

TRADE OF

Industrial Insulation

PHASE 2

Module 2

Geometry & Pattern Development

UNIT: 1

Basic Construction

Produced by

SOLAS

**An tSeirbhís Oideachais Leanúnaigh agus Scileanna
Further Education and Training Authority**

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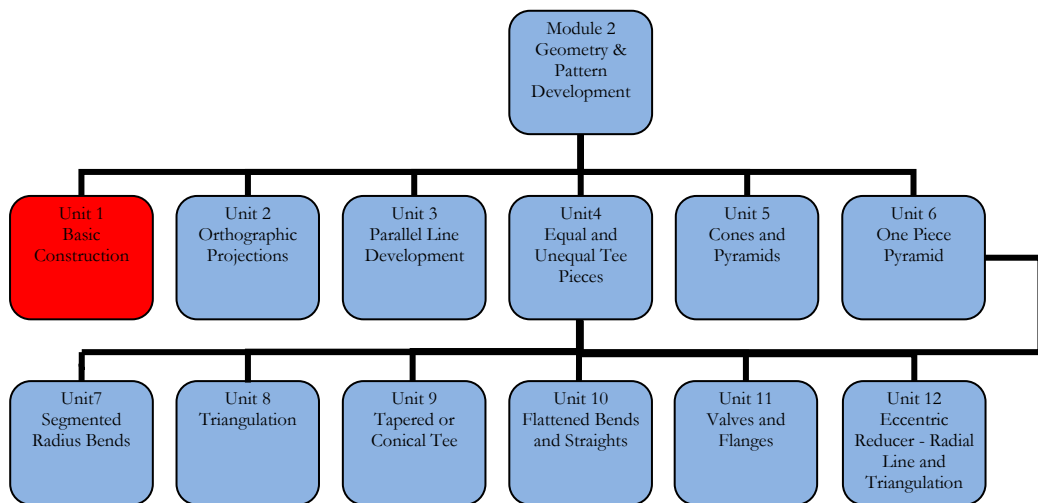
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Unit Objective

By the end of this unit *each apprentice* will be able to:

- Correctly use drawing instruments and equipment.
- Identify and draw different line types.
- Construct, bisect and divide lines and angles.
- Use different methods to construct an ellipse.
- Geometrically divide circles, semi-circles and quarter-circles.
- Locate tangent points and arc centres.



Introduction

Drawing is an international language. It is a graphical form of communication achieved by means of engineering drawings. If a drawing is prepared correctly by an Irish engineer, it can be “read” or interpreted by a German, American or Japanese architect or craftsman, provided it has been drawn to the proper international standards such as BS 8888: 2004 or similar. Failure to adhere to the proper standards in drawing practice could lead to all sorts of mistakes and problems in manufacturing and assembly with the possibility of serious litigation if products are manufactured incorrectly due to bad drawings.

1.0 Drawing Equipment

Key Learning Points

- Correct use of drawing instruments: set squares, tee square, compass, pencils, erasers etc.
- Drawing layout: sheet sizes, title blocks, relevant information
- Use and meaning of lines to standards in BS 8888: 2004, line weights and types

1.1 Drawing Instruments

The following minimum set of instruments is required in order to construct good quality technical drawings:

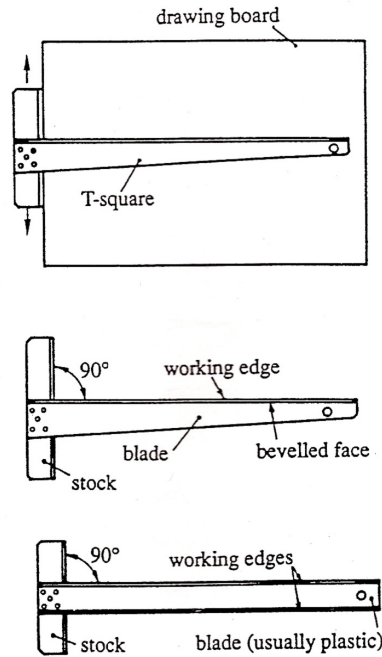
- A drawing board to take A2 paper.
- Strips of masking tape or drawing board clips.
- A Tee square.
- Two set squares.
- A protractor.
- A 150 mm compass and also spring bow compass.
- An eraser.
- Two pencils - a 2H and an HB, together with some sharpening device - file or sandpaper.
- At least a radius curve.

