. They should be combined with a set square and properly aligned to each other to draw a vertical line. The three steps needed to draw a vertical line are summarized as follows.

1. Properly align the edge of the T-square with the edge of the drawing table
2. Properly align the edge of the set square with the edge of T-square
3. Use the edge of the set square to draw the line

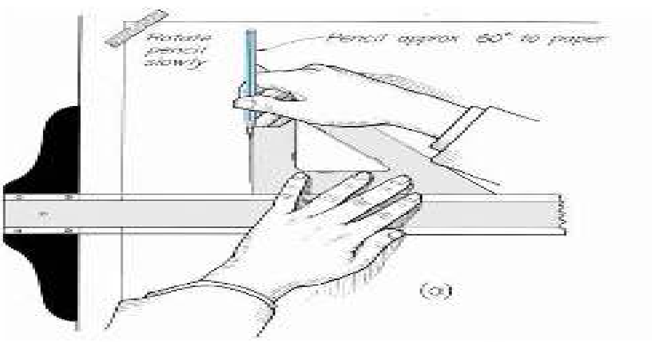



**Figure 1.11** Drawing a vertical line

3.3 Drawing an inclined line

The steps needed to draw an inclined line is identical to that used for a vertical line except that the inclined edge of the set square is used to draw the line. The three steps needed to draw an inclined line are summarized as follows.

1. Properly align the edge of the T-square with the edge of the drawing table
2. Properly align the edge of the set square with the edge of T-square
3. Use the edge of the set square to draw the line

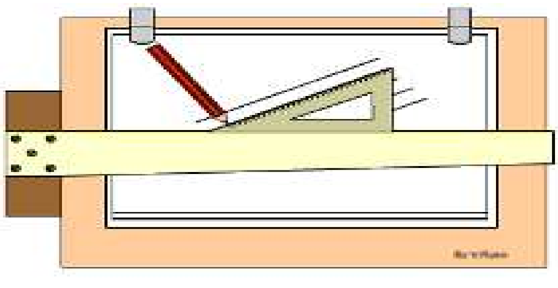


**Figure 1.12** Drawing an inclined line

3.4 Drawing simple plane figures

Tools and procedures required to draw horizontal, vertical and inclined lines are illustrated in the previous section. In this section, we will extend this concept to drawing of simple plane figures.

**Example1:** Draw the following triangle with the given dimension.

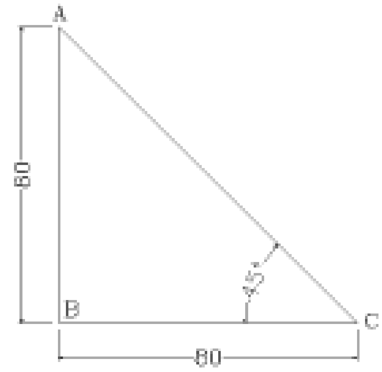



**Figure1.13** triangle

Drawing the triangle can be done in three steps.

1. Use the procedure given in section 1.10 to draw the horizontal line BC with the given dimension.
2. Use the procedure given in section 1.11 to draw the vertical line AB with the given dimension.
3. A plastic rule can be used to join end points A and C

**Example 2**: Draw the rectangle given below with the given dimension

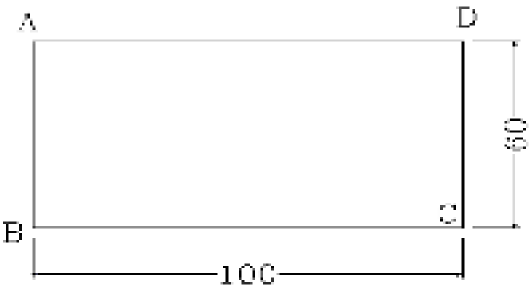


**Figure 1.14** Rectangle

1.Drawing the rectangle can be done in four steps.

2.Use the procedure given in section 1.10 to draw the horizontal line BC with the given dimension.

3.Use the procedure given in section 1.11 to draw the vertical line CD with the given dimension.

4.Use the procedure given in section 1.11 to draw the vertical line BA with the given dimension.

5.plastic rule can be used to join end points A and D

**Example 3**: Draw the circle given below with the given radius

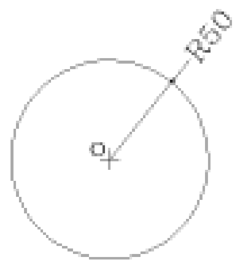



**Figure 1.15**Circle

Drawing the circle can be done in three steps.

1. On the drawing paper, mark the center point o at some suitable location
2. Open your compass with a radius equal to 50mm
3. Use point o as center and draw the circle.

**Example 4**: Draw a circular arc as shown in the figure below.

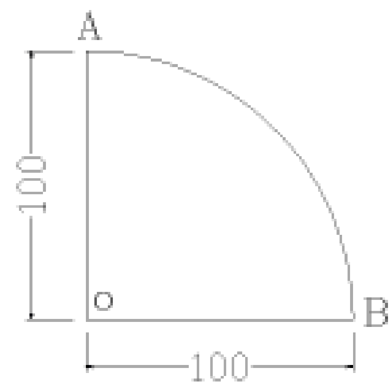


**Figure 1.16** Circular arc

The arc can be drawn in three steps

1. Use the steps given in section 1.10 to draw the horizontal line OB with the given dimension
2. Use the steps given in section 1.11 to draw the vertical line OA with the given dimension
3. Open your compass with a radius equal to 100mm and draw arc AB using point o as center

**Example 5**: Draw the regular hexagon given below with the given dimension

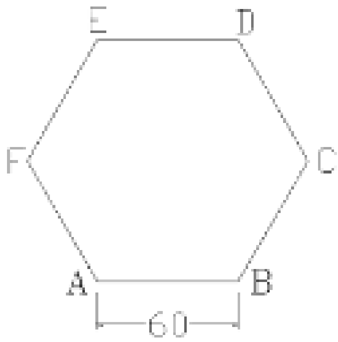



**Figure 1.17** regular hexagon

**Note**: For a regular polygon, all sides are equal to each other. In addition, all included angles are equal.

The following procedure can be used to draw the polygon.

1. Use the steps given in section 1.10 to draw the horizontal line AB with the given dimension
2. Use 30-60 set square to draw lines BC, CD, AF and FE as illustrated in section 1.3
3. A plastic rule can be used to join end points E and D

**Example 6**: Draw the regular octagon given below with the given dimension.

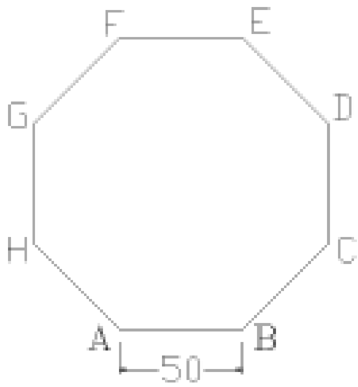


**Figure1.18** regular octagon

The steps needed to draw a regular octagon are very similar to that of a regular hexagon. The only difference is that all inclined lines are drawn using 45 degree set square.

**Detail steps are summarized as follows**.

1. Use the steps given in section 1.10 to draw the horizontal line AB with the given dimension
2. Use the 45 degree set square to draw lines BC, DE, FG and AH as illustrated in section 1.3
3. Use the steps given in section 1.11 to draw the vertical lines CD and GH with the given dimension

4. A plastic rule can be used to join end points F and E

**Example 7**: Draw a circle with a radius of 50mm and divide it in to 12 equal parts.

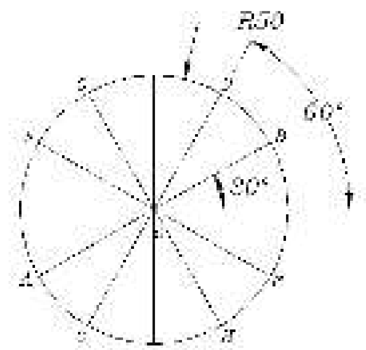



**Figure 1.19Detail steps** regular octagon

When a circle is divided in to 12 equal parts, 12 equal sectors are created each having a central angle of,

$$\emptyset = \frac{360}{12} = 30^0$$

**Now follow the procedure given below.**

1. Using your T-square and set square draw a horizontal and a vertical line which intersect somewhere at the midpoint. Let their point of intersection be O.

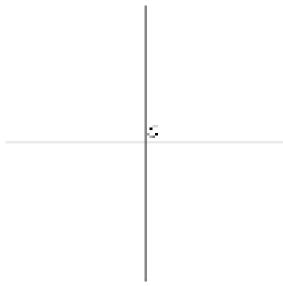


**Figure 1.20**Detail steps regular octagon

2. Open your compass with a radius equal to 50mm and draw a circle using point O as center

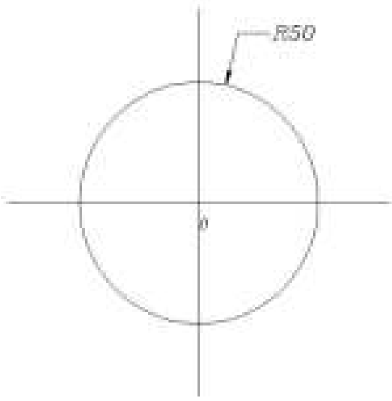



**Figure 1.21**Detail steps regular octagon

3. Use your T-square and 30-60 set square to draw an inclined line AB such that it passes through the center of the circle.

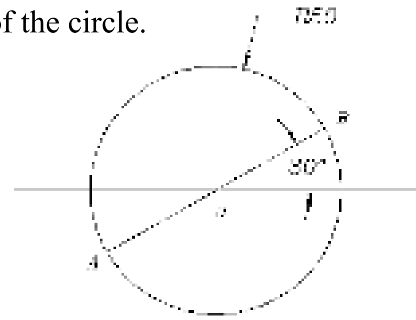


**Figure 1.22** Detail steps regular octagon

4. Use your T-square and 30-60 set square to draw an inclined line CD such that it passes through the center of the circle.

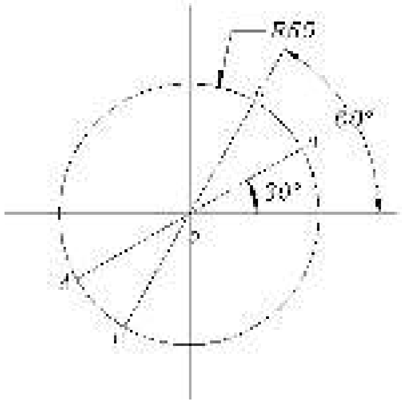



**Figure 1.23** Detail steps regular octagon

5. Repeat step #3 and #4 on the opposite side to get lines EF and GH.

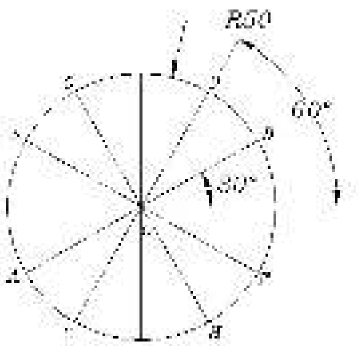



**Figure 1.24** Detail steps regular octagon

**Example8**: Draw the following triangle with the given dimension.

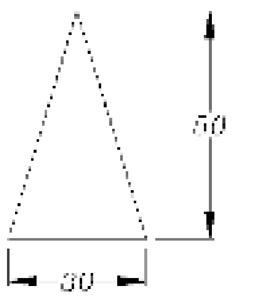


**Figure 1.25** Detail steps draw triangle

Follow the procedure given below to draw the triangle.

1. Take an appropriate datum point and mark point A on your paper.
2. Through point A draw a long horizontal line using a T-square.

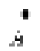



**Figure 1.26** Detail steps draw triangle

3. From point A measure a distance of 30mm to the right and mark point B.


**Figure 1.27** Detail steps draw triangle

4. Find the midpoint of line AB and mark point O.
5. Using your T-square and setsquare draw a vertical line through point O.


**Figure 1.28** Detail steps draw triangle

6. From point O measure a vertical distance of 50mm and mark point C

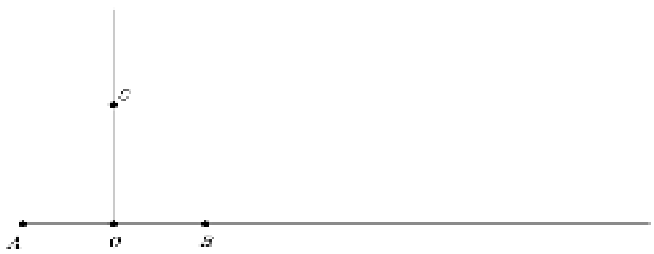



**Figure 1.29** Detail steps draw triangle

7. Use a straight edge and join points A and C. Similarly join points B and C.

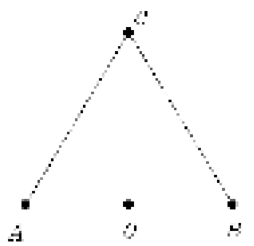


**Figure 1.30** Detail steps draw triangle

8. Erase all construction lines and construction points.

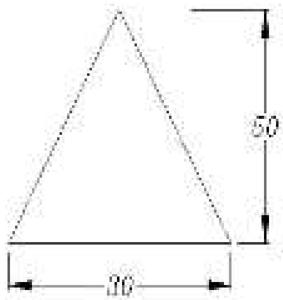
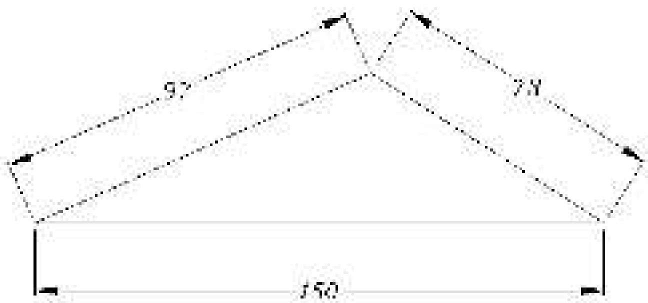



**Figure 1.31** Detail steps draw triangle

**Example9**: Draw the following triangle with the given dimension.



igure 1.32Detail steps draw triangle

The steps we have to follow to draw the triangle above is as follows.

1. Take an appropriate datum point and mark point A on your paper.
2. Through point A draw a long horizontal line using a T-square.

**Figure 1.33** steps 1draw triangle

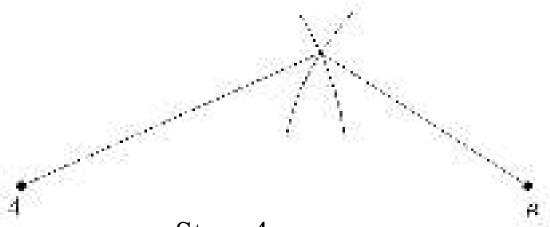
3. From point A measure a distance of 150mm to the right and mark point B.


Steps 2

4. Open your compass with a radius of 97mm and strike an arc using point A as center

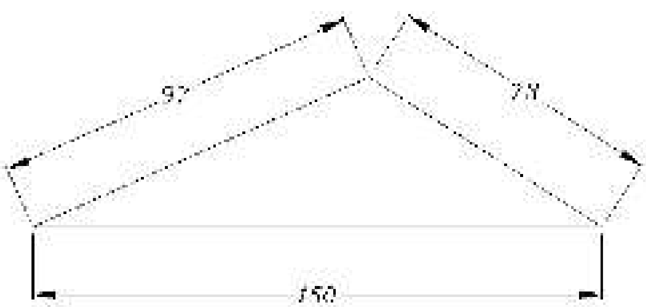
Steps 3

5. Open your compass with a radius of 73mm and strike an arc using point B as center



Steps 4

6. Erase all construction lines and construction points.



Steps 5

## 1.2 sheet metal products fabricated techniques

- **Tools and equipment**

  Any sheet metal work begins with pattern development. This can be provided in the form of a standard blue print or part drawing which shows all the dimensions required to produce the part. Once you have a blue print of pattern development the next step will be **lay out**. The term lay out means that the pattern given in the part drawing must be transferred to sheet metal. We redraw the given pattern on sheet metal with one to one scale. Once lay out is over the next step will be cutting. We cut the lay out along its exterior boundaries and remove it from the blank material. Then we make the necessary forming. This involves folding along edges or rolling or both. Finally we join the edges.

Therefore, the steps that we follow in sheet metal work can be summarized as follows.

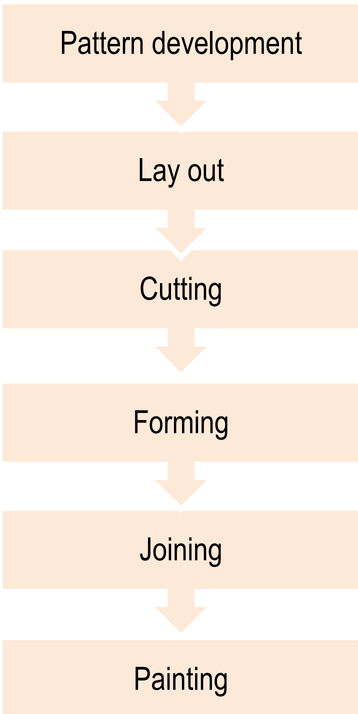



**Figure1.33**sheet metal products fabricated techniques

All the stages of sheet metal work we have seen above require various hand tools and machines. These hand tools and machines are summarized in the table below.

Table 2 Hand tools (machines) needed to carry out sheet metal processes

| ***Sheet metal processes*** | ***Hand tools (machines) needed*** |
|---|---|
| Pattern development | - Manual drafting using drawing instruments<br>- CAD applications |
| Lay out | -Scriber<br>-Divider (Trammel)<br>-Steel rule<br>-Try square<br>-Set square<br>-Combination set<br>-Center punch<br>- Hammer |
| Cutting | -Snip<br>-Bench shear<br>-Foot operated shearing machine<br>-Hydraulic shearing machine |
| Forming | - Folding machine<br>- Rolling machine |
| Joining | -Hammer<br>-Bench vice<br>-Rivet gun<br>-Welding machine |
| Painting | - Spray machine |

## 1.3 Organizational and industry standards

**The following points outline the process undertaken when fabricating sheet metal standard organization**

**1.WorkingwithBlueprint**

In accordance with blueprints generated by the engineer, the sheet metal product specifications will be specified. Rough drawings will be made to understand the scope of the fabrication process.

**2. Finalizing Drawings**

Once all the details have been finalized on, the final shop drawing will be made. Here, in-depth calculations are made to determine the levels of stress on the different parts of sheet metal. This analysis and calculation will determine the process to be followed in terms of fabrication.

**3.MetalFabrication**

This is the actual process of metal fabrication, where raw material undergoes several different processes to create the final product. This product is fabricated in accordance with the design guidelines and budget.

**4.ProductFinishing**

Once the product has been fabricated, it undergoes some finishing processes to make it commercially viable. Once the metal sheet is cut, bent, and formed into a desired shape, the surface finish is made with powder and paint coatings, silk screening, and other custom surface treatments. Various automated surface finishing treatments are designed to enhance unique properties of metal sheets such as conductivity, resistance, etc.For more information on your you can contact the Woodward-Fab team today!

**Self-check**

**Test –I** Multiple question

________1. Ellipse, Parabola and involutes can be drawn using ____________.

A. French curve B. Compass C. Set square D. T-square

E. None

________ 2. 30-60 set square cannot be used to draw lines inclined at _______.

A. 450 B. 300 C. 600 D. 900 E. all

________3. Angles which cannot be obtained using set square can be drawn sing __________

Compass B. French curve C. Template D. Protractor

-------------4.----------------- is Organizational and industry standards procedure

A. Working with blueprint B. Finalizing drawing C. Metal fabrication D. Product finishing

## Operation sheet -1 Draw the following regular hexagon s

**Operation Title Preparing drawings for fabricated sheet metal products**

**Purpose** The aim is that if students put the shape on hard paper according to the drawing given to them, they can convert it to sheet metal

**Instruction** Read the drawingprocedure ,instruction carefully and follow the order

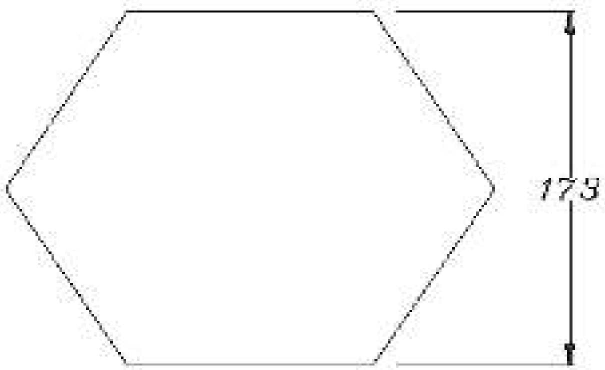



**Figure 1.34** regular hexagon

**Tools and equipment**

1. divider
2. steel ruler
3. compass
4. eraser
5. pencil
6. haredpaper
7. setsquare

Quality criteria all dimension are per specification legible, neatness are very important

Precaution safety first

## LAP Test -1

Task 1 measure each width of the hexagon

Task 2 the neatness

Task 3 the angels

## Unit two Identify fabrication techniques

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- features of sheet metal products
- materials used in fabricated products
- terminology, symbols and standards

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify features of sheet metal products
- Identify materials used in fabricated products
- Identify terminology, symbols and standards

## 2.1 Features of Sheet metal product

With bent sheet metal we mean the typical features that allow you to get the shape of the detail designed, starting from a flat metal sheet, cut out along the shape to be realized through welding and bending operations. These features have various fields of application according to the design method and/or the approach used. And these, in their turn, are influenced by the characteristics of the material chosen and the shape to be realized.

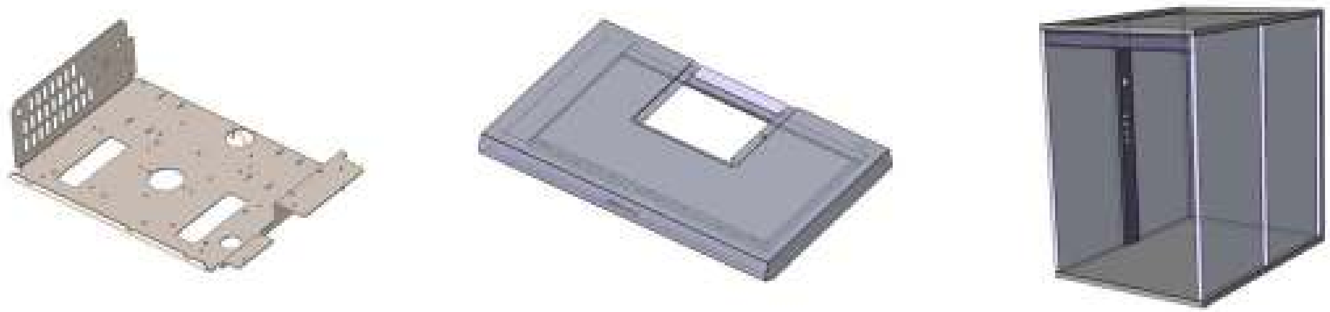


**Figure2.1** sheet metalFeatures

The approach to produce a detail in bent sheet metal includes a number of typical processes. Here are the most important ones:

Cutting of the shape of the flat metal sheet, executed with cutting machines such as laser cutting, oxygen lance cutting or punching;

- bending in the specific areas of bends, which requires specific machines and processes, as bending and roller leveling, according to the type of bend to be realized;
- execution of special features, such as forming or notching, to create slits, air intakes, punching and holes for fixing screws or rivets, etc.

In Think Design, one of the most important advantages in the use of the sheet metal feature is that designers, by means of a series of functions and parameters, can get all the information necessary for the realization of a particular model, which is soon ready for production. The 2D developed view, for instance, can be used for cutting the metal sheet.

To be more practical, let’s analyze the process to produce a base element. The starting point is a flat rectangular shape, to which we add a bend feature.

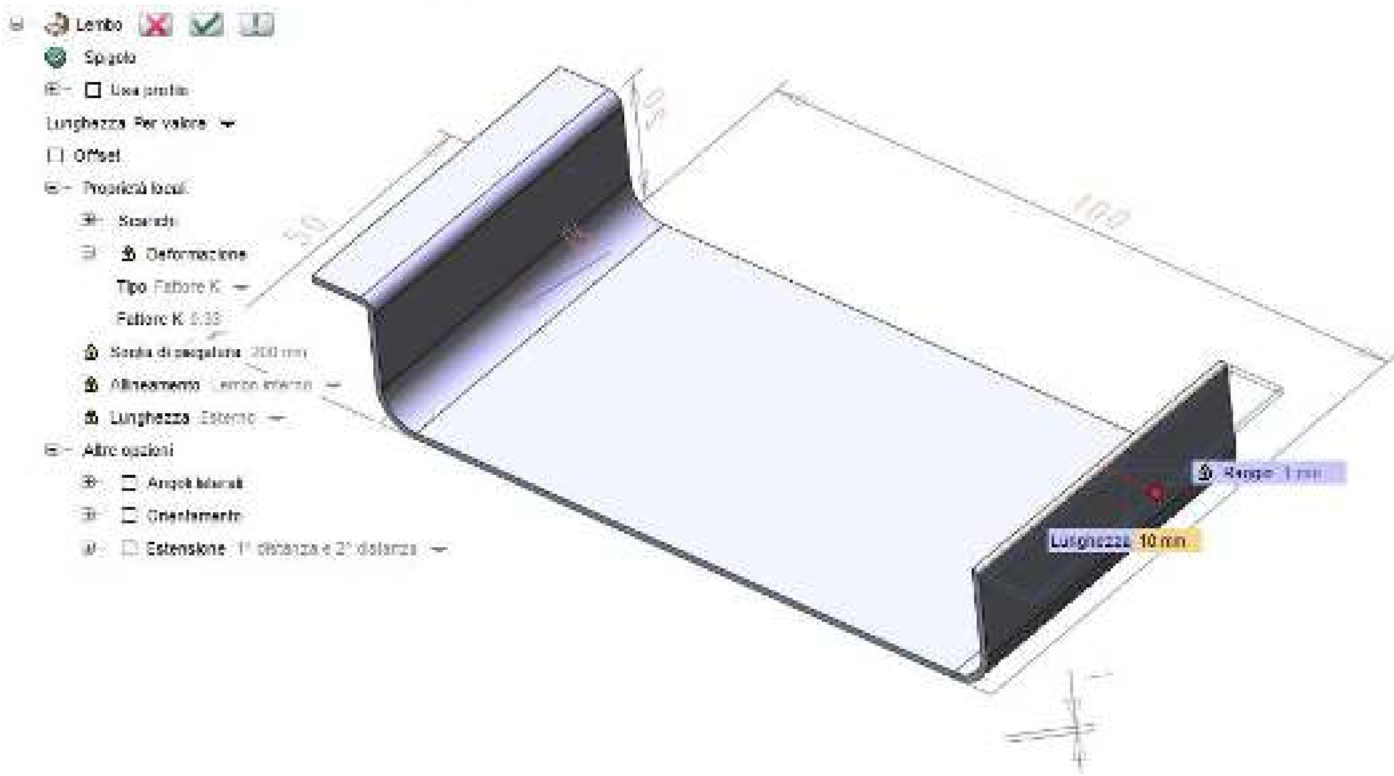



**figure**2.2 bend feature

The operator disposes of a specific command with a series of parameters which allow the control of the main features of the bend processing, such as the bend length and radius, the type of deformation and the characteristics of the relief to be carried out.

These parameters refer to the actual size of the model. This information saves time to the designer who, in this way, can avoid calculating in advance all the parameters and the necessary developments. The flat developed view carries out automatically all the necessary calculations to perform a precise cutting of the metal sheet, and also all the features relating to the bending process (bend lines and angle, etc.).

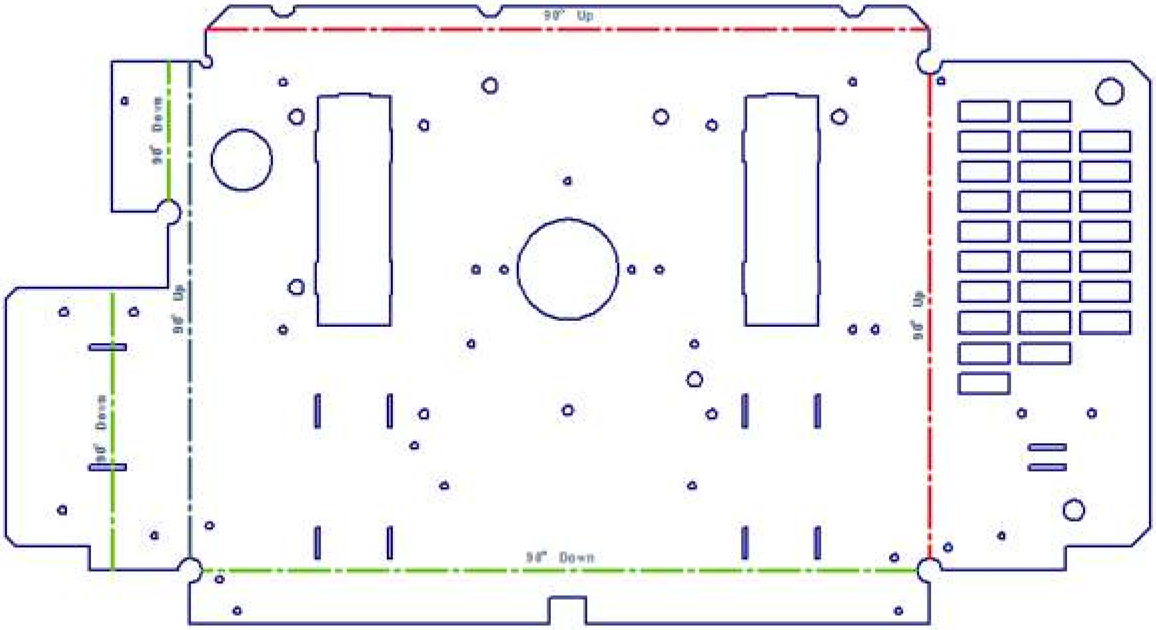
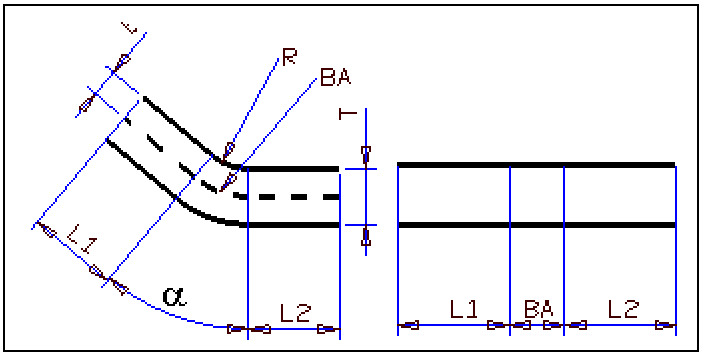



**Figure 2.3** sheet Metal Slot and Drill features

Moreover, the 2D developed view of a sheet metal detail (Flat Pattern View) calculates, for each bend, the relative bend allowance (BA), taking into account the bend radius and angle, and the thickness of the material as well.




$$L = L1 + BA + L2$$

**Figure 2.4** bending allowance terminology

The development can be calculated according to different criteria: in some cases the neutral axis (K factor) is kept into account, in others, such as the “Bend Deduction”, depend on the type of material that appears in specific tables (Bend Table Manager). Besides that, a series of properties parameters allow various representations of the bend lines – with hatches and different colors – so that the latter can be directly interpreted by the CAM systems for cutting and nesting. To insert an additional technical detail, consider that the 2D view can be exported to DXF or DWG format.The functionalities for the production of sheet metal details are directly integrated into the 3D modeling environment; this means that the designer disposes of the parametric solid modeling features that allow a very flexible and simple approach to the realization of the model. By means of the Unbend and Rebend commands it is possible to apply Slot or Drill features to the solid in both developed and bent statuses thus getting the correct development.

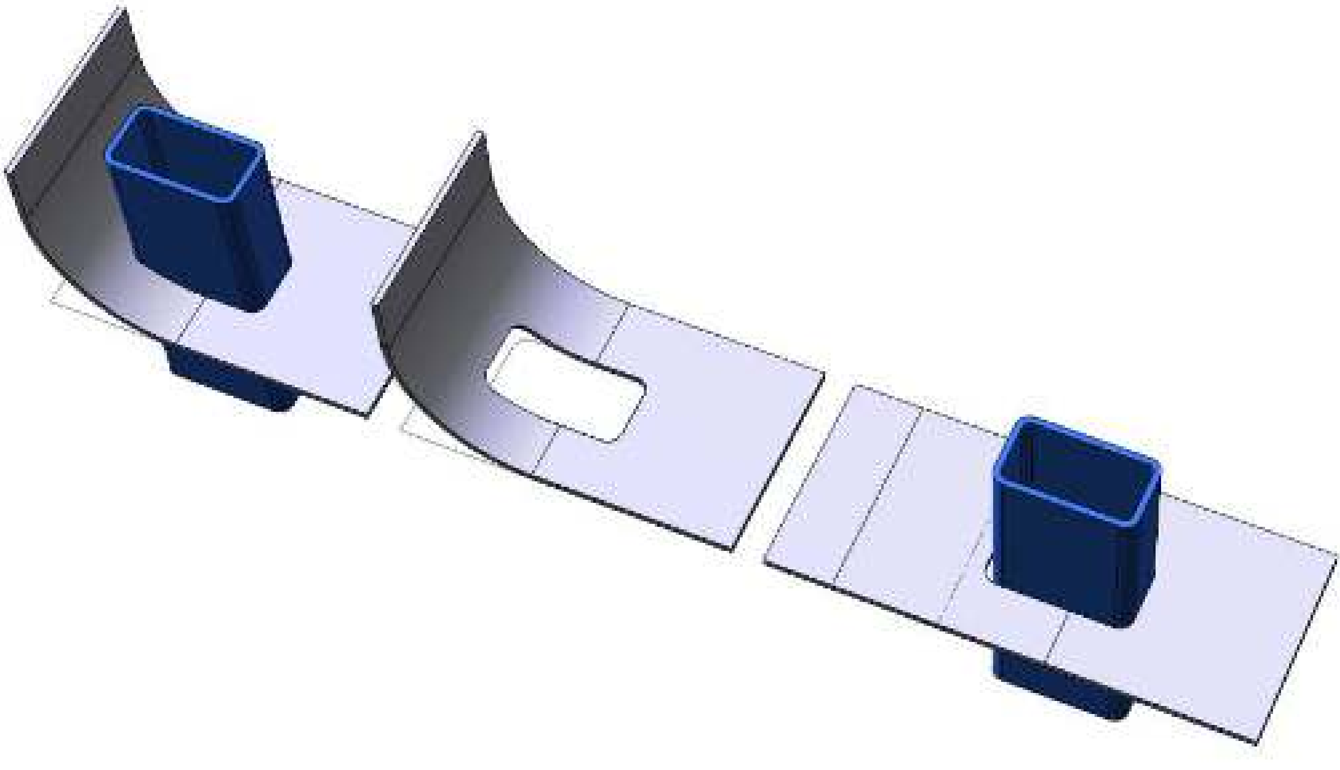


**Figure 2.5** Roller leveling bending techniques

So far we have talked about standard bends, but there are details that require more complex developments. The parameters to be set include a threshold value that allows the definition of the maximum radius for the creation of the bend with the bending machine. Beyond this value, other bending techniques must be considered, such as, for example, the roller leveling. In this case large radii, conical radii and ruled surfaces can be unbent directly along the length of the arc, without taking into account the bending indications (bend lines and the bend allowance calculation).

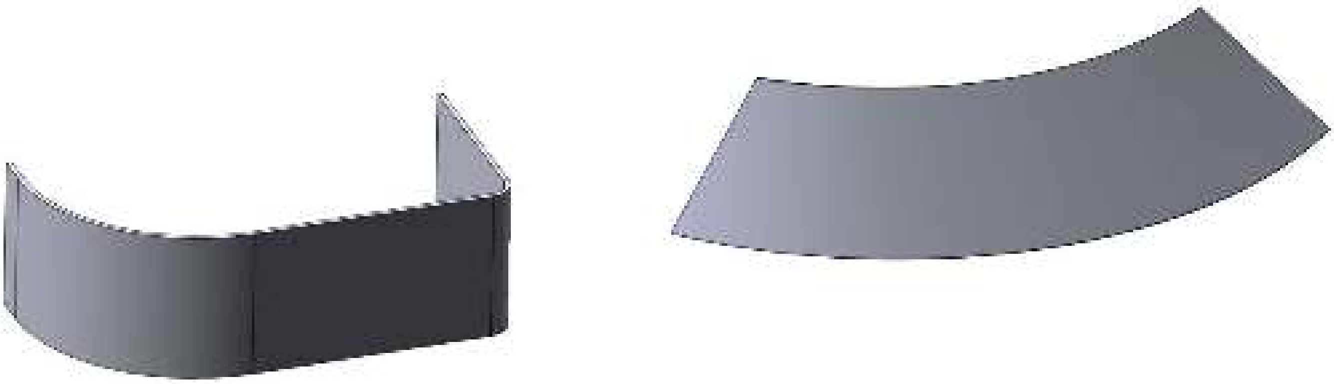


**Figure 2.6** set of regular bends

With the “Step Bend” function, it is possible to obtain, by performing a set of regular bends through a sequence of steps, an approximation of the desired shape.

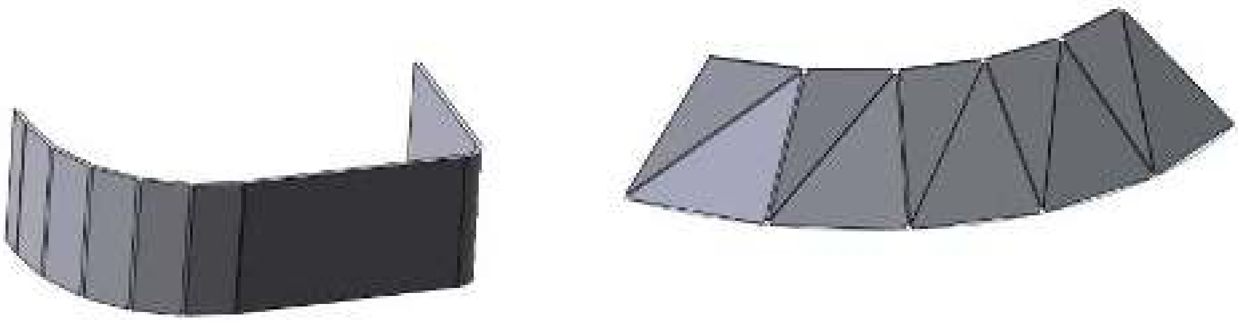


**Figure 2.7** sequence of stepsnotches

For example, to create a protective casing, first define the overall dimensions and the thickness of the sheet, then empty the solid while creating the shell (using the Solid Shell function) and, finally, carry out, through the “Rip” function, the notches of the needed sides. With this workflow it is extremely easy to produce the initial shape; the operator has to focus exclusively on the main dimensions of the casing, thus making parameterization easier.

Let’s consider now the represented solid, which has been obtained through the two features of Sweep and Shell obtaining a thickness of 1 mm.

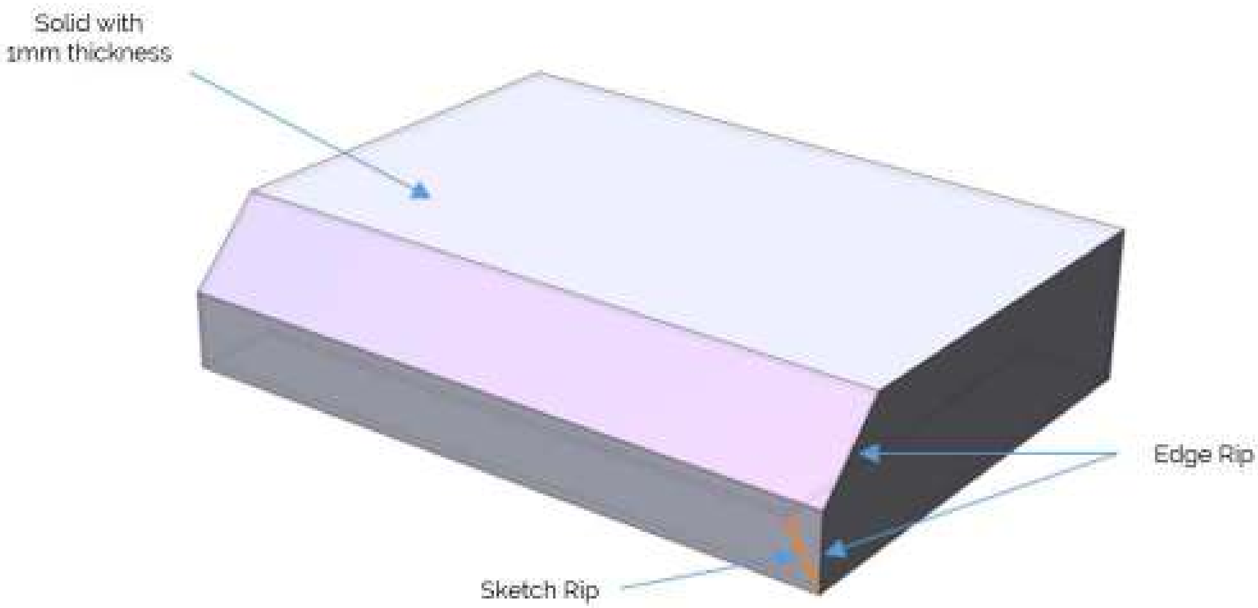



Figure 2.8 sweep and shell fetchers

The opening zones have been defined by applying the function of notching with the “Edge Rip” and “Rip by 2 points” functions, then, the relating bend fillets have been automatically carried out with the Unbend and Rebend functions.

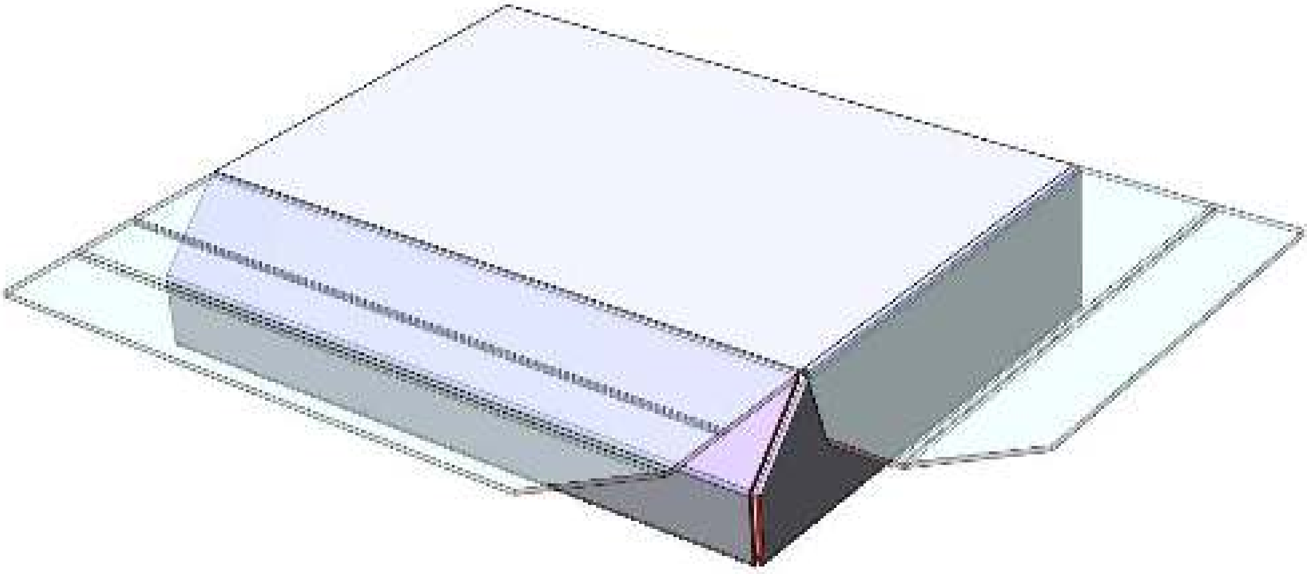


**Figure 2.9** sheet metal coping flange

In this way, both the unbend process and the shape creation are simple and immediate, since the flanges have been created by copying the geometries, and the clearances in the notches are minimized, thus making welding easier.