Drawing Board

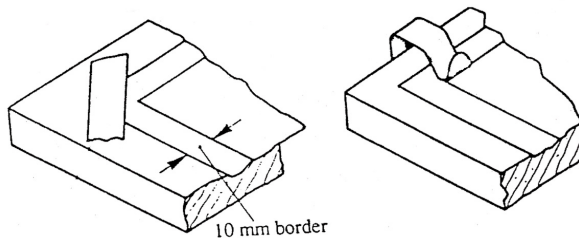
Most often made from wood, often from 12 mm thick plywood. Sizes vary, but for school and college work one measuring 650 mm by 470 mm is suitable for working with A2 size (or smaller) papers. The surfaces of all drawing boards should be cleaned at regular intervals, by wiping with paper or cloth and occasionally by re-sandpapering to ensure the surfaces are flat, smooth and clean.

Tee Square

Usually made from hardwoods, the best are from mahoganies, but good quality beech squares are suitable. Make sure the blade length is long enough for your board. Tee squares must be kept clean. Wipe regularly with paper or cloth and occasionally plane the drawing edge to keep it straight. Screws holding the blade to the handle may need to be tightened.

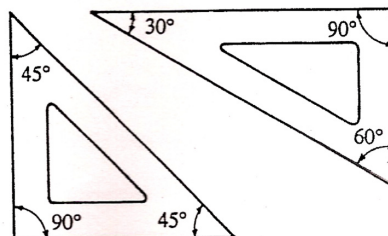


Fixing sheets of paper to the board - *drawing paper* can be fixed with pieces of sticky tape - masking tape is the best as well as being the cheapest, although 'Sellotape' can also be used. Clips are often used in schools and colleges. It is best to avoid using drawing pins for this purpose because they tend to damage the corners of the board after long use.



Set Squares

Two are necessary, unless you have an adjustable square. A 60°, 30° and a 45° set squares are needed. Set squares are usually made from plastic and require regular cleaning with paper or cloth.



Protractor

for constructing angles, which are not set square angles. A plastic protractor, measuring up to 180 degrees is suitable.

Compasses and Dividers

A good quality pair of compasses, which can draw circles up to 150 mm radius is an essential item of equipment. A pair of smaller 'spring bow' compasses is a valuable asset when drawing circles of 25 mm and less radius. Although not absolutely essential a pair of dividers can prove to be of use at times, e.g. when measuring from another drawing to determine an unknown dimension. Set the steel point of the compass just a little lower than the tip of the compass pencil.

Erasers

Essential for correcting mistakes. Vinyl erasers are preferable to rubber erasers - they make a cleaner job of 'rubbing out'. Be careful of rubber dust formed when erasing from a pencil drawing. It can be a source of annoyance causing smudges on your drawings if it is allowed to accumulate unnecessarily.

Pencils

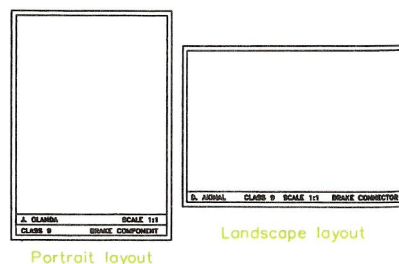
Can be purchased in nine grades of 'hardness' - from H to 9H - and six grades of 'blackness' - from B to 6B. There are also two other grades - F and HB. Two pencils are advisable - a 2H or 3H for drawing with instruments and an HB for freehand drawing such as lettering. Many draughts men like to sharpen their 2H pencils to a 'chisel' point and their HB pencils to a round point. Keep your pencils sharp by having either a small smooth file at hand, or a piece of fine sandpaper on which the pencil point can be sharpened as needed.