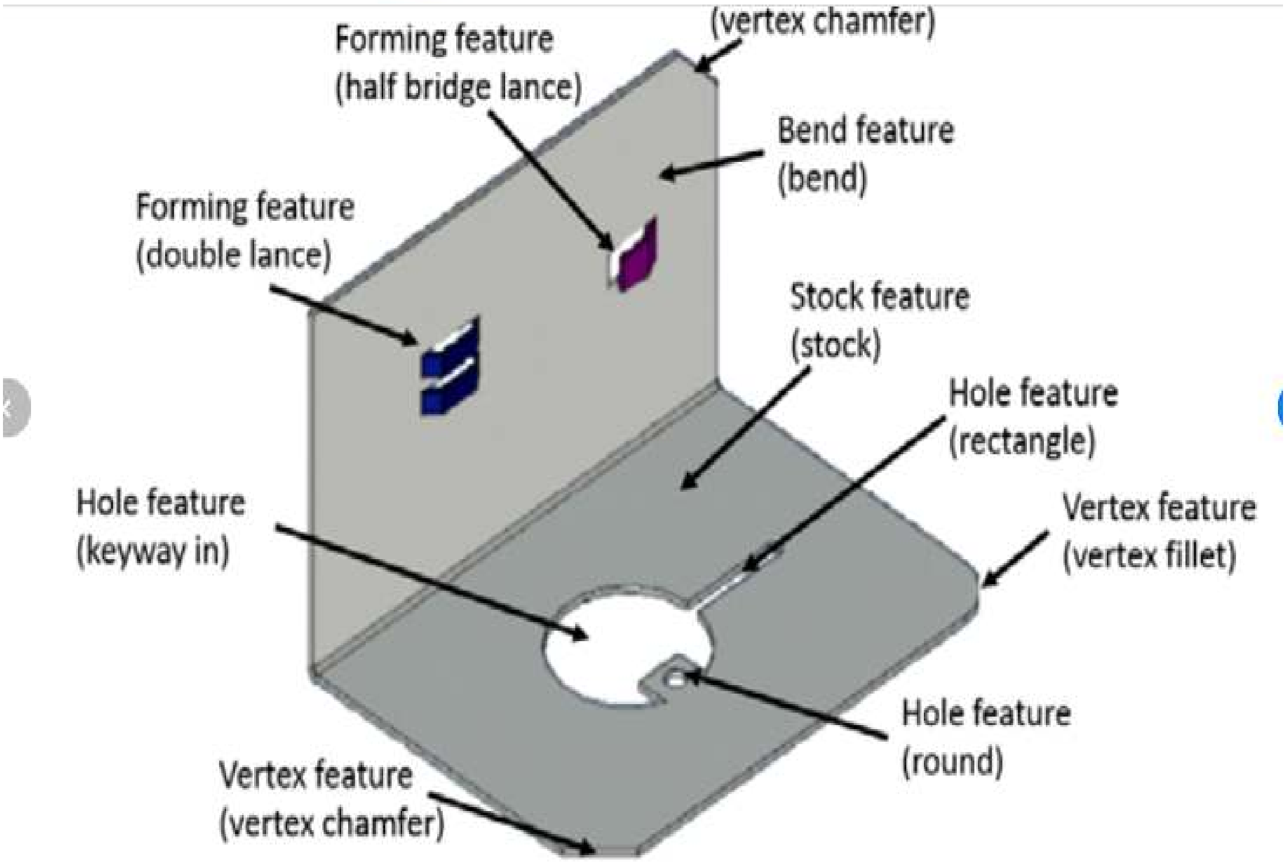



Figure 2.10features of sheet metal product

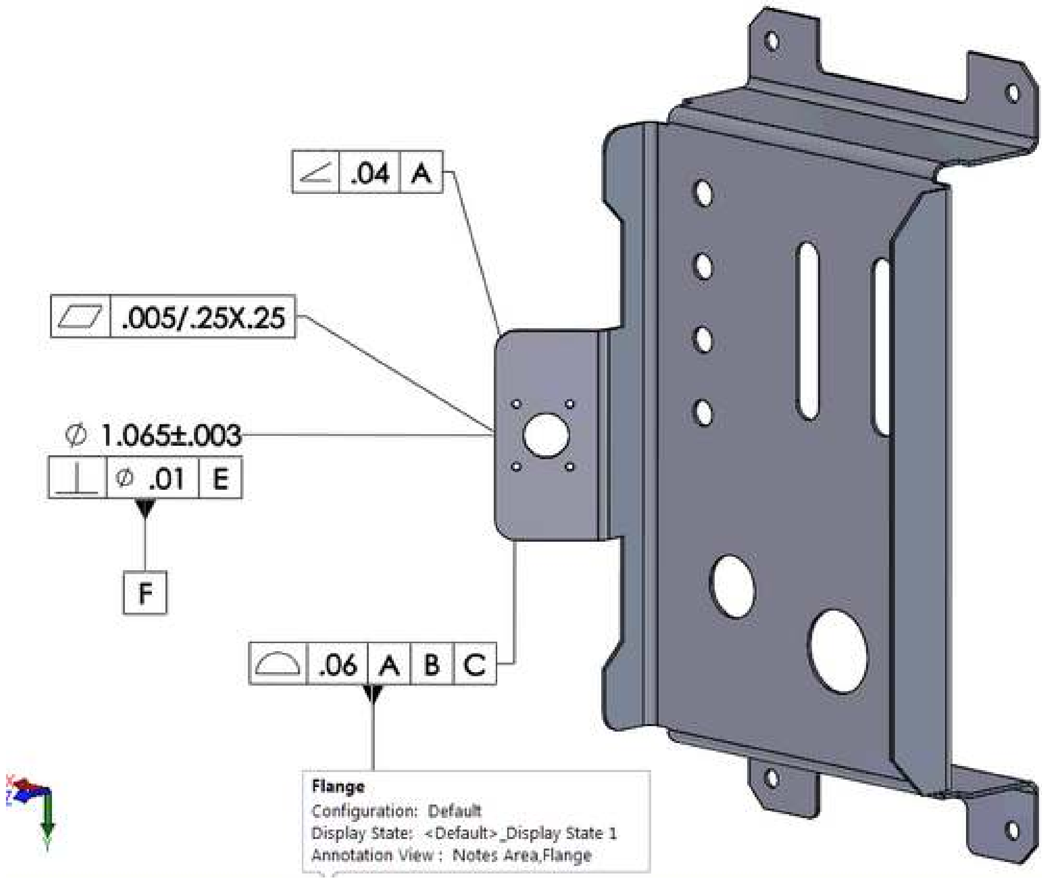



**Figure 2.2** Display of metal fetchers with symbol

**Example representsAngularity**

Angularity controls the orientation of a surface or a feature of size at any angle, not just 0 degrees or 90 degrees.The feature control frame for angularity is shown below:

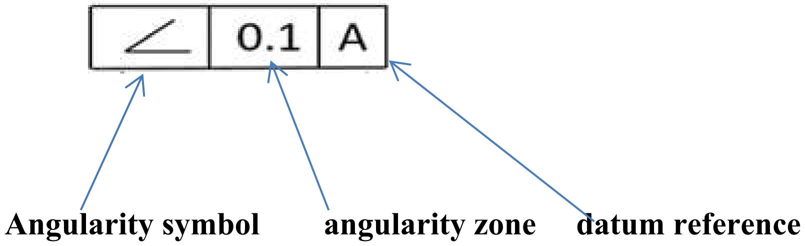



**Figure 2.2** Figure Feature control frame for angularity

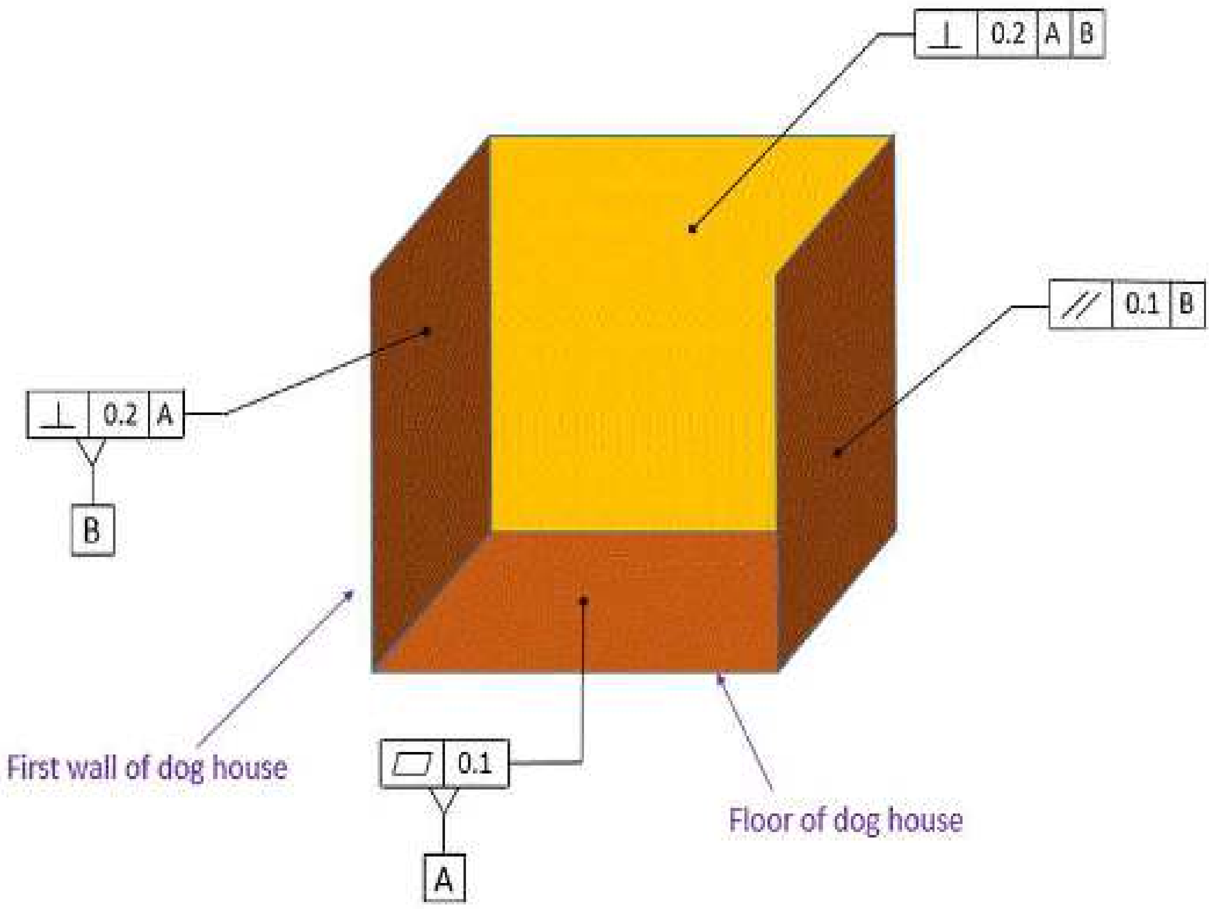



**Figure 2.3**Display of drawing symbols and interpretation

## 2.2materials used in fabricated products

### 2.2.1Types of Sheet Metal Fabrication Materials

There are many different types of sheet metals available that are suitable for various fabrication processes. The choice of metal depends on the final use of the fabricated parts. Common metals and alloys that are widely used for the sheet metal fabrication process are:

- Carbon Steel
- Stainless Steel
- Aluminum
- Magnesium
- Bronze
- Copper

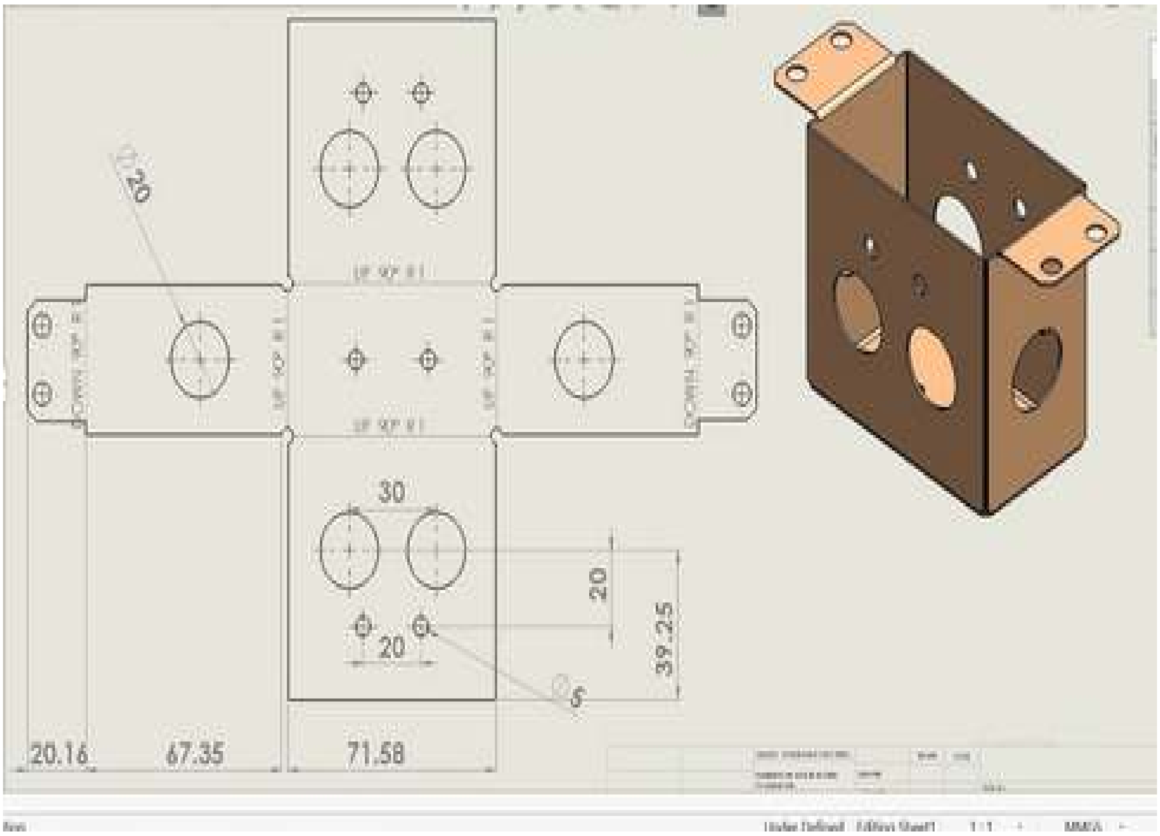
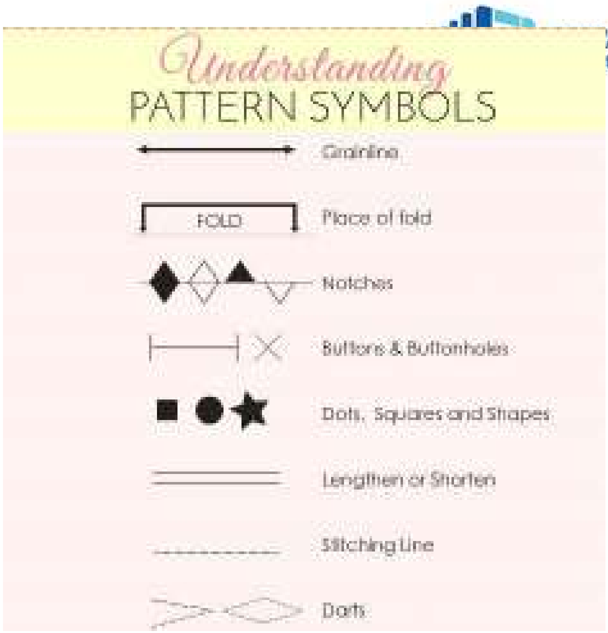
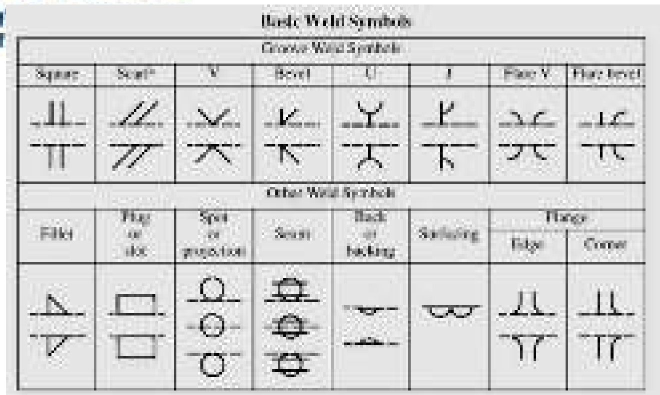



**Figure 2.4**Sheet Metal Fabrication product

## 2.3 terminology symbols and standards

| GD&T Symbol | Control Type | Name | Summary Description |
|---|---|---|---|
| ⏤ | Form | Straightness | Controls the straightness of a feature in relation to its own perfect form |
| ⏥ | Form | Flatness | Controls the flatness of a surface in relation to its own perfect form |
| ○ | Form | Circularity | Controls the form of a revolved surface in relation to its own perfect form by independent cross sections |
| ⌭ | Form | Cylindricity | Like circularity, but applies simultaneously to entire surface |
| ⌓ | Profile | Profile of a Surface | Controls size and form of a feature. In addition it controls the location and orientation when a datum reference frame is used. |
| ⌒ | Profile | Profile of a Line | Similar to profile of a surface, applies to cross sections of a feature |
| ⊥ | Orientation | Perpendicularity | Controls the orientation of a feature which is nominally perpendicular to the primary datum of its datum reference frame |
| ∠ | Orientation | Angularity | Controls orientation of a feature at a specific angle in relation to the primary datum of its datum reference frame |
| // | Orientation | Parallelism | Controls orientation of a feature which is nominally parallel to the primary datum of its datum reference frame |
| ⌖ | Location | Position | Controls the location and orientation of a feature in relation to its datum reference frame |
| ◎ | Location | Concentricity | Controls concentricity of a surface of revolution to a central datum |
| ⌯ | Location | Symmetry | Controls the symmetry of two surfaces about a central datum |
| ↗ | Runout | Circular runout | Controls circularity and coaxiality of each circular segment of a surface independently about a coaxial datum |
| ⌰ | Runout | Total runout | Controls circularity, straightness, coaxiality, and taper of a cylindrical surface about a coaxial datum |




### 2.1.1 Some examples of products made with metal fabrication include:

- Hand tools.
- Bolts, nuts, and screws.
- Cans.
- Cutlery.
- Pipes and pipe fittings.
- Metal windows and doors.
- Equipment attachments.
- Car parts.
- Drawing in fabrication Shop drawings (also known as fabrication drawings) are **detailed plans that translate design intent**. They provide fabricators with the information necessary to manufacture, fabricate, assemble and install all the components of a structure

The following variables may be present and may include, but are not limited to, the examples listed under the scope. All work is undertaken to relevant legislative requirements, where applicable.

| Variable | Scope |
|---|---|
| Template material | Steel plate, perspex, timber, cardboard, paper etc |
| Storage procedures | Including labelling, identification, eg template lofts |
| Development methods | Thickness, bend, pitch, angle, circumference, perimeter |
| Allowances | Thickness, bend, pitch, angle, circumference, perimeter |
| Standards/codes and symbols | All work carried out in accordance with legislative and regulatory requirements |

Table 2.2 drawing variables

**Equipment requirements**

To successfully complete this unit you are required to supply the following for your use.

- Drawing instruments (compass set with extension bar)
- Eraser
- Pens
- Pencils (a 0.5 mm mechanical pencil, with HB lead is preferred)
- Scale rule
- 45 degree set square (220 mm)
- 60/30 degree set square (300 mm) both the 45° and the 60/30° squares are available in a set
- Scientific calculator.

Clothing and Occupational health and safety requirements

The Occupational Health and Safety Act require you to protect yourself. Therefore, you must supply your own personal industrial clothing and equipment.

• Industrial type trousers and shirt, or overalls

• Safety boots or solid leather shoes

• Safety glasses

• Ear muffs and/or ear plugs.

All accidents and injuries that happen during classes must be reported to your trainer.

Note: This workbook is designed as a self-paced learning package which means that you decide what you will do and when you will do it. However, it is very strongly suggested that you follow the sequence of this workbook as presented.

Complete any theory and study components before attempting the associated pattern development.

### 2.3.1Sheet metal products fabricated techniques

Sheet Metal fabrication is the creation of useful metallic parts and structures by the application of multiple fabrication processes. Sheet metal fabrication is basically a broad term that involves various complex processes like cutting, forming, bending, welding, machining, and assembling. Fabrication shops or Fab shops are the places where the processes related to sheet metal fabrication are performed. In this article, we will explore the materials, processes, and tools required for sheet metal fabrication.

### 2.3.2Types of Metal Fabrication Processes

The journey to the final product from raw sheet metals proceeds through various sheet metal fabrication processes. All the sheet metal fabrication processes can be grouped into the following three categories:

- Cutting
- Deformation
- Assembly

**Under these three categories, there are a number of other types of operations.**

- Shearing Operation
- Blanking & Fine Blanking Operation
- Punching Operation
- Piercing Operation
- Perforating Operation

- Slotting Operation
- Notching Operation
- Bending Operation

### 2.3.3Thermal Cutting

Laser cutting is the preferred option for cutting sheet. A very quick and precise cutting method that guarantees good results. With thicker materials, plasma cutting may be used because of its quickness. This advantage is only evident with thicknesses upward of 10 mm though. At the same time, cutting quality favours laser cutting. So we would advise to rather go with laser cutting services. Mechanical Cutting

The most widely and frequently used sheet metal fabrication process is cutting. A variety of different types of machinery are used to cut sheet metal to manipulate it for making a component. They are:

Laser Cutting: Laser cutting is a very quick, energy-efficient, and precise sheet metal cutting process that uses a powerful laser to cut thin or medium gauges of sheet metals.