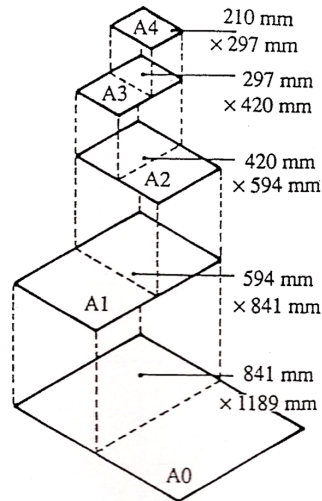
Curve Aids

French curves' and radius curves make the drawing of small radius curves and varied shaped curves much easier.

1.2 Drawing Sheets

The figure below shows two typical drawing sheet layouts for school or college use when working on A2, A3 or A4 sheets of drawing paper. The sheets can be in either an upright position, which is known as 'portrait' or in a horizontal position, known as 'landscape'.





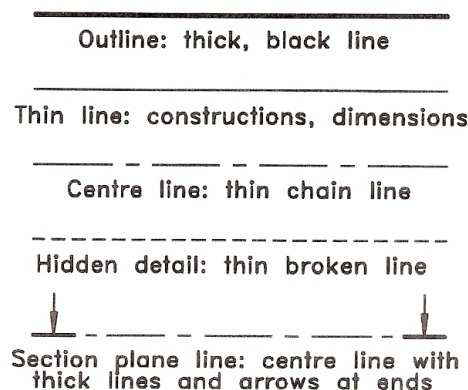
Drawing paper is graded according to its size, weight and surface texture. The sizes of drawing paper normally used are part of what is known as ‘the A series’. The largest size sheet (A0) has an area of approximately 1m². The next sheet size in the series is A1, and is exactly half the size of A1, and so on for the rest of the sheet sizes. The figure above shows this relationship.

If a sheet of A3 paper is folded over, two sheets of A4 paper will be formed. The most common sizes used for drawing work are A2, A3 and A4.

Border or margin lines: these surround the drawing. For an A4 size sheet these should be set in 10 mm; for an A3 sheet, 15 mm and for A2, 20 mm. The idea of a margin is so that the outer edges of the drawing area are protected if the sheet edges become damaged - at least the drawing area may not be affected.

1.3 Drawing Line Types

The figure below shows some of the types of lines for technical drawings. Note that the lines for the outline of drawings should be thicker than other lines. This makes the outline stand out clearly against the other details in your drawings. BS8888:2004 recommends that outlines should be about twice as thick as other lines.



Refer to module 2 – unit 2 – section 2.3 – lines and lettering.

1.4 Title Blocks

In general the title block is located at the bottom right-hand corner of the drawing sheet. For convenience of drawing layout it may be put in the top right-hand corner. It is recommended that spaces are provided in all title blocks for the following:

- Name of company.
- Drawing number.
- Description or title of drawing.
- Scale.
- Date and signature.

Other pieces of information which may be included are:

- A material or parts list.
- Job or order number.
- Treatment, finish of parts etc.
- Tolerances on dimensions not individually tolerance.
- General notes.

1.5 Storing Equipment and Drawings

When a drawing session is finished, it is important that the equipment is stored away neatly and in clean dry conditions. Dirty and damaged equipment does not help in the production of good, neat and clean drawings.

The best method of storing drawings is for each apprentice to have a folder in which the drawings are placed without folding. Drawing equipment should be placed in their purpose made sleeves and also kept in a folder.