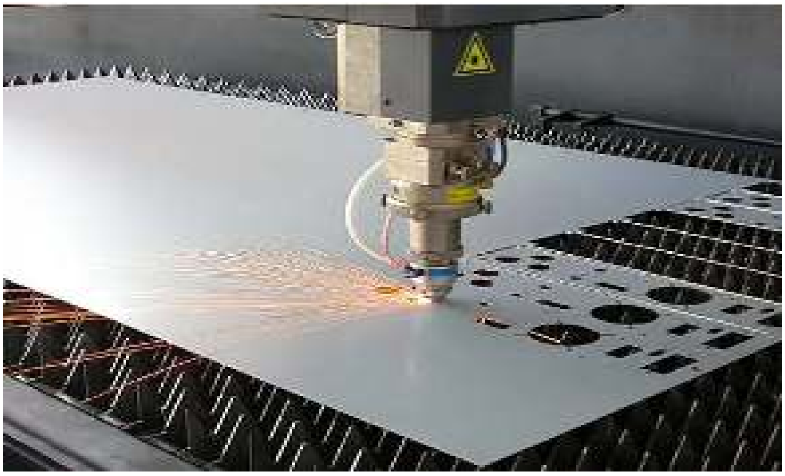


**Figure2.5Laser Cutting**

**Water Jet Cutting:** In water jet cutting, a high-pressure jet of water with abrasive substances is used to cut the sheet metals. As water jet cutting does not generate heat in the process, this sheet metal fabrication process is particularly useful for metals having low melting points to avoid deformation due to heat generation.

**Figure2.6 Water Jet Cutting**

**Plasma Cutting:**Plasma cutting is used for thicker sheet metals. In this metal fabrication process, a jet of hot plasma is used to penetrate the metal sheets. This method is highly powerful having low setup costs, however, less accurate than laser cutting or water jet cutting.

**Figure2.7**Plasma Cutting

### 2.3.4Mechanical Cutting

Shearing, or die cutting, refers to a process that cuts sheet metal without burning or melting it. Also, it does not produce any chips. In essence, shearing is not too different from cutting with scissors. In shearing, a punch presses the work piece against a fixed die or blade. The clearance between is such that the work piece does not fit through, causing it to shear. It is a great and cost-effective method to cut sheets into size whenever complex cuts are not necessary. Punching Punching is another way for cutting holes into a sheet. A metal punch hits the sheet, perforating it. It is suitable for large-scale production but not cost-effective for smaller jobs. The reason lies with the need for a separate tool for different cuts. Bending When it comes to actual engineering, there aren't many metal components that elude the bending section of a fabrication shop. Press brakes are responsible for the folding of sheet metal parts. This is probably the most difficult step in metal manufacturing because of the complexity of some bends. An engineer must be well acquainted with the limitations of metal bending to things that are actually producible.

**ShearingOperation**

Shearing is the process of separating the sheet metal into two or more pieces, normally by cutting along a line. Commonly used to cut into rectangular shapes but can produce other shaped parts.

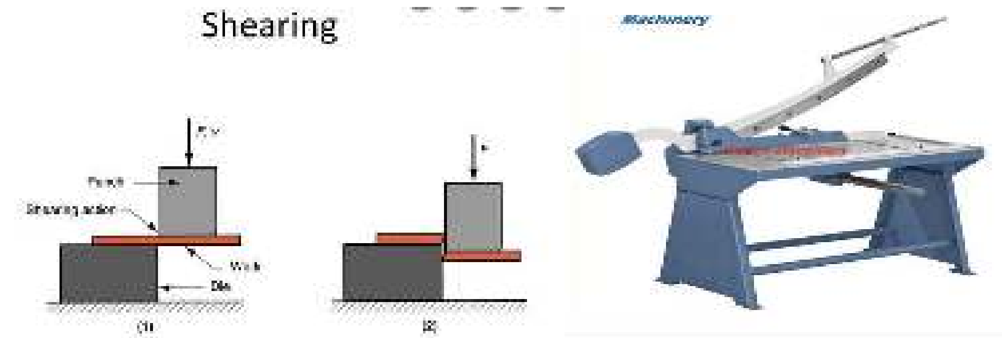



Figure2.8 **ShearingOperation**

Blanking & Fine Blanking OperationBlanking is the process of cutting out a predefined shape from the sheet metal; the part that is punched out is known as the blank and is the required product, the metal left behind is waste.Fine blanking is similar but provides more accuracy, with smooth edges and no distortion by applying clamping force and using small and close tolerances.

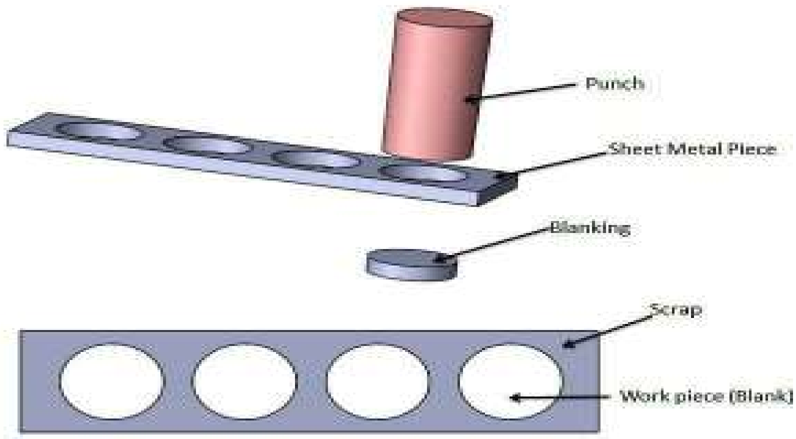



Figure 2.9 Punching Operation

**Punching Operation**

Punching is the same process as blanking, but the required product is the metal left behind, ratherthan the part that is punched out. It uses the same punching press and punch and die operation, itis just the opposing desired product.

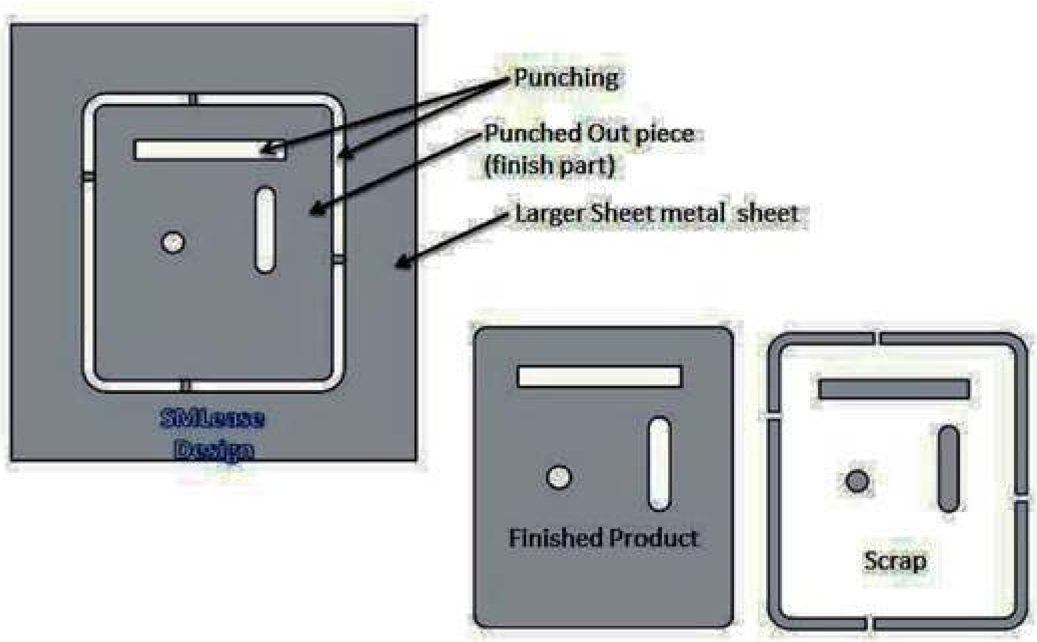



Figure 2.10 **Punching Operation**

**Piercing Operation**

Piercing is the process of cutting small, cylindrical holes in the sheet metal whilst removing verylittle quantity of material. This is done by using a bullet shaped punch during the punch and die operation.

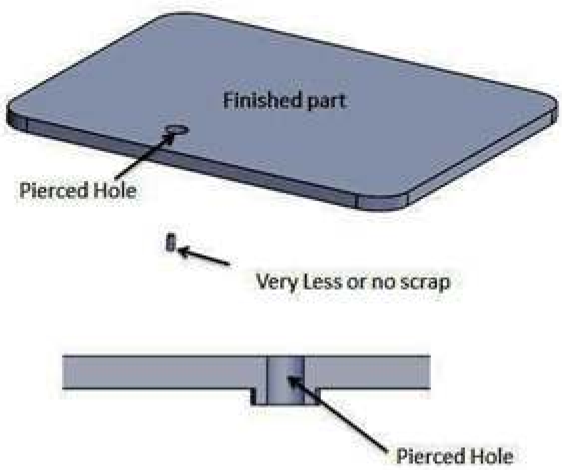


Figure 2.10 **Piercing Operation**

Perforating Operation and Slotting Operation

Perforation is a similar process to piercing, but the holes are not usually round in shape.Perforating commonly consists of more than one hole that has been punched in a pattern.

Slotting is the process of cutting rectangular holes onto sheet metal, sometimes unfinished.

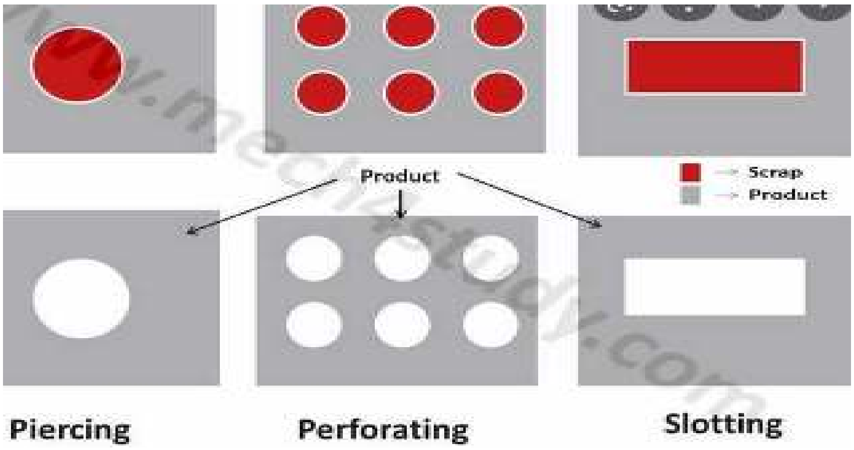



**Figure 2.11**piercing ,perforating ,slotting

**Notching Operation**

Notching is the process where shapes are cut from the edges of the sheet metal; removing and trimming and creating notches at the edge.

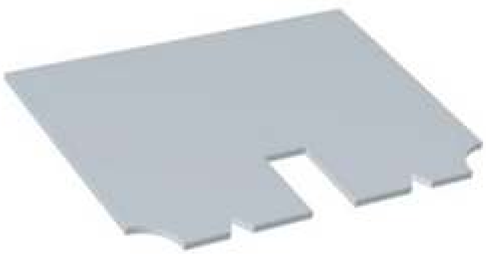


**Figure 2.12** Notching Operation

**Sheet Metal Forming Operations**

Forming operations cause stress below the sheet metal's ultimate strength, resulting in distortion.

**Bending Operation**

Bending is the process of transforming the straight sheet metal into a curved form. There are anumber of different types of bending such as:

1.V bending

2.U bending

3.Edge Bending

**Applications of Bending Operation:**

- Drawing board clip, tube light frame, air conditioning duct etc.
- Automotive industries.Delivery of fluids, either gaseous or liquid, in a
- Process plants in Containers. This is the explanation of various Sheet Metal Operations that are performed on the sheet to get a required shape which was explained in a detailed manner.

Bending Terminology

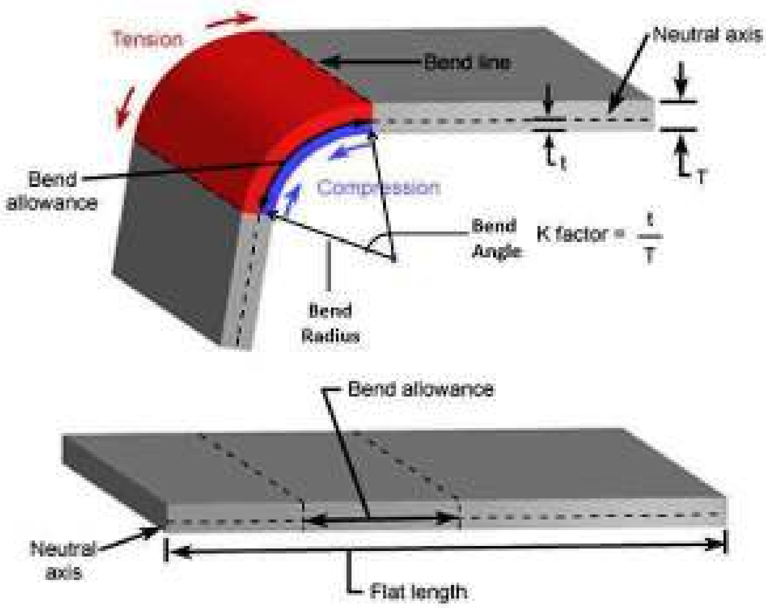



Fig 2.13 Bending -Sheet Metal Operations

## Self-check-2

**Test –I**Matching question

--------------1. Shearing OperationA. Compass

--------------2 removing and trimming the edgeB. types of bending

--------------3. V bending CNotching Operation

-------------4.Types of materialD..To control the flat surface

-------------5.Fechers of sheet metal product E.Bending

-------------6.drawing equipmentFPunching

--------------7.FlatenessG .Carbon steel

## Self-check-2

**Test –II** Describe the definition of symbol

| no | Symbol | Description |
|---|---|---|
| 1 |  | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |

## Self-check-2

**Test –I II short answer**

A. Discuss the importance of template.----------------------------------------------------------
-----------------------------------------------------------------------------------------------------
----

B. List common material for template making and explain their application.----------------
-----------------------------------------------------------------------------------------------------
---

C. What are the important information 'written-up' or labeled on a template

---

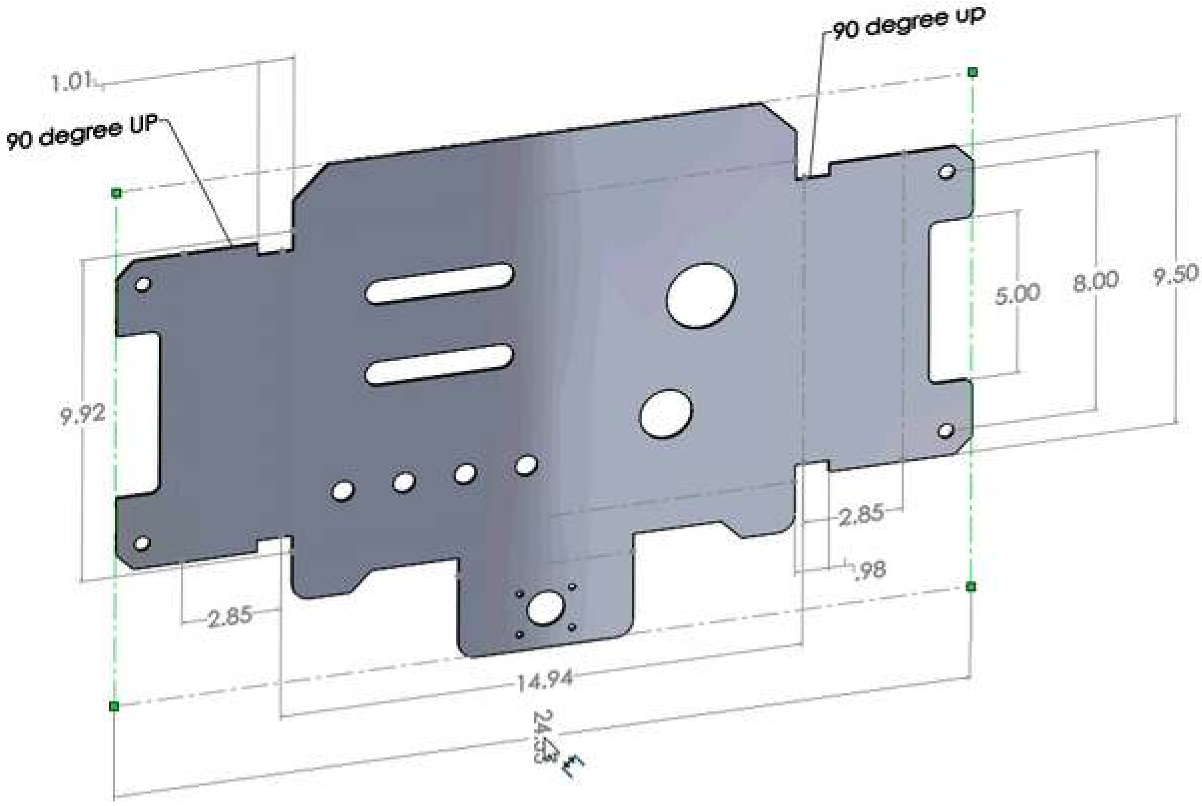
## Operation sheet -2

prepare drawing sheet metal part( model based definition)

**Operation Title sheet metal part**

**Purpose** The aim is that if students perform the drawing by using AutoCAD or solid work then transfer to sheet metal product. .

**Instruction** Read the drawing and follow drawing specification ,symbols fetchers and dimensions properly use




**Tools and equipment**

1.desk top computer

2.steel ruler

3.centr punch

4.chesel

5.drill bit 4mm,5mm,10mm,12mm

6.endmill 6mm

7.drill machine

8.sheet metal cutting machine

9.1.5mm sheet metal

10.scriber

11.hammer

**Quality** criteria all dimension are per specification legible, neatness, smoothens are very importanthigher ,esthetical value needs.

**Precaution**fulfill allsafety requirement

**Procedures in doing the task**

**1.meshering**

**2.lyout**

**3.cutting**

**4.debering**

**5.drilling**

**6.filling**

**7.sllot making**

**8.bending**

## LAP Test -2

Task 1 Apply AutoCAD or solid work

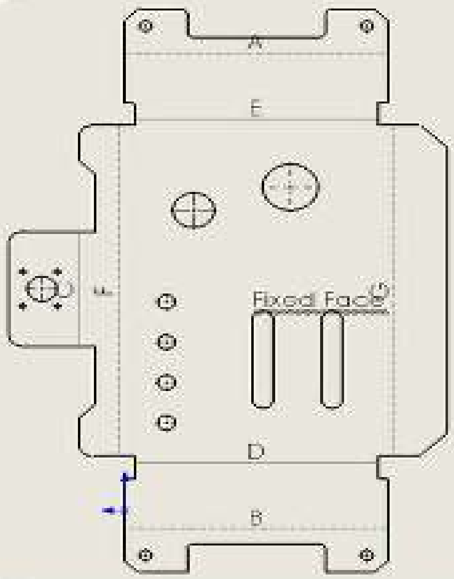
Task 2 measure the parts according to specification

Task 3 perform the bending operation

Task 4 perform the bending operation

Task 4 perform the drilling operation

Task 4 Apply time management




| Bend Table | | | |
|---|---|---|---|
| Tag | Direction | Angle | Inner Radius |
| A | UP | 90° | 0.23 |
| B | UP | 90° | 0.23 |
| C | DOWN | 45° | 0.25 |
| D | DOWN | 90° | 0.25 |
| E | DOWN | 90° | 0.25 |
| F | UP | 90° | 0.23 |
| G | UP | 90° | 0.23 |

Table operation sheet 2 bending procedure

# Unit three Prepare detail drawing

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Carrying out calculation
- draw accordance with industry specification
- Ensure drawing including relevant information, full notation and dimensioning

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Perform drawing calculation calculations
- Mark out the drawing accordance with industry specification
- Ensure detail drawing including relevant information, full notation and dimensioning

## 3.1 Carrying out calculation

### 3.1.1Simple geometrical calculation

Perimeter, Area, and Volume

1. The perimeter of a polygon (or any other closed curve, such as a circle) is the distance around the outside.

2. The area of a simple, closed, planar curve is the amount of space inside.

3. The volume of a solid 3D shape is the amount of space displaced by it. Some formulas for common 2 -dimensional plane figures and 3 -dimensional solids are given below.

**Perimeter** is measured in **linear units,**

**Area** is measured in **square units,** and

**Volume** is measured in **cubic units.**

| Area formulas | | |
|---|---|---|
| **Shape** | **Formula** | **Variables** |
| Square | $A = s^2$ | s is the length of the side of the square. |
| Rectangle | A=LW | L and WW\ are the lengths of the rectangle's sides (length and width). |
| Triangle | A=1/2bh | b and h are the base and height |
| Triangle | $A=\sqrt{s(s-a)(s-b)(s-c)}$ where $s=\frac{a+b+c}{2}$ | a , b , and c are the side lengths and s is the semi perimeter |
| Parallelogram | A= bh | b is the length of the base and h is the height. |
| Trapezoid | $A=\frac{b1+b2}{2}h$ | b1 and b2 are the lengths of the parallel sides and h the |

| | | |
|---|---|---|
| | | distance (height) between the parallels. |
| Circle | $A=\pi r^2$ | ris the radius. |

| Perimeter Formulas | | |
|---|---|---|
| **Shape** | **Formula** | **Variables** |
| Square | P=4s | s is the length of the side of the square. |
| Rectangle | P=2L+2W | L and W are the lengths of the rectangle's sides (length and width). |
| Triangle | a+b+c | a,b, and c are the side lengths. |
| Right Triangle, with legs a and b (see Pythagorean Theorem ) | $P=a+b+\sqrt{a^2+b^2}$ | a and bb are the lengths of the two legs of the triangle |
| Circle | $P=C=2\pi r=\pi d$ | r is the radius and d is the diameter. |

| **Shape** | **Formula** | **Variables** |
|---|---|---|
| Cube | V=s3 | s is the length of the side. |
| Right Rectangular Prism | V=LWH | L is the length, W is the width and H is the height. |
| Prism or Cylinder | V=Ah | A is the area of the base, h is the height. |
| Pyramid or Cone | V=1/3Ah | A is the area of the base, h is the height. |
| Sphere | V=4/3πr3 | r is the radius. |

Table 3.1 geometrical formula

3.1.2 Determining of allowances

Understanding the Bend Allowance and consequently the Bend Deduction of a part is a crucial first step to understanding how sheet metal parts are fabricated. When the sheet metal is put through the process of bending the metal around the bend is deformed and stretched. As this happens you gain a small amount of total length in your part. Likewise when you are trying to develop a flat pattern you will have to make a deduction from your desired part size to get the correct flat size. The Bend Allowance is defined as the material you will add to the actual leg lengths of the part in order to develop a flat pattern. The leg lengths are the part of the flange which is outside of the bend radius.