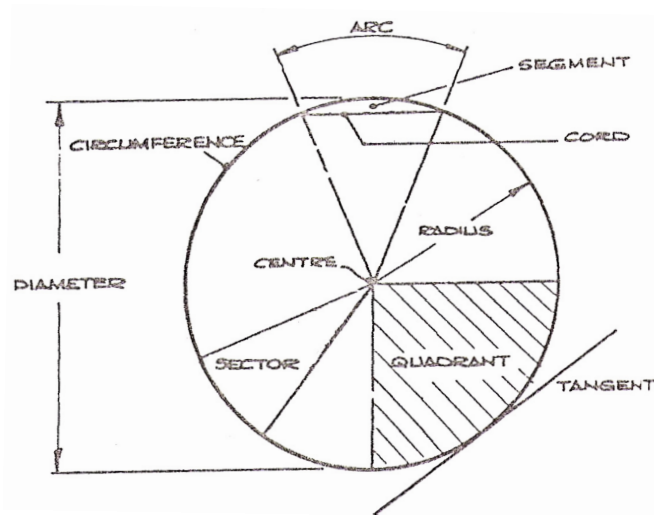
2.0 The Circle

Key Learning Points

- Terminology and properties of the circle
- Drawing of diameters and radii

2.1 Terminology and Properties of the Circle

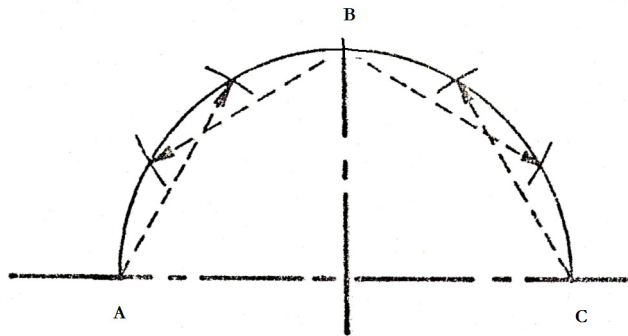
A circle is a plane figure which is bounded by a curved line called a circumference, which is always the same distance from a fixed point called the centre of the circle. Alternatively we could define a circle by saying that it is the path traced out by a point which moves in a plane in such a way that its distance from a fixed point is always constant. This distance from the centre to the circumference is the radius of the circle.



- A **diameter** is a straight line passing through the centre and bounded by the circumference. Clearly the diameter of a circle is twice the radius.
- An **arc** is the name for the part of the circumference between any two points on it.
- A **chord** is a straight line which joins any two points on the circumference.
- A **segment** of a circle is the area which is bounded by a chord and the arc it cuts off.
- A **sector** of a circle is the area which lies between two radii and the arc between them.
- A **quadrant** is the area bounded by two radii which are at right angles to each other and the arc which lies between them. It is a quarter of a circle.
- A **semicircle** is the area bounded by a diameter and that portion of the circumference which it subtends. As its name implies it is half the area of the circle.

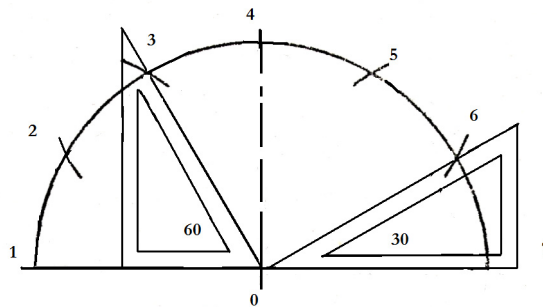
Note: “Subtends” – Think of a central angle (drawn from the centre of a circle). It hits a certain amount of the circle’s arc. This is the amount the angle “subtends”. It is the amount of angle (radians or degree) associated with the angle formed by two intersecting rays or lines.

2.2 Dividing a Semi-Circle into Six Equal Parts Using a Compass



1. Draw a half circle as shown.
2. Leaving the compass set to the radius of the circle, swing this radius from the quarter points of the circle (A, B, C) to divide each quarter circle into three equal parts. This procedure is used to divide a full circle into twelve equal parts.

2.3 Dividing a Semi-Circle into Six Equal Parts Using a 30/60 Degree Set Square



1. Draw the semicircle as shown. Divide the base of the semicircle on half using your compass to get the point 0.
2. From the point 0 draw a line perpendicular until it hits the curvature at point 4. The semicircle has now been divided into two equal parts.
3. Position the 60/30 degree set square on the base line and from point 0 using the 30 degree angle, draw a line from 0 to the curvature to get point 6. Repeat this procedure on the opposite side of the centre line to get point 2.
4. Position the 60/30 degree set square on the base line and from point 0 using the 60 degree angle, draw a line from 0 to the curvature to get point 3. Repeat this procedure on the opposite side of the centre line to get point 5.

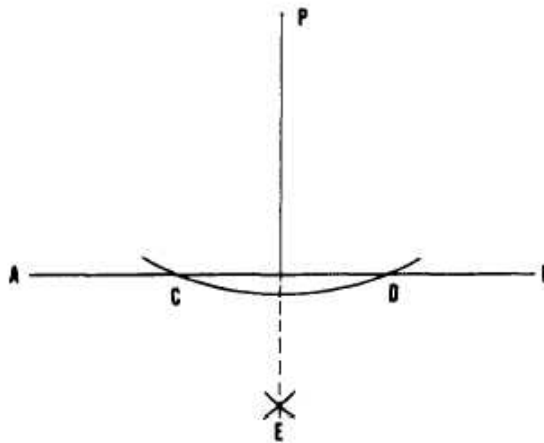
5. The semicircle has now been divided into six equal parts. A full circle can be divided in the same way by drawing the semicircle below the base line and following the procedures as set out above.

2.0 Bisection and Division of Straight Lines and Angles

Key Learning Points

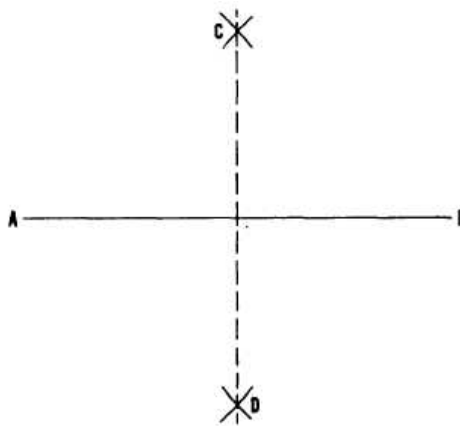
- Construction, bisection and division of straight lines
- Construction, bisection and division of angles
- Construction of a right angle triangle in a semi-circle
- Location of arc centres. Location of tangent points : tangent line to circles, arc to circle

3.1 Construction of Perpendicular Lines



The figure above shows the process of constructing a line perpendicular to another line using a compass. To drop a perpendicular line from point P to AB, set the point the compass point at P and strike an arc intersecting AB at C and D. With C and D as centres and any radius larger than one-half of CD, strike arcs intersecting at E. A line from P through E is perpendicular to AB.

3.2 Bisecting a Line



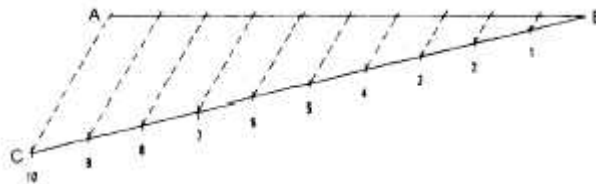
A line can be bisected by trial and error using dividers, that is, by setting the dividers to various distances until you find the point that correctly measures one-half the length of the line. The figure above shows the geometric construction for bisecting a line. To bisect the line AB, use the ends of the line, A and B as centers and set the compass to a radius which is greater than one-half the length of AB. Strike an arc from A and B until they intersect at C and D. A line drawn from C to D bisects AB.

A line may be divided into more than two equal parts by trial and error with the dividers. Geometric construction for dividing a line into any number of equal parts is shown above. To divide AB into 10 equal parts, draw a ray line CB from B at a convenient acute angle to AB. Set a compass to spread less than one-tenth of the length of CB, and lay off this interval 10 times from B on CB. Draw a line from the 10th interval to A, and project the other lines of intersection from CB to AB by lines parallel to the first one. The projected points of intersection divide AB into 10 equal parts.

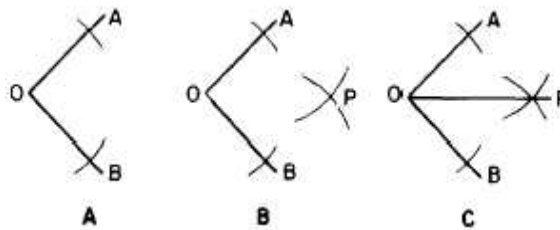
3.3 Bisection of an Angle

Angle

To bisect an angle means to divide it in half. If you know the size of the angle, you can bisect it by simply dividing the size by 2 and laying off the result with a