These tests include bending some samples and then do some measurements and calculations.

Consider a sheet with a 20 mm thickness and a length of 300 mm as shown in Figure 1. We are going to review three bending scenarios with three different bending angles; 60, 90 and 120, and we will calculate K-Factor, Bend Allowance and Bend Deduction for them. The bending tool has a radius of 30 mm which means that our Inside Bend Radius (R) is 30 mm. Let's start with 90 degrees bend which is the simplest scenario.

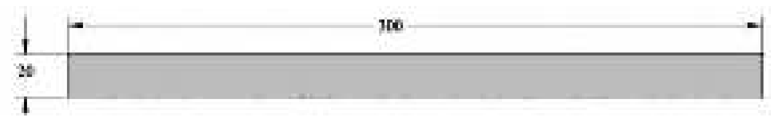



**Figure 3.1** flat sheet

**90 Degrees Bend Angle**

Figure 3.1 illustrates the sheet that is bent with the bend angle of 90 degrees. We will start by calculating the Bend Allowance. From there we can calculate the K-Factor and the Bend Deduction. After bending the sheet we need to do some measurements as shown in Figure 2.

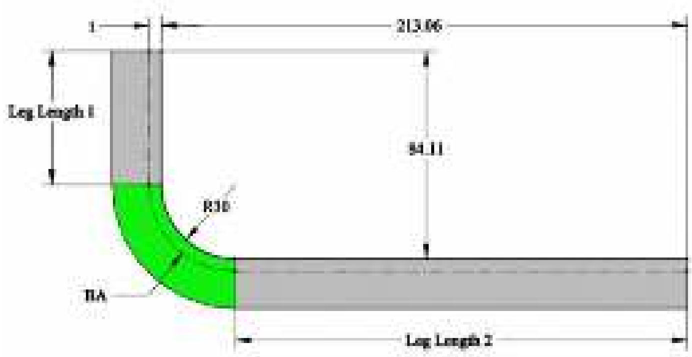


Figure 3.2 degree bend

We can calculate the Leg Length 1 and 2 as follows:

$$Leg\ Legnth\ 1 = 84.11 - R = 84.11 - 30 = 54.11$$
$$Leg\ Legnth\ 2 = 213.06 - R = 213.06 - 30 = 183.06$$

At the neutral axis we have:

$$Initial\ Length = Leg\ Legnth\ 1 + BA + Leg\ Length\ 2$$

In this formula the initial length is 300 mm. By replacing Initial Length, Leg Length 1 and 2 in the above equation we can calculate the Bend Allowance as follows:

$$300 = 54.11 + BA + 183.06$$
$$BA = 62.83$$

We know that BA is the length of the arc on the neutral axis. The length of the arc for this scenario can be calculated as:

$$BA = \frac{2 * \pi * R'}{4}$$

Where R' is the radius of the arc on the neutral axis. By inserting the Bend Allowance value in the above equation we reach to:

$$R' = \frac{2 * BA}{\pi} = \frac{2 * 62.83}{\pi} = 40$$

Now if we subtract R from R' we can find the distance of the neutral axis (t) from the inner face:

$$t = R' - R = 40 - 30 = 10\ mm$$

From the K-Factor equation we have:

$$K = \frac{t}{T} = \frac{10}{20} = 0.5$$

**Bending Angles Less Than 90 degrees**

For our second scenario we are going to discuss the calculations for bending angles less than 90 degrees. As an example we are going to use 60 degrees as our bending angle. Again we have to do some measurements as shown in Figure 3.3 Then we have to calculate Leg Length 1 and Leg Length 2.

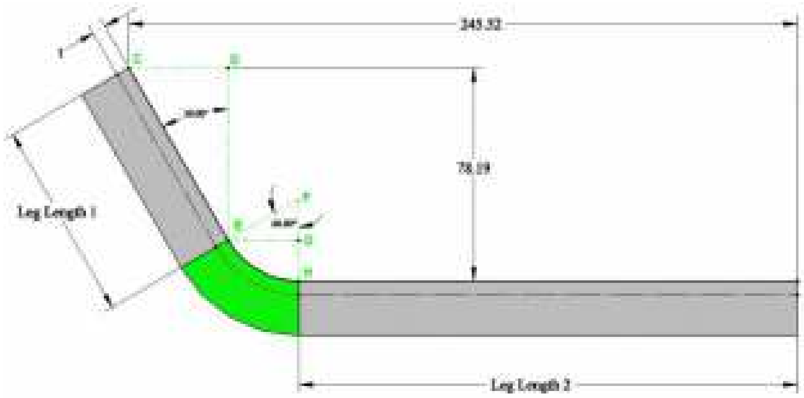
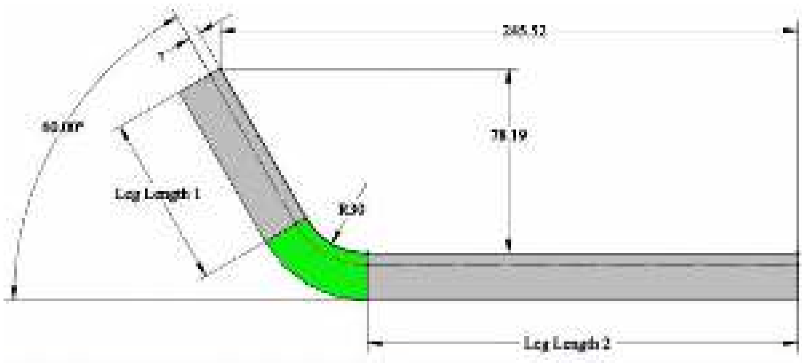



Figure 3: 3 degrees bend




Let’s start by calculating Leg Length 1. From figure 3 .3we know that

$$\cos 60 = \frac{FG}{R} \rightarrow FG = R * \cos 60$$

Where R is the Inside bend radius which is equal to 30 mm in this example. We can calculate Leg Length 1 through a few simple equations as follow:

$$GH = FH - FG \rightarrow GF = R - FG \rightarrow GH = R - R * \cos 60 \rightarrow GH = 30(1 - \cos 60) \rightarrow GH = 15$$

$$78.19 = DE + GH \rightarrow DE = 78.19 - 15 = 63.19$$

$$\cos 30 = \frac{DE}{\text{Leg Length 1}}$$

$$\text{Leg Length 1} = \frac{63.19}{\cos 30} = 72.97$$

Now let’s calculate Leg Length 2:

$$\sin 60 = \frac{EG}{R} \Rightarrow EG = R * \sin 60 \rightarrow EG = 25.98$$

$$\sin 30 = \frac{CD}{Leg\ Length\ 1} \rightarrow CD = 72.97 * \sin 30 \rightarrow CD = 36.48$$

$$Leg\ Length\ 2 = 245.52 - CD - EG = 183.06$$

Now that we have both Leg Length 1 and 2 we can use the following equation again to calculate the Bend Allowance:

$$Initial\ Length = Leg\ Legnth\ 1 + BA + Leg\ Length\ 2$$

$$BA = 300 - 72.97 - 183.06 = 43.97$$

To calculate R’ which is the radius of the arc on the neutral axis we can use the following equation:

$$BA = \frac{2\pi R'A}{360} \rightarrow R' = \frac{360 * BA}{2\pi A}$$

A is the bending angle in the above equation so

$$R' = \frac{360 * 43.97}{2\pi * 60} = 42$$

To calculate the neutral axis distance from the inner face (t) we can subtract inside bend radius from R’:

$$t = R' - R = 42 - 30 = 12$$

And by having t and the sheet thickness (T) we can calculate the K-Factor as follow:

$$K = \frac{t}{T} = \frac{12}{20} = 0.6$$

**Bending Angles Greater Than 90 degrees**

Like previous scenarios let's start by calculating Leg Length 1.

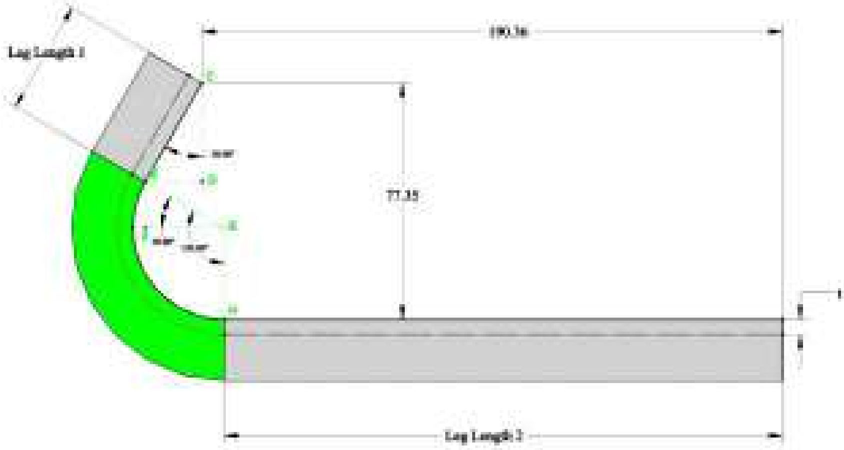



Figure 3.4 degrees bend

Based on Figure 3.4 we have:

$$\sin 30 = \frac{EF}{EG} = \frac{EF}{R} \rightarrow EF = R\sin 30 = 15$$

$$77.35 = CD + EF + GH \rightarrow CD = 77.35 - EF - R \rightarrow CD = 77.35 - 15 - 30 = 32.35$$

$$\cos 30 = \frac{CD}{Leg\ Length\ 1}$$

$$Leg\ Length\ 1 = \frac{32.35}{\cos 30} = 37.35$$

Next we calculate Leg Length 2:

$$\sin 30 = \frac{ED}{Leg\ Length\ 1} \rightarrow ED = 37.35\sin 30 = 18.68$$

$$\cos 30 = \frac{FG}{EG} = \frac{FG}{R} \rightarrow FG = R\cos 30 = 25.98$$

$$Leg\ Length\ 2 = 190.36 + ED - FG = 190.36 + 18.68 - 25.98 = 183.06$$

Now we can calculate the Bending Allowance:

$$Initial\ Length = Leg\ Legnth\ 1 + BA + Leg\ Length\ 2$$

$$BA = 300 - 37.35 - 183.06 = 79.59$$

By having BA we can now calculate K-Factor:

$$BA = \frac{2\pi R' A}{360} \rightarrow R' = \frac{360 * BA}{2\pi A} = \frac{360 * 79.59}{2\pi * 120} = 38$$

$$t = R' - R = 38 - 30 = 8$$

$$K = \frac{t}{T} = \frac{8}{20} = 0.4$$

**Bend Deduction Calculation**

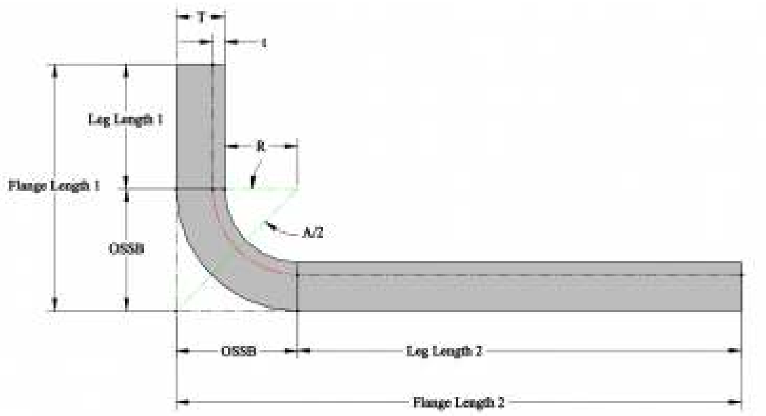
As explained in my first post the Bend Deduction can be calculated using the following equation:

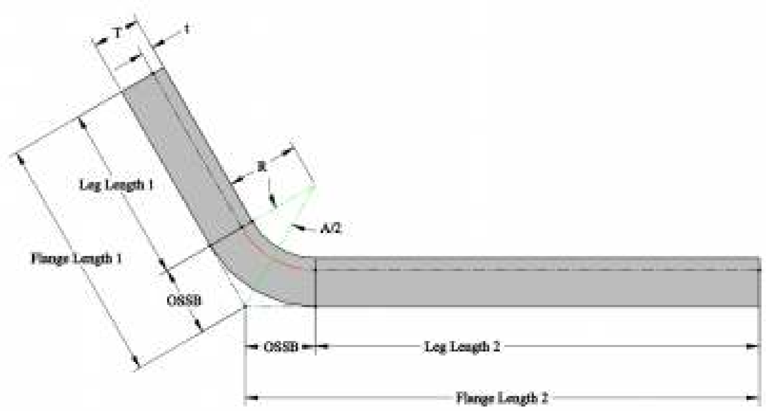
$$BD = 2 * OSSB - BA$$

Where OSSB is the outside setback. OSSB is defined as illustrated in figure 5 for different bending angles and can be calculated using the equation below:

$$\tan\frac{A}{2} = \frac{OSSB}{R+T} \rightarrow OSSB = (R+T)\tan\frac{A}{2}$$

Where A is the bending angle, T is the sheet thickness and R is the bending radius.



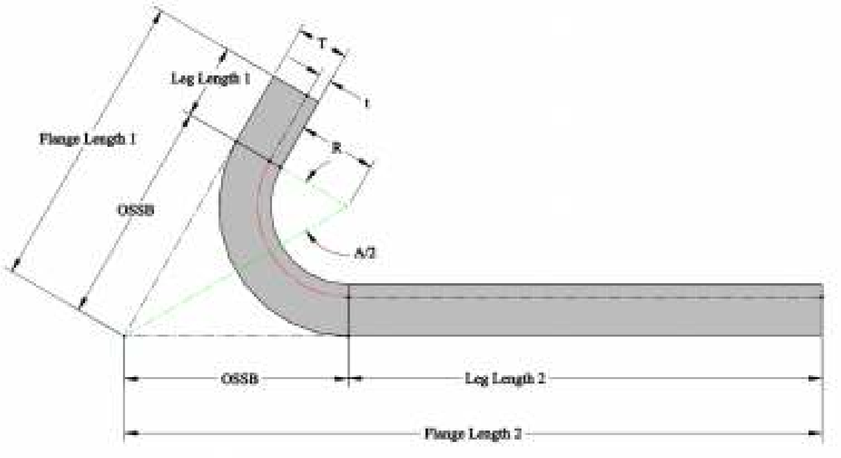



**Figure 3.5**: outside setback OSSB in different bending angle

## 3.2Draw accordance with industry specification

### 3.2.1Understanding Pattern Development and method

Making patterns or pattern developments is an important part of industrial drafting. Many different industries use them. Familiar items such as pipes, ducts for hot- or cold air systems, parts of buildings, aircraft, automobiles, storage tanks, cabinets, boxes and cartons, frozen food packages, and countless other items are designed using pattern developments. To make such items, a drafter must first draw them as a pattern or pattern development.

A pattern development, also called a stretch out or simply a development, is a full-size layout of an object made on a single flat plane. A development that is not full size is not a pattern; it is simply a drawing or representation of the pattern. Therefore, outlines for very large objects drawn at a reduced scale are not pattern developments.

The pattern is the original part of the pattern development from which flat patterns can then be cut from flat sheets of material that are folded, rolled, or otherwise formed into the required shape (see Figure 3.2). Materials used include paper; wood; fiberboard; fabrics; various cardboards, plastics, and films; metals such as steel, tin copper, brass, and aluminum; and so on.

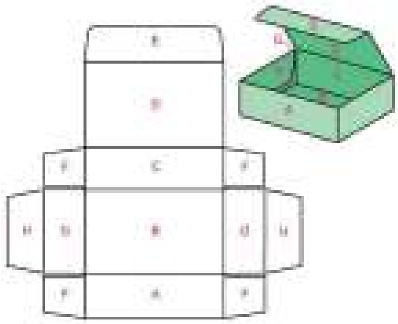


Figure 3.2 part of the pattern development

### 3.2.2Types of Developments

The type of development needed for an individual object depends on the object’s shape. The three basic types are parallel-line development, radial-line development, and triangulation.

### 3.2.3Parallel Line Development

The parallel line method of pattern development is based on a system of lines drawn parallel to one another on the surface of a sheet metal article and is used to develop items such as elbows, segmental bends, Tee-pieces or valve boxes for example. In general it is used to develop square, rectangular and cylindrical shapes (prisms). An example of parallel development can be seen below.

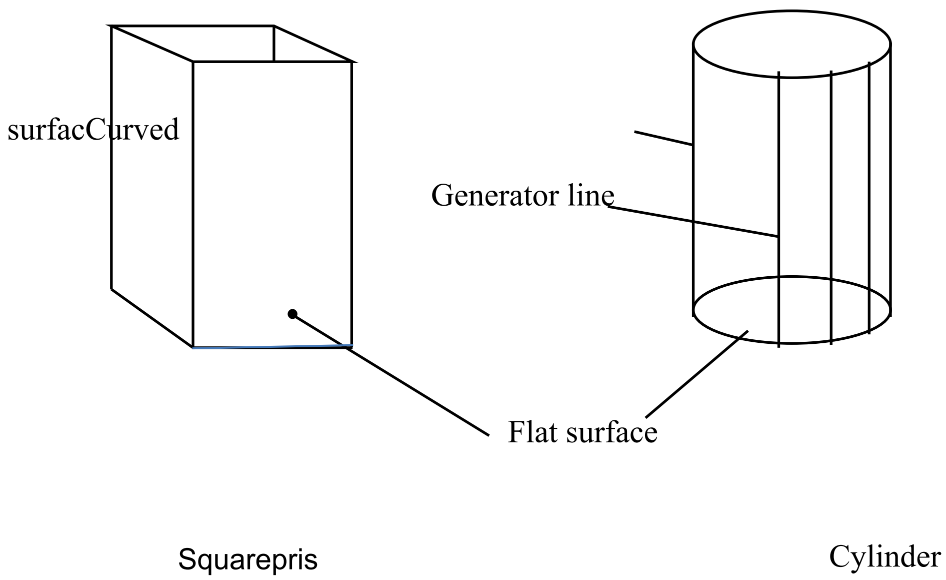



**Figure 3.3**Parallel Line Developments shapes

Table 3.2 The terminology used in parallel line development can be listed under the following
three headings.

| Shapes | Lines | Surface |
|---|---|---|
| prism | centreline | flat surface |
| cylinder | girth line | inclined surface |
| pattern | generator line | .curved surface |
| | datumline. | |

### 3.2.4Parallel Line pattern Development Examples and steps

Step 1 Draw the required views; for example – top and side view.

The pattern development cannot be commenced until the required views have been drawn. the two views required when the pattern for a square or rectangular prism is to be developed. Whereas Fig 3.4 shows the two views requiredwhen the pattern for a cylindrical prism is to be developed.

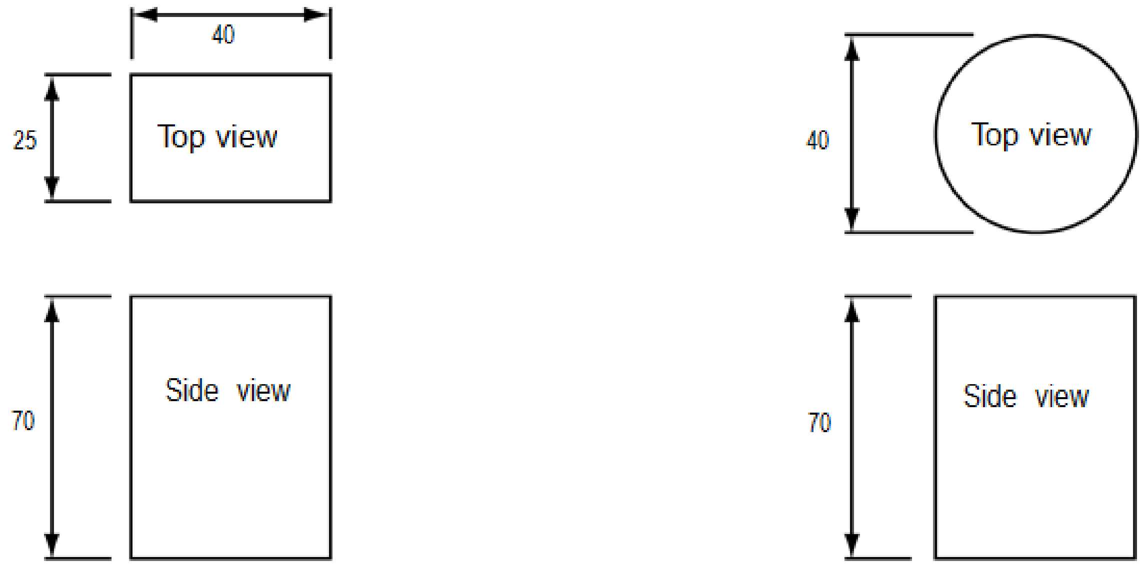



**Figure 3.4**Parallel Line pattern Development Examples and steps

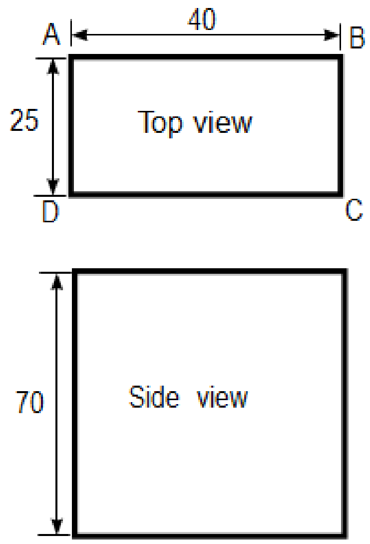
**Step 2** Calculate the perimeter/circumference using the dimensions provided in the top view.