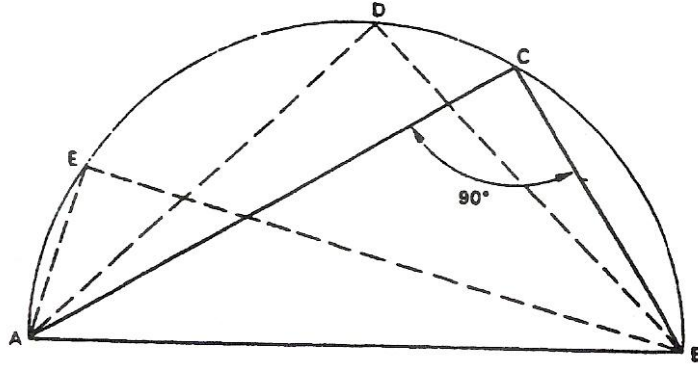


protractor. Geometric construction for bisecting an angle is shown in figure below, To bisect the angle AOB, first lay off equal intervals from O on OA and OB. With the ends of these intervals as centers, strike intersecting arcs of equal radius at P. Draw a line from O through the point of intersection of the arcs, P. The line OP bisects angle AOB



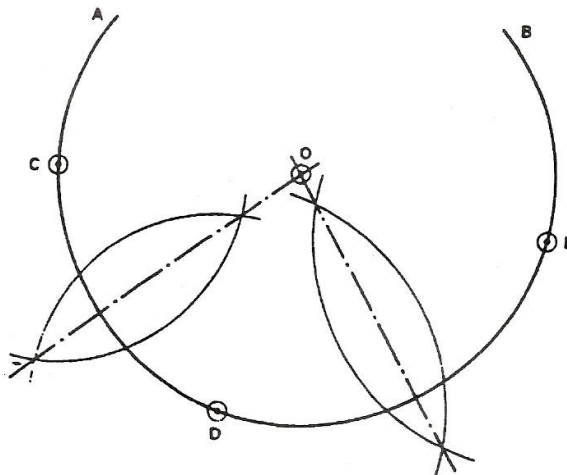
3.4 Right-Angle in a Semi-Circle.

Select any point C on the circumference of the given semicircle and draw lines from the diameter to termination points A and B to C. Then the angle ACB is 90° . Similarly the angles at E and D are right-angles.



3.5 Locating Arc Centres

Select three points C, D and E on the arc AB. Bisect the arc lengths between these points, using C, D and E as centers. The point O where the bisectors intersect will be the centre of the given arc or circle.

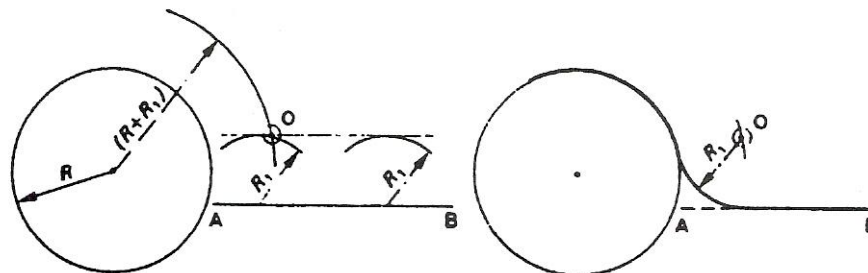


3.6 Tangential Arcs

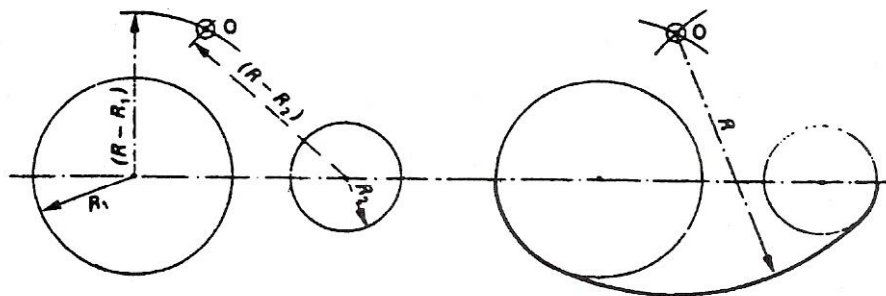
The figure below shows the constructions associated with tangential arcs. Fig. A shows the construction for an arc that is tangential to a circle and a straight line. Construct a parallel line, at a distance equal to the given radius R_1 , to the given straight line AB . Add R_1 to the radius R of the given circle and from the centre of the circle draw an arc to locate point O . With centre O and radius R_1 draw the required arc to touch the straight line and the circle.

Fig. B shows the construction of the external, tangential arc. Let R represent the radius of the given arc, and R_1 and R_2 the radii of the circles it is required to touch. Subtract the circle radii from the given radius of the arc, in turn, and from the respective centres of the circles draw arcs to intersect at point O . With O as centre and radius R draw the required arc to touch the circles externally.

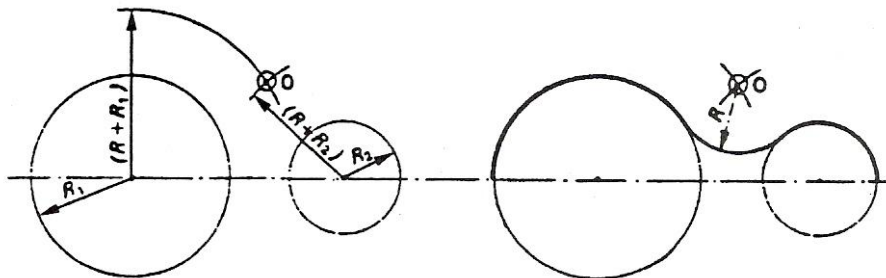
Fig. C shows the construction of the internal, tangential arc. Add the circle radii to the given radius of the arc R . From the respective centres of the circles draw arcs to intersect at a point O . With O as centre and radius R , draw the required arc to touch the circles internally.



A – To draw an arc of given radius to touch a circle and a straight line.



B – To draw an arc of given radius to touch two circles externally.



C – To draw an arc of given radius to touch two circles internally.

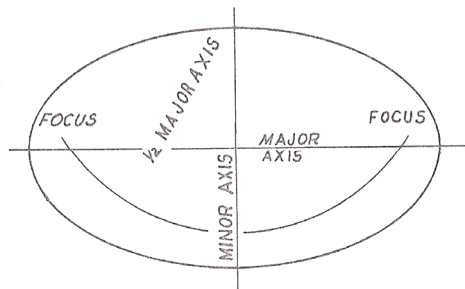
4.0 The Ellipse

Key Learning Points

- Construction of an ellipse: geometrical construction and simplified construction, trammel method
- Neatness and accuracy

4.1 The Ellipse – Definition

One of the most important constructions used in drawing is that of the ellipse. An ellipse is the path traced by a point which moves in a plane so that the sum of its distances from *two fixed points is always constant*. The two fixed points are called the “foci” of the ellipse. The ellipse is *symmetrical about two axis* which are perpendicular bisectors of each other. The longer axis is called the *major axis* and the shorter axis is called the *minor axis*. There are several ways of constructing an ellipse, all of which give satisfactory results.



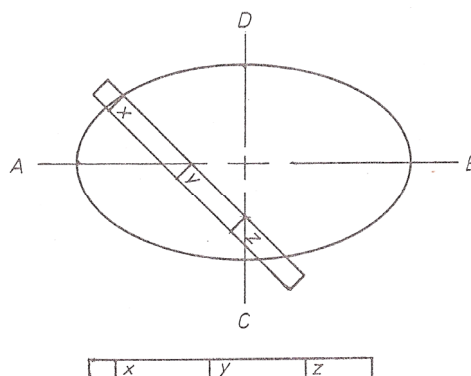
4.1 Constructing an Ellipse Using the “Trammel” Method

Let AB be the major axis and CD the minor axis of the required ellipse.

Along the straight edge of a piece of thin cardboard mark the points X, Y and Z so that $XZ = \frac{1}{2} AB$ and $XY = \frac{1}{2} CD$.