The perimeter of both are set out below as an example.

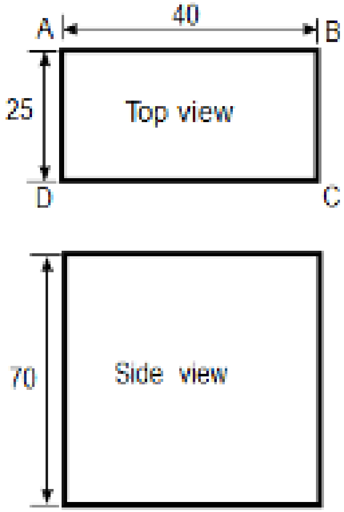
| Perimeter of the rectangle | Circumference of the circle |
|---|---|
| Perimeter $= (\text{length} + \text{width}) \times 2$<br>$= (40 + 25) \times 2$<br>$= 65 \times 2$<br>$= 130$ mm | Circumference $= \pi \times \text{diameter}$<br>$= 3.142 \times 40$<br>$= 125.68$ mm |

## Rectangular prism development

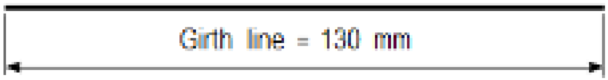
**Step 3** Identify the four corners of the rectangular top view which can be don either letters or numbers; as illustrated below



**Step 4** Commence the pattern by drawing one line, equal in length to the calculated perimeter; eg 130 mm, at step 3

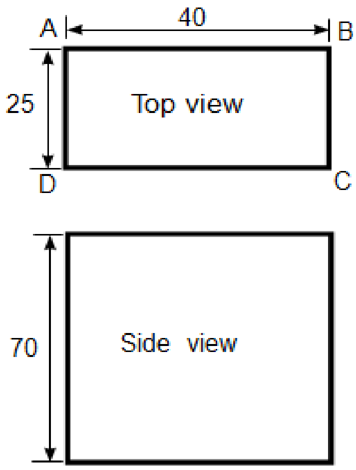


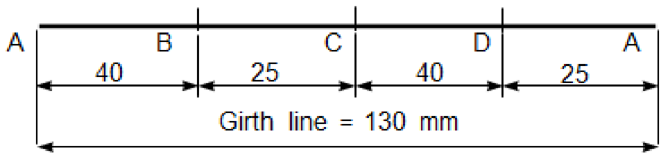

The stretched out version of the perimeter is known as the girth line, which is often drawn to one side and on the same plane as the base of the front view.




step 3 **Commencing the pattern**

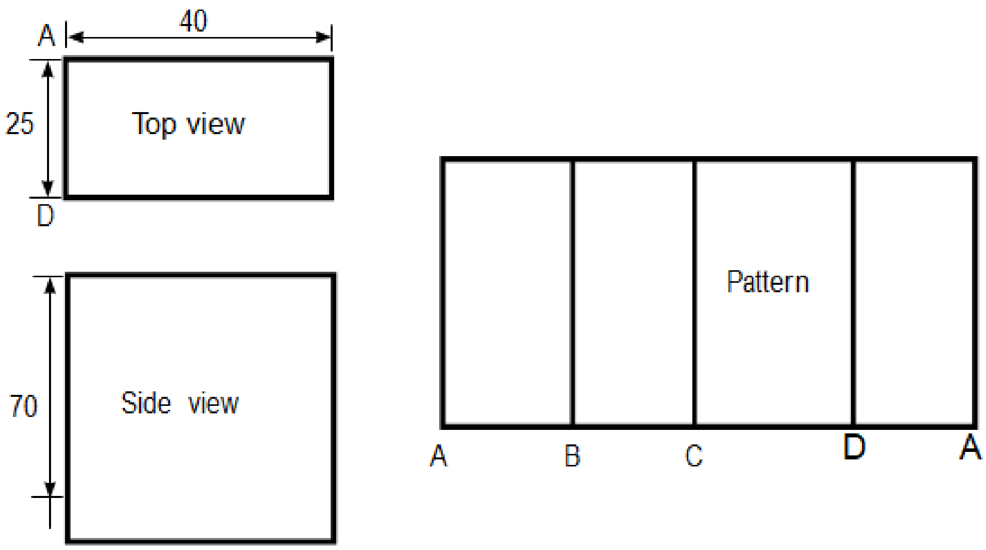
**Step 5** Mark off the four top view measurements AB, BC, CD and DA on the girth line of the pattern




From step 4 – **Marking off**

**Step 6** The pattern is completed by constructing five parallel lines which are drawn perpendicular to the girth line, from each of the five points A, B, C, D and A. These lines are drawn to a height equal in height to the side view. The patter is finally completed when a line is drawn parallel to the girth line to connect the top of the five lines A, B, C, D and A.




**A completed pattern**

## Pattern development of a cylindrical prism

**Step 1** Draw the required views; for example – top and side view.

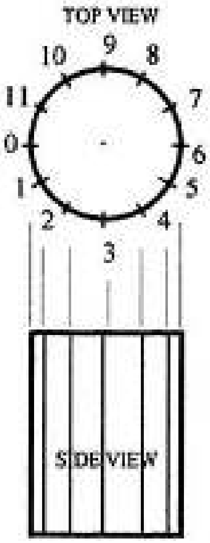
Pattern development cannot be commenced until the required views have been drav showed the two views required when the pattern for a cylindrical prism is to be developed.

**Step 2** Calculate the circumference using the dimension provided in the top view.

The circumference of the top view of is set out below as an example.

| Circumference of the circle |
|---|
| $\text{Circumference} = \pi \times \text{diameter}$<br>$= 3.142 \times 40$<br>$= 125.68 \text{ mm}$ |

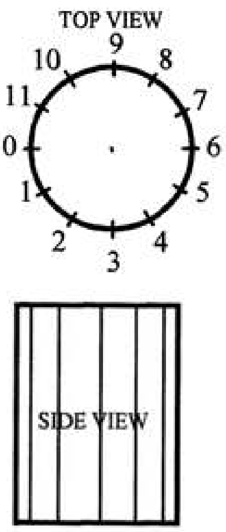
**Step 3** Divide the circumference of the top view into 12 equal parts, as illustrated



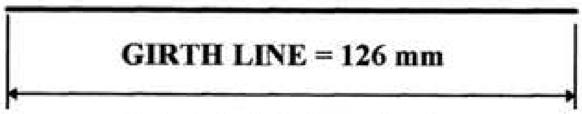

Project each of the points located in the top view to the side view, where they are presented as a series of vertical and parallel lines.



**Step 4** Commence the pattern by drawing one line, equal in length to the calculated perimeter; eg 126 mm, as Step4

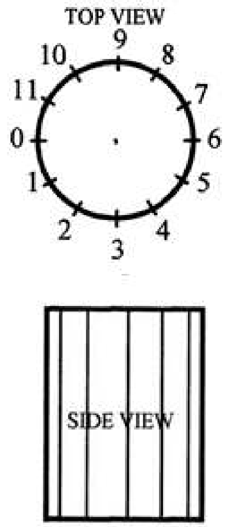



$$
\begin{aligned}
1/12\text{th circumference} &= (\pi \times \text{diameter}) \div 12 \\
&= (3.142 \times 40) \div 12 \\
&= 126 \div 12 \\
&= 10.5 \text{ mm}
\end{aligned}
$$

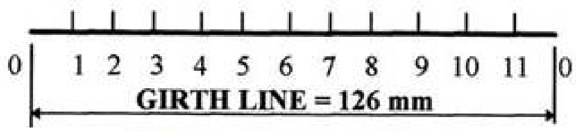



**Stp4 Calculated perimeter**

**Step 5** Divide the girth line into the 12 equal measurements with each measurement being 1/12th of the top view circumference step 5

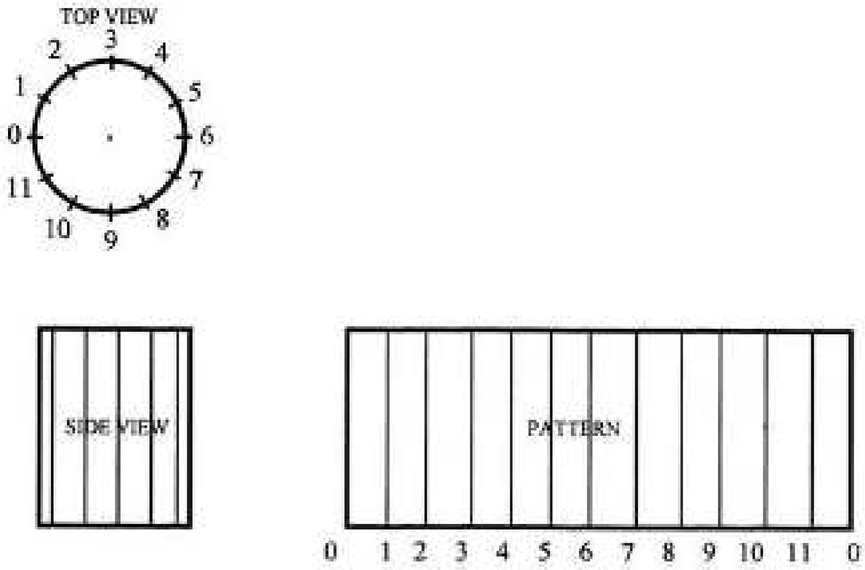



$$\begin{aligned} \text{1/12th circumference} &= (\pi \times \text{diameter}) \div 12 \\ &= (3.142 \times 40) \div 12 \\ &= 126 \div 12 \\ &= 10.5 \text{ mm} \end{aligned}$$




**Step5 – Dividing the girth**

**Step 6** The pattern is completed by constructing 13 parallel lines which are drawn perpendicular to the girth line, from each of the 13 points 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 0. These lines are drawn to a height equal to that of the side view. The pattern is finally completed when a line is drawn from the top of the side view parallel to the girth line to connect the top of the pattern.




Completing the pattern



**Example1**: The figure below shows a 90x30x50 box. Prepare geometric development of the box from hard paper using the given dimension.

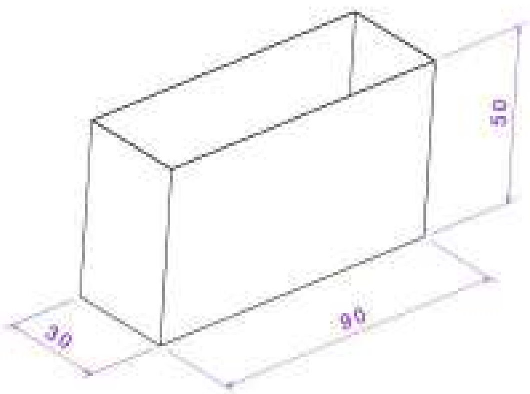
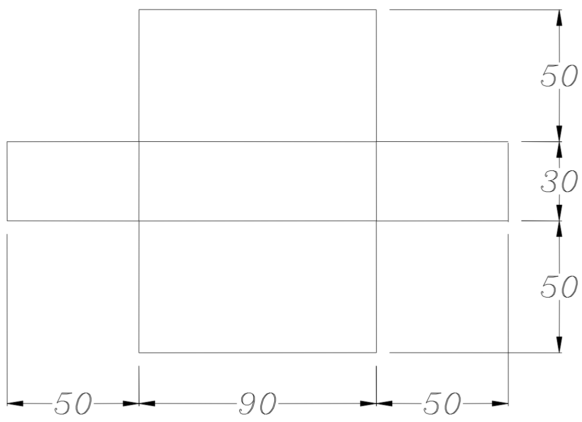



**Figure 3.5** example geometric development

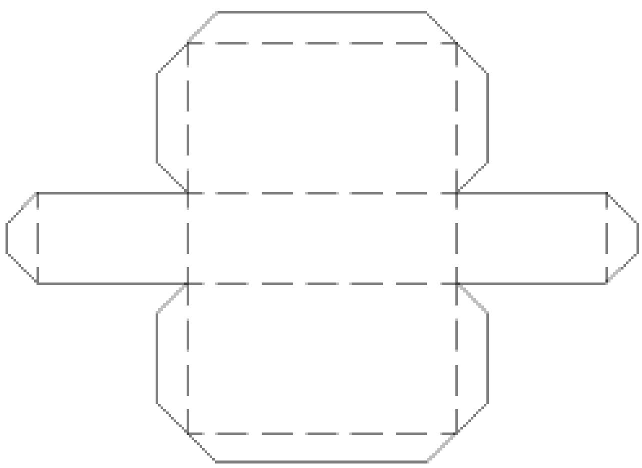
**Step 1**

So the first thing we need to do is to understand the figure. Here the object is a box in which the bottom becomes part of the development. So to make the development we cut the box along all the four edges and then stretch it on a flat surface. Doing so we get the following shape.




**Step 2**

Now it is time to think about joining method. The material from which you make the object determines joint design and amount of allowance required. To prepare the box from hard paper you may use an allowance of 10mm on all sides as shown below.



**Example2**: The figure below shows a model of a bag which is to be prepared from hard paper. Prepare geometric development of the bag using the given dimension.

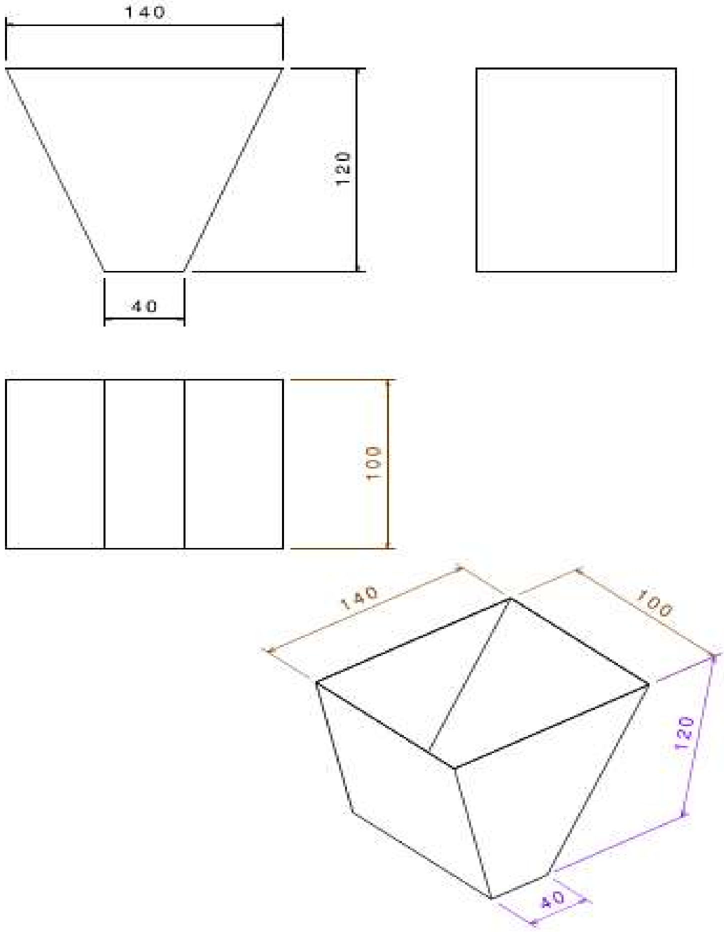



**Figure 3.5** example geometric development

A bag in a sense means that we are going to include the bottom in to the development. To make the development we cut the bag along all the four edges and then stretch it over a flat surface. Doing so we get the following shape.

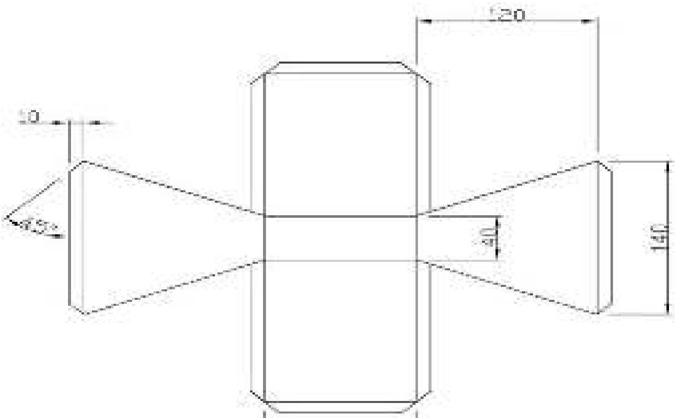


**Figure 3.6** example geometricbag development

**Example3**: A hexagonal prism, edge of base 20 mm and axis 50 mm long, rests with its base on a horizontal plane such that one of its rectangular faces is parallel to the vertical plane. It is cut by a plane which is perpendicular to the vertical plane, inclined at $45^0$ to the horizontal plane and passing through the right corner of the top face of the prism. Prepare geometric development of the truncated prism using the given dimension.

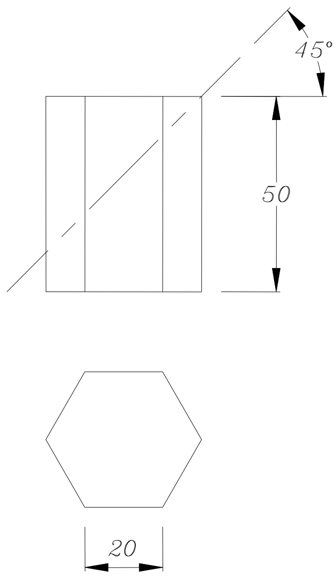



**Figure 3.7** geometric development of the truncated prism

To solve problems like this it is a must to draw the given view accurately to scale. So you may start with the top view and then project important points to the front view. Then dimensions of the pattern are driven from the front view.

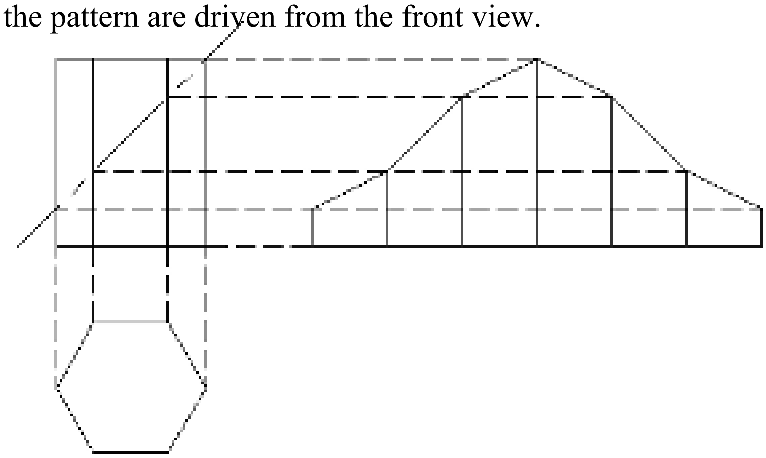


**Figure 3.8** step 1 development truncated prism

Finally you may add an allowance of 5mm as shown below.

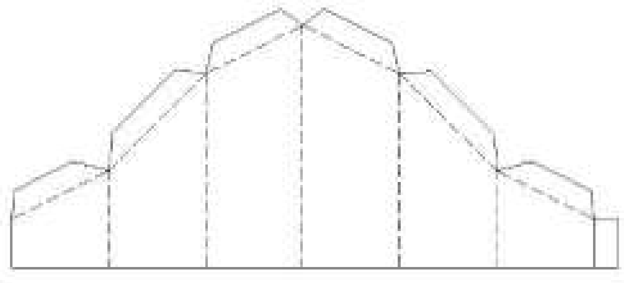


**Figure 3.9** step 2 development truncated prism

**Example4**: A cylinder of diameter 80mm and height 120mm rests with its base on a horizontal plane. It is cut by a plane which is perpendicular to the vertical plane, inclined at $45^0$ to the horizontal plane and passing through the right corner of the top face of the cylinder. Prepare geometric development of the truncated cylinder using the given dimension.

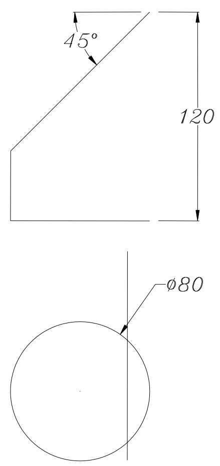



**Figure 3.10** geometric development of the truncated cylinder

To solve problems like this it is a must to draw the given views accurately to scale. Then we divide the circle in to 12 equal parts. Then we project each division point to the front view. Finally we derive the pattern from the front view as shown below.

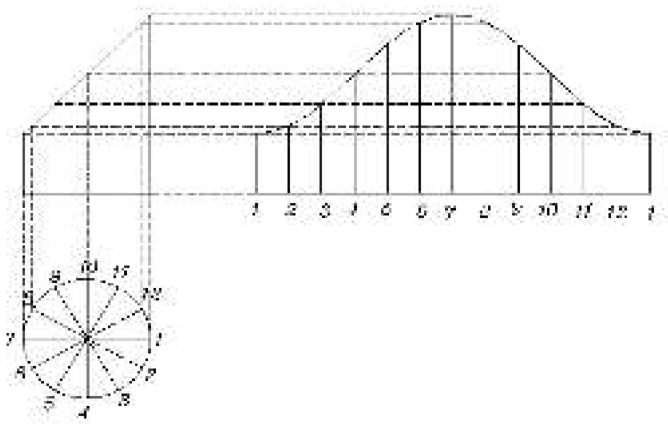


**Figure 3.11 step 1** geometric development of the truncated cylinder

**Example5**: The figure below shows a model of some house hold equipment. Prepare geometric development of the model from hard paper using the given dimension.

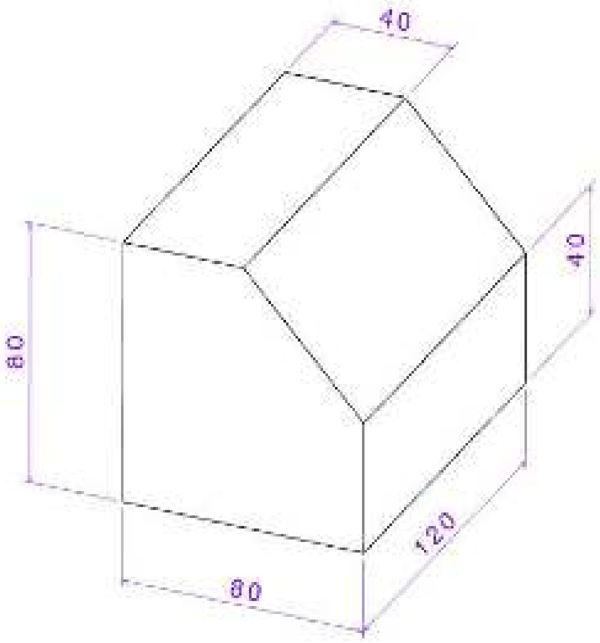


**Figure 3.12** geometric development of model

Here it must be clear that the given model is something like a liquid tank. Meaning, it is closed all around. So like any of the examples we have seen above we cut the object along its edges and stretch it over a flat surface. There may be many different ways of doing this and all the different paths that we take for cutting may yield a different shape. One of those possibilities yields the following pattern

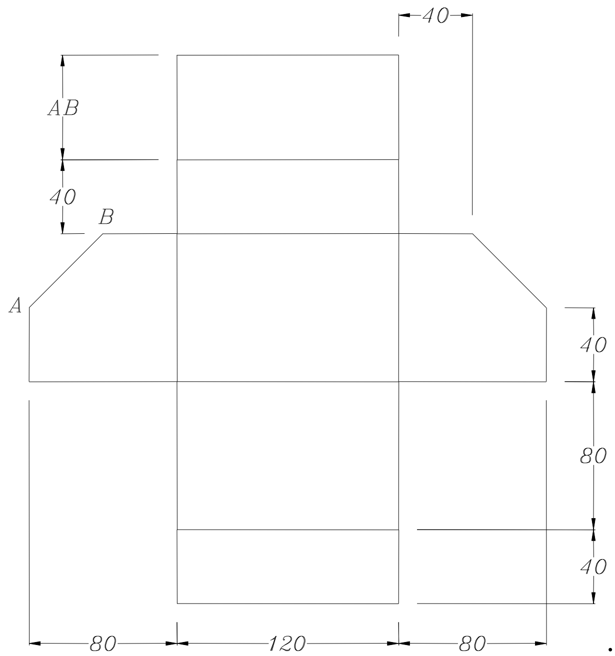



**Figure 3.13 step 1** geometric development of model

Finally we may add an allowance of 10mm as shown.

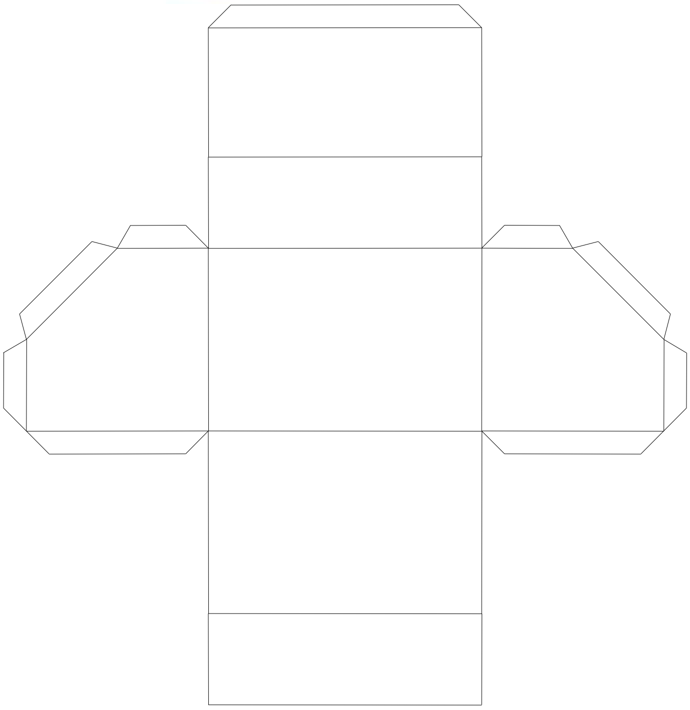


**Figure 3.14 step 2** geometric development of model

### 3.2.5 Radial-Line Development

The edges on cones and pyramids are not parallel. Therefore, the stretch out line is not a continuous straight line. Also, instead of being parallel to each other, measuring lines radiate from a single point. This type of development is called radial-line development.

Imagine the curved surface of a cone as being made up of an infinite number of triangles, each running the height of the cone. To understand the development of the pattern, imagine rolling out each of these triangles, one after another, on a plane (flat surface). The resulting pattern would look like a sector of a circle. Its radius would be equal to an element of the cone, that is, a line from the cone's tip to the rim of its base. Its arc would be the length of the rim of the cone's base.

**Terminology**

The terminology used in radial line development can be listed under the following four headings:

**Shapes**

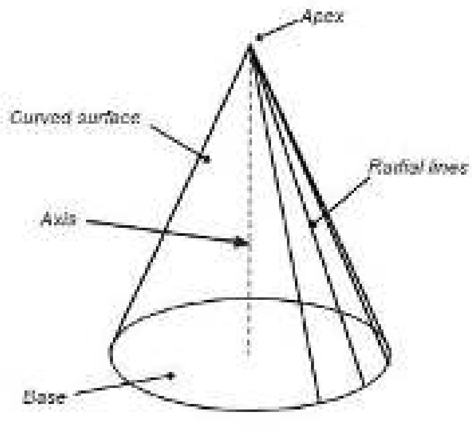
- Cone
- right cone
- pattern

**Points**

- Apex

**Lines**

- axis
- centerline
- radial lines
- base circle **Figure 3.15** the cone
- arc




**Surface**

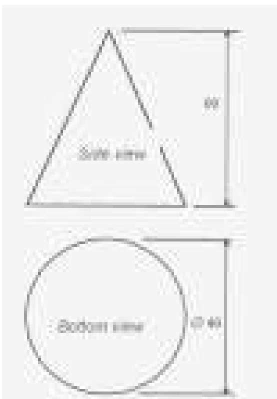
- curved surface

**Pattern development**

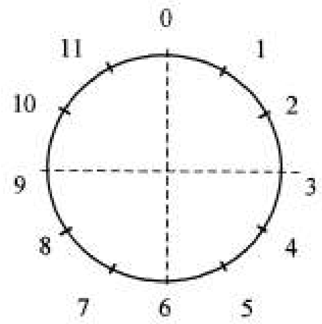
The following logical sequence of events is presented, to assist you to learn to develop patterns for right cones using the radial line pattern development technique

**Step 1** Draw the required views; for example – the side view and the top or bottom view.

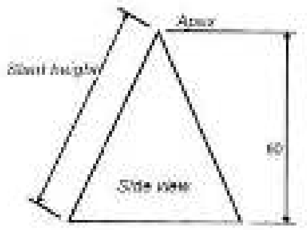
With these two views drawn the radial line pattern development for a right cone can be commenced.




**Step 2** Divide the circumference of the top/bottom view into 12 equal divisions.

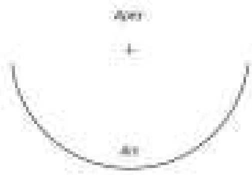



**Step 3** Set your compass to the slant height of the side view; apex to base.




**Step 4** Commence the pattern by scribing an arc, which has a radius equal to the slant height of the side view.

Slant height = pattern radius



**Step 5** Set your compass to 1/12th of the cone's base circumference.
The dimension can either be copied from one of the bottom view divisions or it can be calculated.

1/12$^{th}$ of circumference =π x diameter

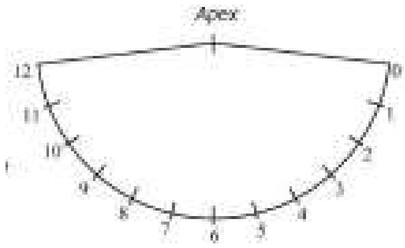
= π (3.142 x 40) ÷ 12

=126 mm ÷ 12

=10.5 mm

**Step 6** The pattern is completed by stepping off 1/12th of the base diameter of the cone (10.5 mm) twelve times along the arc of the pattern, to reproduce the cone's base circumference.

Outline the three sides of the pattern apex to 0, apex to 12 and the arc 0 to 12. Slant height




Example:

**Pattern development of right cone**

While learning about this pattern development, you will once again follow the six basic steps you learnt earlier in the introduction to radial line development.

**Step 1** Draw the required views, which once again you will note are the top or bottom view and side view. These two views provide the two pieces of information required to layout the pattern for this right cone.

- The vertical height, which is 95 mm.
- The slant height which is used as the radius to commence the pattern layout.
- The diameter of the base of the cone, which is 90 mm.

**Step 2** Divide the circumference of the bottom view into 12 divisions, as illustrated in the drawing 2B. The lines drawn from each of these points on the circumference to the apex, represent those drawn from the cone's base to the apex in the side view.

**Step 3** Set your compass to the slant height of the side view; apex to base.

**Step 4** With your compass set at this measurement, scribe an arc to commence the pattern layout.

**Step 5** Set your compass to 1/12th of the cone's base circumference, eg 0 to1 of the bottom view.

A more accurate method of obtaining 1/12th of the circumference of the cone's base is to calculate it.

1/12th of circumference x diameter = $\pi$ 3.142 x 90 ÷ 12 282.75 ÷ 12 23.56 mm

1/12th of circumference = $\pi$ x diameter

=3.142 x 90 ÷ 12

=282.75 ÷ 12

=23.56 mm

**Step 6** With your compass set at this measurement, step it off 12 times along the arc of the pattern layout, so as to transfer the cone's base circumference to the pattern layout.

Finalize the pattern by outlining the two seam lines 0 to apex and apex to 0, and outline the portion of the arc required.

Note, each of the points 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11 on the arc of the pattern can be joined to the apex with a light construction line if you wish. These lines will assist you when rolling the cone into shape, but are of no other practical use to the pattern.

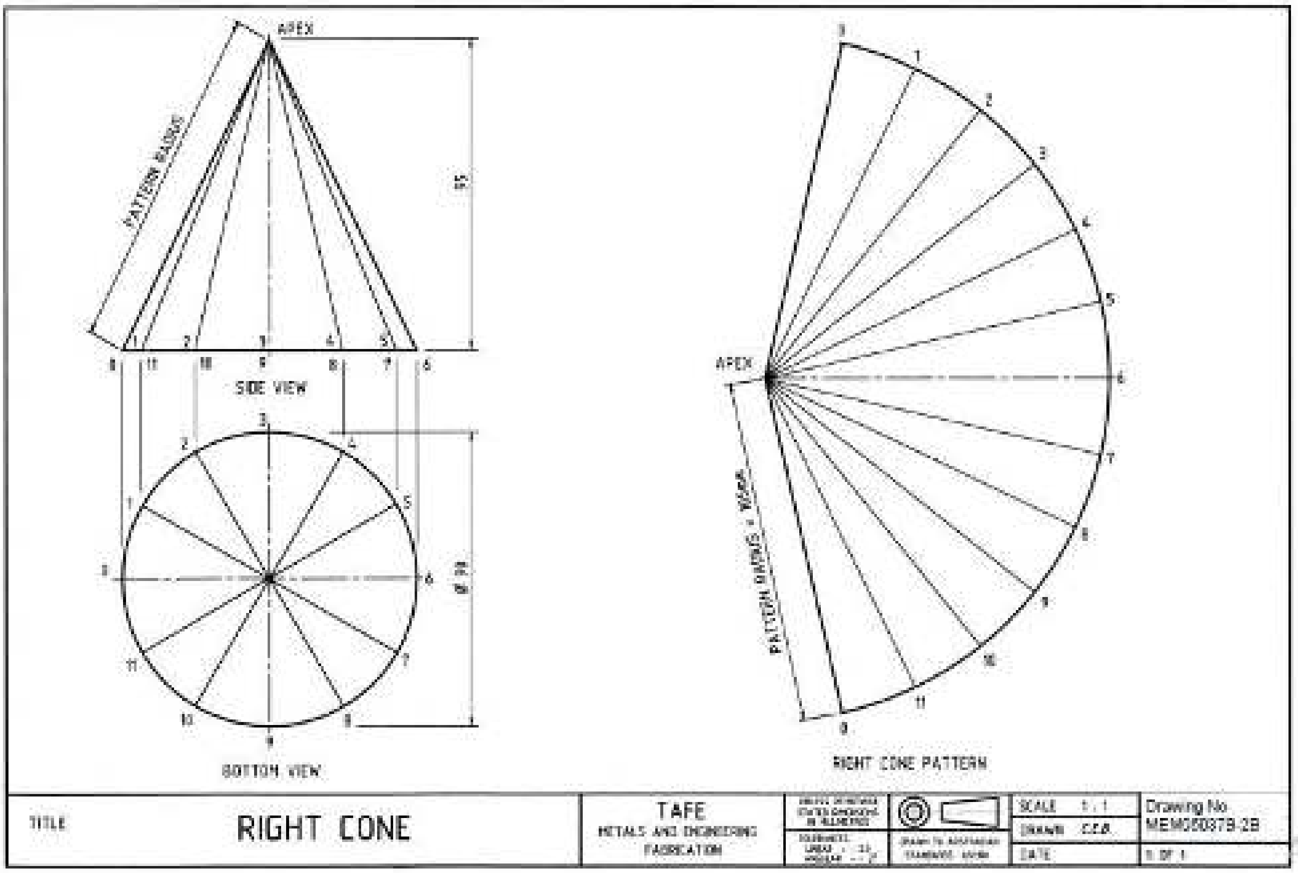



**Figure 3.16** development of right cone

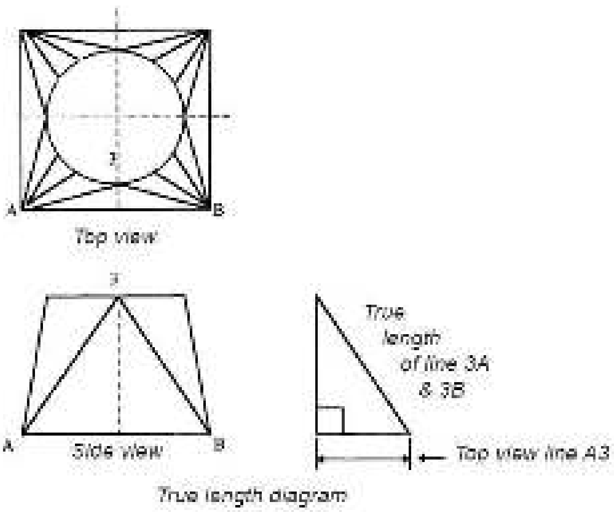
### 3.2.6Triangulation

Triangulation is the name given to a pattern development method to develop the shapes, or more correctly the surfaces of shapes, which do not consist of either parallel or radial line elements. However, it must be made clear that all surface shapes can be developed using this triangulation method.

In this method the surface of the object to be developed is divided into a number of triangles, with each triangle (as a true shape and size) being placed next to each other to produce the pattern for the given object.

**The golden rule of triangulation states:**

The true length of a line is obtained by placing the top view (or bottom view) length of a line at right angles to its vertical height.



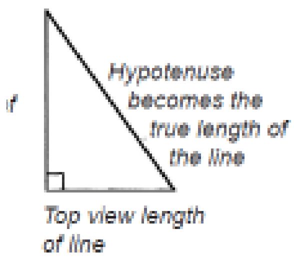




**Figure 3.17** true length diagram

In the above example the top view line A3 has been placed at right angles to its vertical height, so as to obtain its true length which can be used in the pattern development of this square to round

**Terminology :**The terminology used in triangulation can be listed under the following headings.

**Shapes**

- top view
- side view
- true length diagram
- transition
- square to round
- rectangle to round
- primary triangle
- secondary triangle
- pattern.

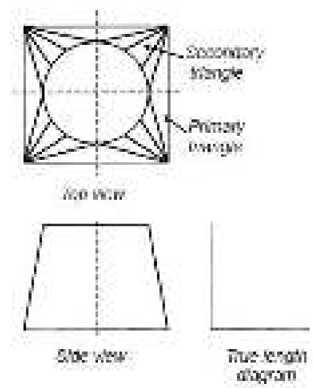



**Figure 3.18** triangulation

**Line**

- centerline
- triangular (generator) lines
- top view line
- side view vertical height line
- circumference
- half circumference
- 1/12th circumference

**Surface**

- flat surface
- curved surface.

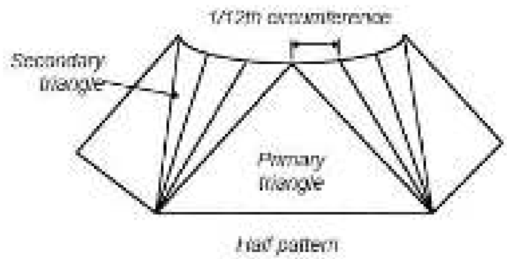



**Figure 3.19 half pattern**

A half pattern is often produced in preference to a whole pattern, because two halves are easier to shape and form when compared to a whole pattern. The two halves are joined by an appropriate method to produce the final component.

**Triangulation pattern development steps**

The following sequence of events is presented as a logical approach to pattern development while using the triangulation development method. Such a sequence of events will not only ensure an accurate pattern, but also an effective and efficient use of all resources, including time.

**Step 1** Draw the required views; for example – top and side view. Pattern development by triangulation cannot be commenced until these two views are drawn. Fig 1 illustrates the two views required for the development of a concentric square to round transition.

These two views provide all of the information required to develop the pattern for this square to round transition.

For example, all of the following dimensions are true length and can therefore be transferred directly to the pattern development:

- the sides of the square are all true length
- the dimensions AX and BY are also true length
- each of the 1/12th divisions of the circle's circumference is a true length.

The only lines which are not true length are the triangulation lines which connect the square to the circle. A0, A1, A2 and so on. True length of these triangulation lines will have to be obtained.

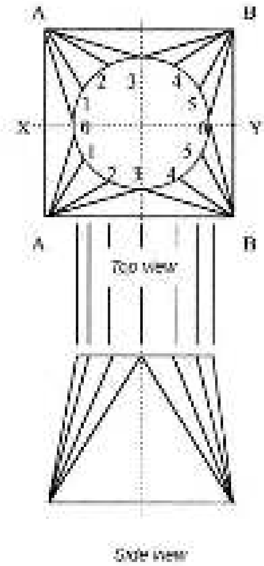



**Figure 3.20 Two views**

Step 2 Construct the true length diagram.

Note: With transition pieces such as this square to round, only one true length diagram is required. The height of this true length diagram is equal to the vertical height of the side view; as can be seen in Fig 2. You will also note that the true length diagram consists of a right angle.

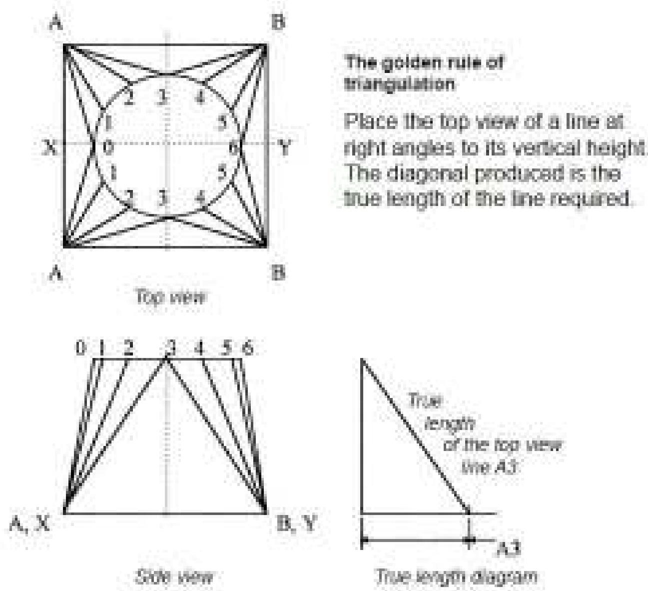



**Figure3.21 True length diagrams**

In Fig 2, the true length diagram (a right angle) can be seen constructed to the right of the side view. The vertical arm of this true length diagram being equal in height to the side view, while top view triangulation dimensions, such as A3 are transferred and located on its horizontal arm, as illustrated. The diagonal line created is the true length of the top view line A3, which can now be transferred from the true height to the pattern as per Fig 3.

**Step 3** Commence the pattern development by constructing the primary triangle AB3. Note, in this example only a half pattern will be developed

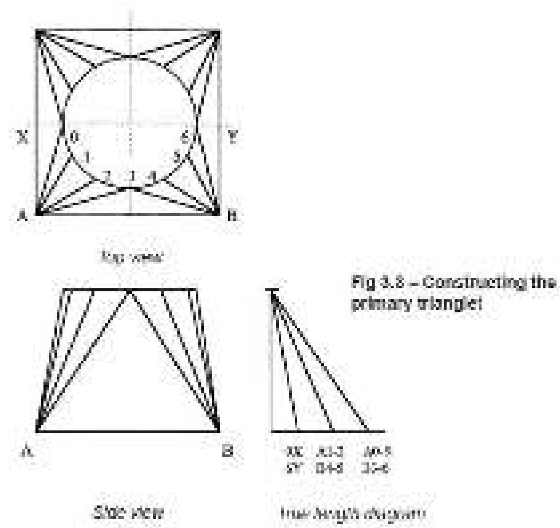



**Figure 3.22**. Primary triangle

The primary triangle AB3 is commenced by drawing a horizontal line, equal in length to the top view line AB.

- Whereas to locate the position of 3 in the pattern the true length line A3 (which is also B3) is transferred from the true length diagram to the pattern with a compass.
- Centre the compass on A, swing an arc above the line AB. This procedure is then repeated from point B of the pattern, producing the true location of point 3. That is where the two arcs intersect.

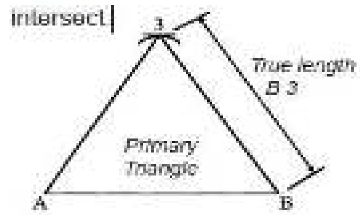



**Figure 3.23**pattern development

Step 4 Plot the location of the next two points in the pattern, which are points 2 and 4.

- The locating of these next two points will create the next two triangles. These triangles being A–3–2 and B–3–4, both of which are secondary triangles.
- To do this, the true length of the top view lines A2 and B4 need to be obtained from the true height diagram and transferred to the pattern, when centering at both A and B arcs are scribed either side of point 3.

Whereas the two measurements 3–2 and 3–4 are simply 1/12th of the circle's circumference. These are both stepped off from point 3. To the left to intersect the arc scribed from A to create the point 2 and similarly to the right from 3 to locate the point 4.