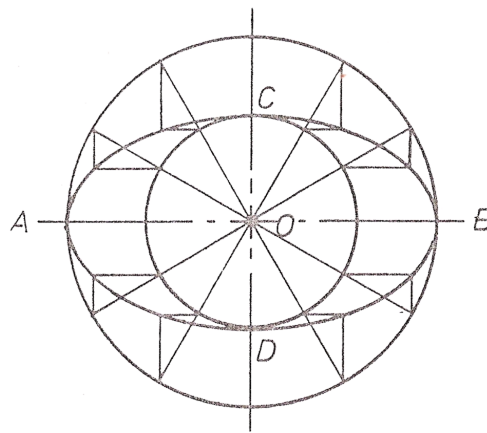
Place the piece of cardboard so that point Y is always on the major axis and point Z is always on the minor axis. For every such position the point X defines a point on the ellipse.

Mark each point separately and join them by a smooth curve. This is an ellipse constructed by the trammel method.



4.2 Constructing an Ellipse Using the Auxiliary Circle Method

1. With centre O (intersection of the major and minor axis), and radius AO, draw a circle.
2. With the same centre and radius CO, draw another circle.
3. Divide the circles into twelve equal sectors.
4. Where the radial lines cut the large circle draw verticals.
5. Where the radial lines cut the smaller circle draw horizontals to cut the verticals as shown.
6. The Point Of Intersection of these horizontal and vertical lines is a point of the required ellipse. Join these points by a smooth curve to complete the ellipse.



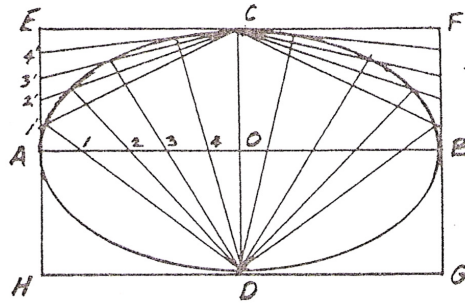
4.3 To Construct an Ellipse by the “Rectangular” Method

Give AB = Major axis, and CD = Minor axis.

For clarity the whole of the ellipse has been drawn but only half the construction has been shown. The other half of the construction can be obtained by applying the same construction from point C instead of from point D.

1. Draw AB and CD so that they are perpendicular bisectors to each other at point O.
2. Complete the rectangle EFGH.
3. Divide O and OB into the same number of convenient equal parts and number them 1,2,3, and so on. (Here five equal parts have been taken).
4. Divide AE and BF into the same number of equal parts. Number these 1', 2', 3', and so on.
5. From D draw lines through points 1, 2, 3, and so on, on AO and OB.
6. From C draw lines to the points 1', 2', 3', and so on, on AE and BF.
7. The points of intersection of these lines with the lines from the point D are points of the ellipse.
8. Join these points with a smooth curve. This will give one half of the ellipse symmetrical about AB.

9. To complete the ellipse repeat the construction by using point C and dividing AH and BG into the appropriate number of equal parts.



4.4 Neatness and Accuracy

As mentioned earlier, clean hands and clean drawing instruments should be the first priority when drawing. The layout and presentation of the drawing on the drawing sheet is another priority that should be adhered to when drawing. This helps towards the final presentation of the drawing.

Measurements should be accurate to within $\pm 0.5\text{mm}$ and angles to within $\pm 1^\circ$. It is very important that pencils are kept sharp so that the accuracy of the drawing is maintained. Excessive “rubbing out” should be avoided.

To finish the drawing to a high standard, neat legible lettering and numbering is essential. Untidy lettering and numbering will take from your drawings and spoil the overall appearance and professionalism of the drawing.

Summary

Drawing is an international language. It is a graphical form of communication achieved by means of engineering drawings. Any engineering drawing should show everything that is required for the job. A complete understanding of the object or part should be possible from the drawings. There should be no misunderstandings or ambiguity which could cause misreading of the drawings.

For drawings to be effective, they must be presented in a neat and orderly fashion. Various views such as the elevation, plan and end views of an object should be neatly presented on the drawing sheet supported with clear dimensions and neat lettering. The overall presentation of the drawing should have a professional finish.

S O L A S

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