**Calculation**

1/12th of circumference = (3.142 x diameter)/12

= (3.142 x 80)/12

=188/12

=15.7mm

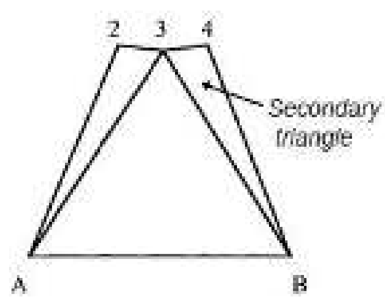



**Figure 3.24** secondary triangles (1)

**Step 5** Plot the next two points 1 and 5, to create the next two secondary triangles in the pattern.

- To do this, the true length of the top view lines A1 and B5 need to be obtained from the true height diagram and transferred to the pattern, in the same way as A2 and B4 were.
- Whereas the two measurements 3–2 and 3–4, which are 15.7 mm in (1/12th of the circle's circumference), are stepped off, one from point 2 to locate point 1 and the other from point 4 to locate point 5.

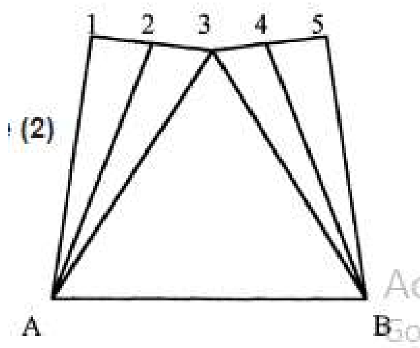



**Figure 3.25Secondary triangles (2)**

**Step 6** Locate the next two points 0 and 6, so as to add the next two primary triangles.

- Begin by transferring the top view length A0 (B6) to the horizontal arm of the height diagram, so that its true length can be obtained.
- Next, transfer the true length of A0 (B6) to the pattern. Centre the compass at A and scribe an arc to the left of point 1. Repeat this procedure from B.
- Now with the compass set to 15.7 mm, scribe an arc from point 1 to intersect the arc scribed from A, to locate the point 0 to the left of point 1. Repeat this procedure from 5, to locate point 6.

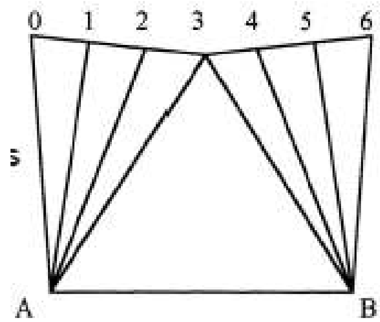



**Figure 3.26**Adding primary triangles

**Step 7** Complete the half pattern by locating the two points X and Y which can be found in the top view.

Transfer the top view true length line AX directly to the pattern. Centre the compass at A and scribe arc AX to the left of A. Repeat this procedure from B to produce arc BY to the right of B.

- Now, transfer the top view line 0X to the true length diagram, to obtain its true length.
- Next, transfer the true length of 0X to the pattern. Centre the compass on 0 and scribe arc 0X to intersect the arc scribed from A, to locate the point X. Repeat this procedure from point 6 to locate the point Y.

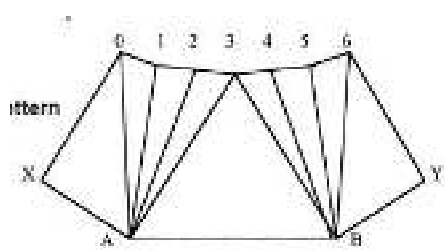



**Figure 3.27**finalizing the pattern

- Finalize the pattern by outlining and draw light construction lines for each of the surface triangulation lines from A and B to points 0, 1, 2, 3, 4, 5 and 6 respectively.

## 3.3 Ensure drawing including relevant information, full notation and dimensioning

Procedures for checking accuracy of patterns

### 1. Square and rectangular prisms

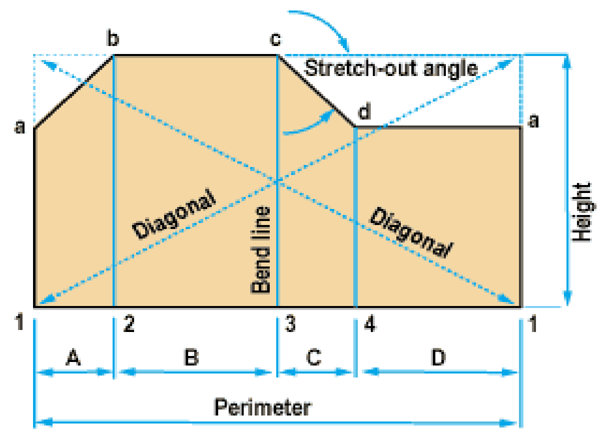



**Figure 3.3.1**Square and rectangular prisms

a. Check the perimeter of the prism equals the length of the pattern.

b. Check the height of the prism equals the height of the pattern.

c. Measure and check that the diagonal lengths are equal.

d. Check the position and length of the bend lines.

e. Check the accuracy of the pattern angles.

### 2. Cylinders

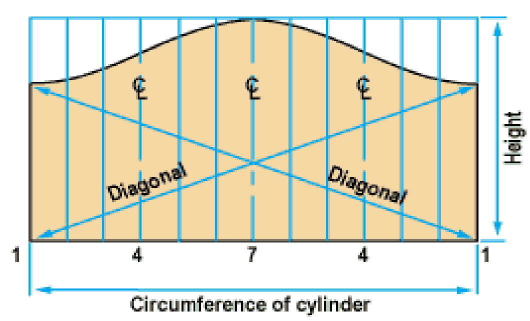


**Figure 3.3.2**Circumference ofCylinders

a. Check the circumference of the cylinder equals the length of the stretch out.

b. Check the height of the cylinder equals the height of the pattern.

c. Measure and check that the diagonal lengths are equal.

d. Check the ordinate heights of centre lines and ends are correct.

e. Check the curved outline has a smooth constant curvature.

**3. Radial line patterns**

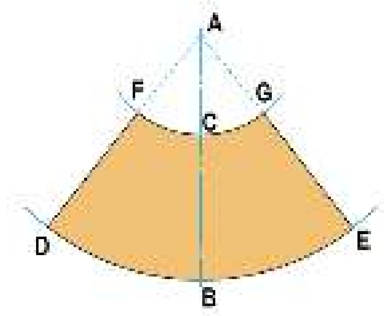



**Figure 3.3.3Radial line patterns**

a. Check the slant height from point B to apex point A.

b. From point B check the base curve to D which is half the bottom mean circumference.

c. From point B check the base curve to E which is half the bottom mean circumference.

d. Check the curved distance FCG is equal to the small mean circumference.

e. Check the diagonal FE is equal in length to the diagonal GD.

f. If any of the measurements are not equal, then go back over the layout sequence.

g. Triangulated layout patterns

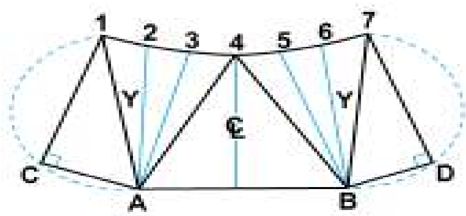



**Figure 3.3.4 steps Radial line patterns**

a. Measure diagonals C7 and D1. These should be equal.

b. Measure around curve points 1 to 7. It should be equal to half the circumference.

c. Check that the angles 1CA and 7DB are 90 degrees by using a plate square or a semicircle method.

d. Bisect lines A1 and B7 locate center point Y.

e. Using point Y as the center and Y1 and Y7 as the radii, draw semicircles. Points C and D should intersect on semicircle to prove they are 90 degrees.

### 3.3.1Developed patterns are ensured to comply with job specifications and work standards

**Step 1**- select a sheet metal product for which pattern is going to be developed

**Step 2**- select appropriate materials to produce the product /sheet metal/ according to the specification/

**Step 3-** Select appropriate tools and instruments required to perform development

**Step 4-**select right development method

**Step 5-** transfer shapes and dimensions from working drawing to the work piece

Remember all required allowance are added

**Step 6-** cut out the pattern according to its specification

**Step7-**finalize your work

**Step 8-**report to your instructor for evaluation

**Step 9-**Observe all OHS procedures

## Self-check-3

## Test –I

Multiple question

1. The rectangular prism has 40mm length and 25mm width  what are the perimeter of the prism

A.150mm    B.130mm    C.155mm    D.126mm

2.Volume is measured in _____________.

A. Cubic units.
B. square units
C. linear units
D. All

3.Ifthe  cylinder have 50mm diameter and 50mm length what are the circumference

A.120mm    B.230mm    C.167mm    D.157mm

4..The rectangular prism have 25 mm length and 48mm width what are the area of the rectangle

A.1200mm$^2$    B.2300mm $^2$    C.1670mm $^2$    D.157mm$^2$

5..The Triangle base have 25mm and 60mm height what are the area of triangle

A.590mm  square    B.750mm square    C. 345    D. 400  mm square

## Self-check-3

## Test –II short answer

1. ______________________ is a full-size layout of an object made on a single flat plane. Should provide overall satisfaction to all concerned.

2. The three method used to pattern development are______________, _____________, and _________________.

3. 

---

4.Write there appropriate formula of the following

A. area of triangle
B. Parameter of rectangle
C. Volume of cone
D. Parameter of ci

5. Discuss steps of checking accuracy of pattern developed with parallel line and radial line development methods

_____________________________________________________________________________

6. Write the formula of bend deduction

7. Bend allowance for

i. Bending Angles less Than 90 degrees
ii. Bending Angles Greater Than 90 degrees
iii. Bending Angles equal to 90 degrees

8. Identify the two views that provide all of the information required to develop the

Pattern.

**Drawing presents the pattern development of a square (prism).**

_________________ view _________________ view

9. Print the six missing dimensions, including the girth dimension in the spaces provided on the pattern of drawing

10. Complete the perimeter calculation in the space provided below.

Perimeter = side × 4

= 40 × 4

= 160 mm

11. Identify the position of the join or seam.

The join position is _______________________________________________ .

12. Explain the term prism.

A prism is ________________________________________________________

## Self-check-3

## Test –III True false

_____________1. The same object may have a different pattern depending up on the path we take during cutting.

_____________2. No pattern can be prepared without drawing orthographic projection of an object accurately to scale.

_____________3. Joint design generally depends up on the material from which the pattern is to be constructed and the purpose for which the object is intended.

_____________4. The main objective of drawing orthographic projection to scale is to obtain true length of unknown dimensions.

_____________5. In geometric development pictorial views are provided just to help the reader understand details so easily.

## Self-check-3

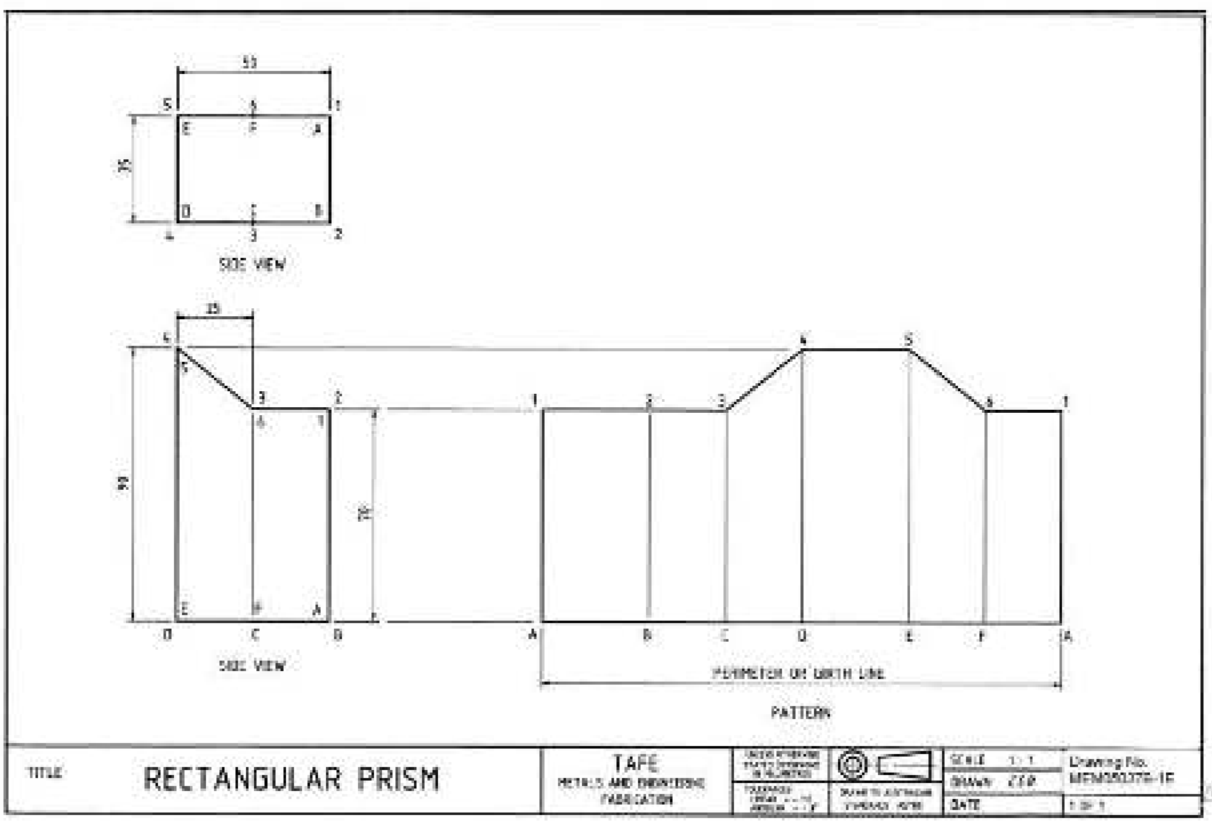
## Test –IV

## Operation sheet -3

**Operation :Paralleled line development**

**Purpose:**The aim is that students perform the geometric development work then transfer to sheet metal product. In accordance specification.

**Instruction:** Read the detailed drawing and follow drawing specification concern drawing , symbols fetchers and dimensions according to the specification




**Tools and equipment**

1 .divider

2. steel ruler

3. compass
4. eraser
5. pencil
6. hared paper
7. setsquare
8..scriber
11.hammer
12.center punch

**Quality** criteria all dimension are per specification legible, neatness, smoothens are very important higher ,esthetical value needs.

**Precaution:**Apply OHS

**Procedures in doing the task**

While Preparing about this pattern development, you will once again follow the six basic steps you learnt in both the previous unit one

**Step 1**

Draw the required views which are the top view and side view. These two views provide the five pieces of information required to layout the pattern.

**Step 2**

Not only is there a need to identify each of the four corners in this example, but also the change of shape (C3 and F6) located midway along the long side of the rectangular prism which can only be seen in the side view. The seam or join is positioned at the corner A–1.

**Step 3**

Calculate the perimeter of this rectangle prism.

Perimeter = (length + width) × 2

**Step 4**

Commence the pattern by drawing its girth line which as you can see has been drawn to the right and on the same horizontal plane as the base line of the side view.

**Step 5**

Mark off the six top view measurements, AB, BC, CD, DE, EF and FA along the girth line of the development, as illustrated.

**Step 6**

Construct the seven parallel lines from and perpendicular to the girth line. Each of these seven lines being A1, B2, C3, D4, E5, F6, and A1 a second time. To easily obtain the correct heights for these lines, project two horizontal construction lines from the side view; one from position 1–6 and the other from 4–5.

Note: Each of the seven vertical and parallel lines can be transferred from the side view to the pattern with a compass.

To finalize the pattern simply join each of the points 1–2, 2–3, 3–4, 4–5, 5–6 and 6–1 with an outline. Also outline the other three sides – A1, A1 and the girth line.

## LAP Test -3

Task 1 measurement

Task 2 development

Task 3 transfer to sheet metal

Task 3 bending accuracy

Task 4 time management

Task 5 overall qualities

develop flat pattern cone

Self-check-3

Test –V

Develop flat pattern cone

**Operationsheet** :triangular line development

**Purpose**: The aim is that students perform the geometric development work then transfer to sheet metal product. In accordance specification.

**Instruction**: Read the detailed drawing and follow drawing specification concern drawing , symbols fetchers and dimensions according to the specification

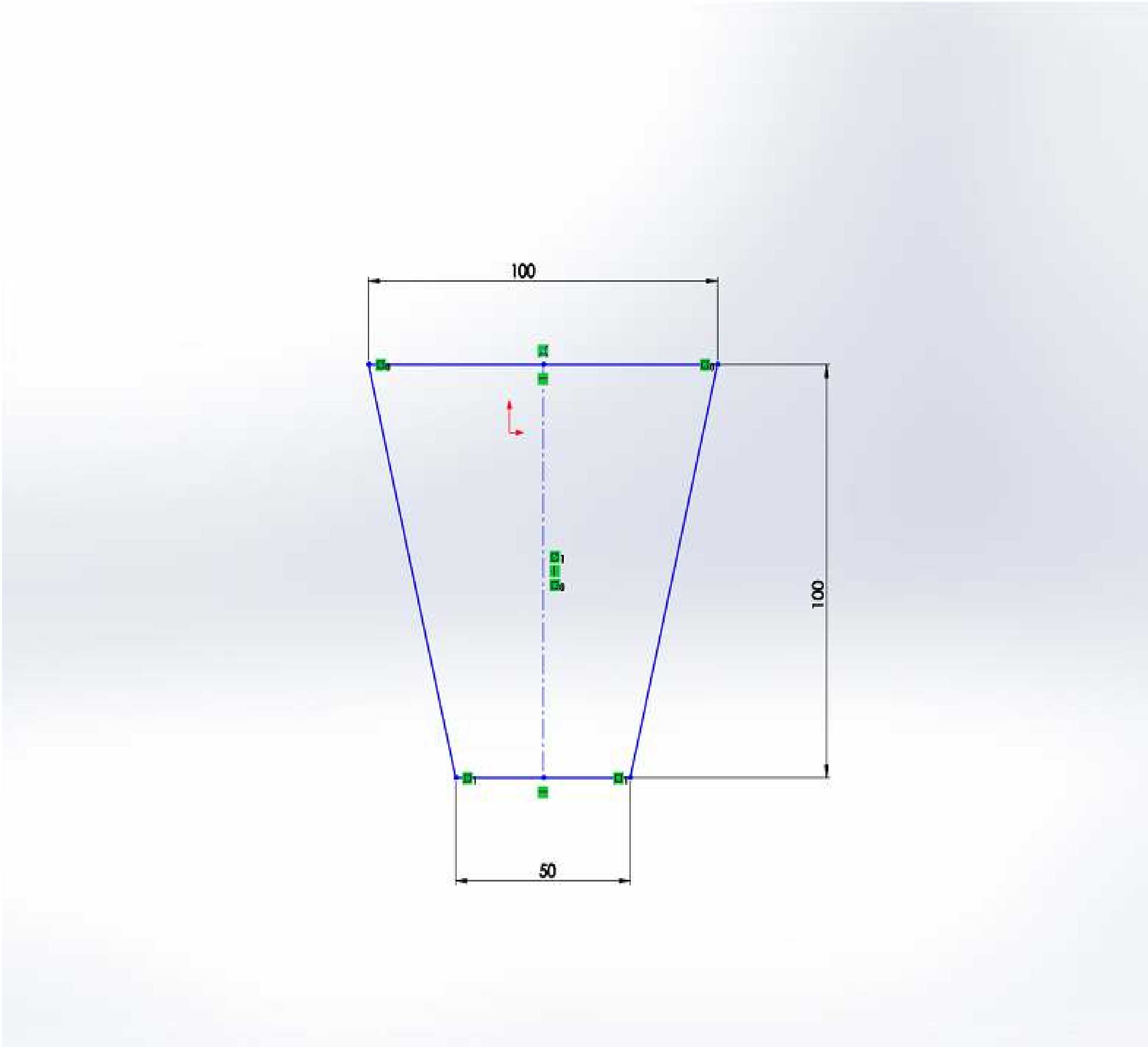



figure 3.3.6flat pattern conedevelopment ( all dimension in mm)

**Tools and equipment**

1 .divider

2. steel ruler

3. compass

4. eraser

5. pencil

6. hared paper

7. setsquare

8..scriber

11.hammer

12.center punch

13.snip

14.haredpeper

**Quality** criteria all dimension are per specification legible, neatness, smoothens are very important higher ,esthetical value needs.

**Precaution:** Apply OHS

**Procedures in doing the task**

1.draw the circle according to the drawing

2.drawe the flat cone shape under the privies circle

3.divide the Circe 12 equal line /place/

4.transfer the line

## LAP Test -3

Task 1 measurement

Task 2 development

Task 3 transfer to sheet metal

Task 3 rolling accuracy

Task 4 time management

Task 5 overall qualities

| Unit Four **Document and store drawings** |
|---|
| This unit is developed to provide you the necessary information regarding the following content coverage and topics:<br>• Document drawings.<br>• Store drawings.<br><br>This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:<br>• Perform drawings Document<br>• Perform drawing Store |

## 4.1Document drawings.

**Production Drawing Documentation**

means all documentation approved by the Employer, necessary for proper execution of the Work and prepared by the Contractor in the time limits and under conditions set forth in this Contract on the basis of all handed over project and documentary materials mentioned of this Contract – 2D drawings generated from the 3D model and their completion to the level of production documentation including lists of parts and weld tables.

## 4.2Store drawings.

How Do Artists Store Their Drawings?

Artists use different methods for drawing, such as graphite, chalk, charcoal, pastels, crayons, etc. All these methods use different mediums, and because of this, the storage of different types of drawing can differ.To make it easier for you, we have a comprehensive guide on how to store our drawings.

**Materials Required for Storage**

1. Acid-free tapes
2. Frames
3. Matting materials
4. Portfolio with acid-free plastic
5. Fixative or varnish
6. Clamshell boxes
7. Glassine
8. Acid-free lining papers

## Self-check-4

## Test –I

Short answer

1.What material are Required for in drawing Storage at least 5

---------------------------------------------------------------------------------------------------------------

2. Discuss Production Drawing Documentation means

-------------------------------------------------------------------------------------------------------------