ENGINEERING DRAWING

LECTURE 1

INTRODUCTION, GEOMETRY, TANGENCY

Objectives :

By the end of the lecture the student should know:

- Importance of eng. Drawing to engineer
- Sum equipment and Instrument of Eng. Drawing
- Geometrical operations
- Tangency and tangents

Introduction:

From the very early days, man realized that if he had to construct any structure or machine correctly and methodically, he must first record his ideas before starting construction work. These recorded ideas become more vivid and forceful if they are shown on paper in form of a drawing of the structure or machine. Such a drawing will be of very great help to the man who looks after the construction of this structure or machine. Indeed, "technical drawing is the language of engineering

Without the good knowledge of drawing, an engineer is nowhere and he could not have constructed the various magnificent structures .or intricate machines. Evidently, any one connected in any way, with engineering construction must understand this language of engineers. Technical drawing is, therefore, indispensable today and shall continue to be so as long as engineering and technology continue to be of use in the activities of man.

By means of drawing, the shape, size, finish, colour and construction of any object (no matter how complex) can be described accurately and clearly. The engineer should develop his skill in two phases of technical drawing: first, he must be able to draw clearly and rapidly, the freehand technical sketches; secondly, he must be proficient in drawing to scale the instrumental drawing. The purpose of the present course is to give the basic principles of the instrumental drawing only.

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Drawing Instruments and Their Uses:

Drawing instruments are used to prepare drawings easily and accurately. The accuracy of the drawings depends largely on the quality of instruments. With instruments of good quality, desirable accuracy can be attained with ease. It is, therefore, essential to procure instruments of as superior quality as possible. Below is the list of minimum drawing instruments and other drawing materials which every student must possess:

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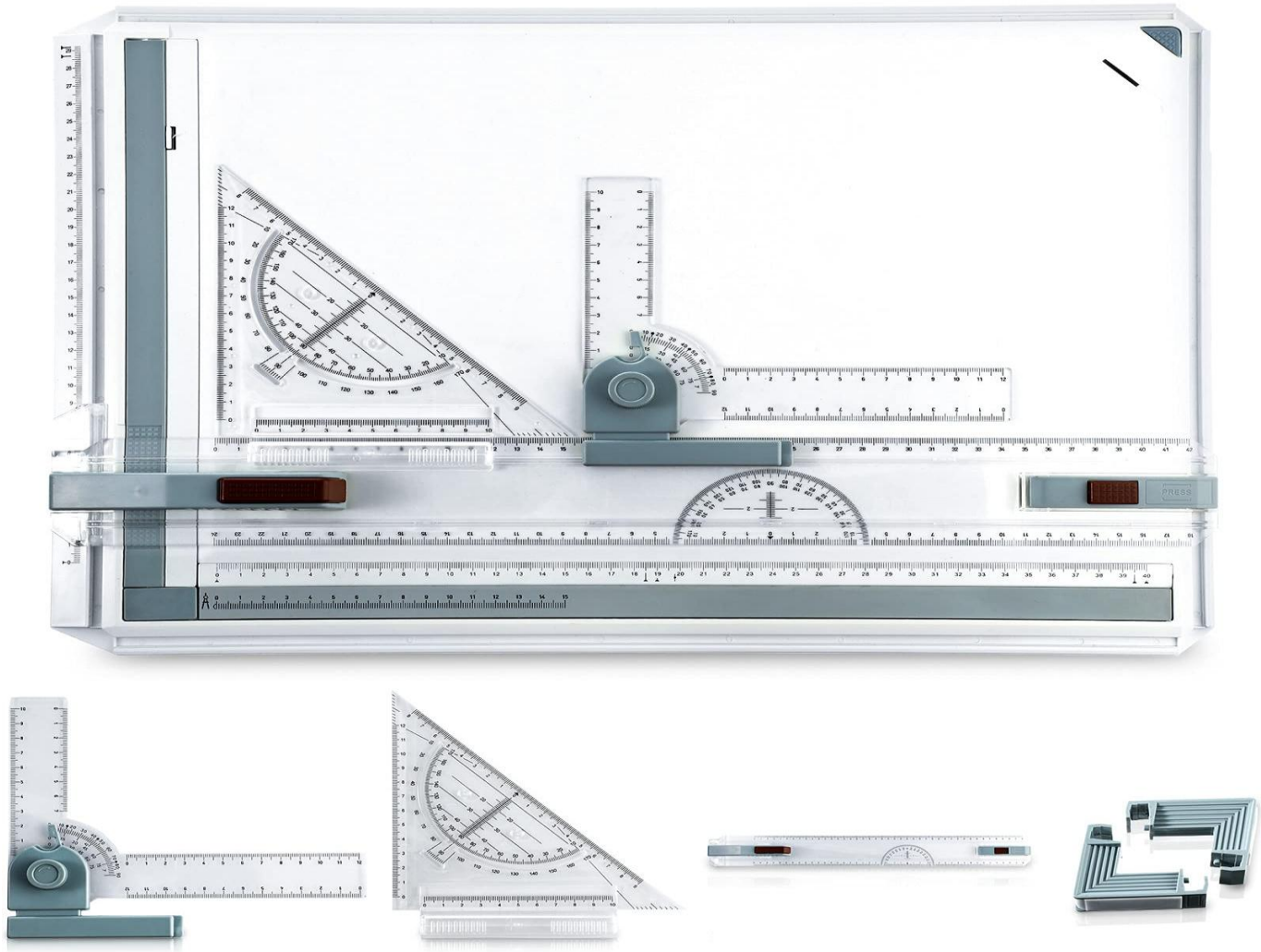
which every student must possess:

1 . Drawing board
2. T-square
3. Set-squares - 45° and (30°- 60°).
4- Compasses
5- Scales
6- Protractors
7 . Drawing papers
8. Drawing pencils
9. Eraser
10- Pins, Clips or Adhesive tape
11- Drafting Machine

Drawing Board:

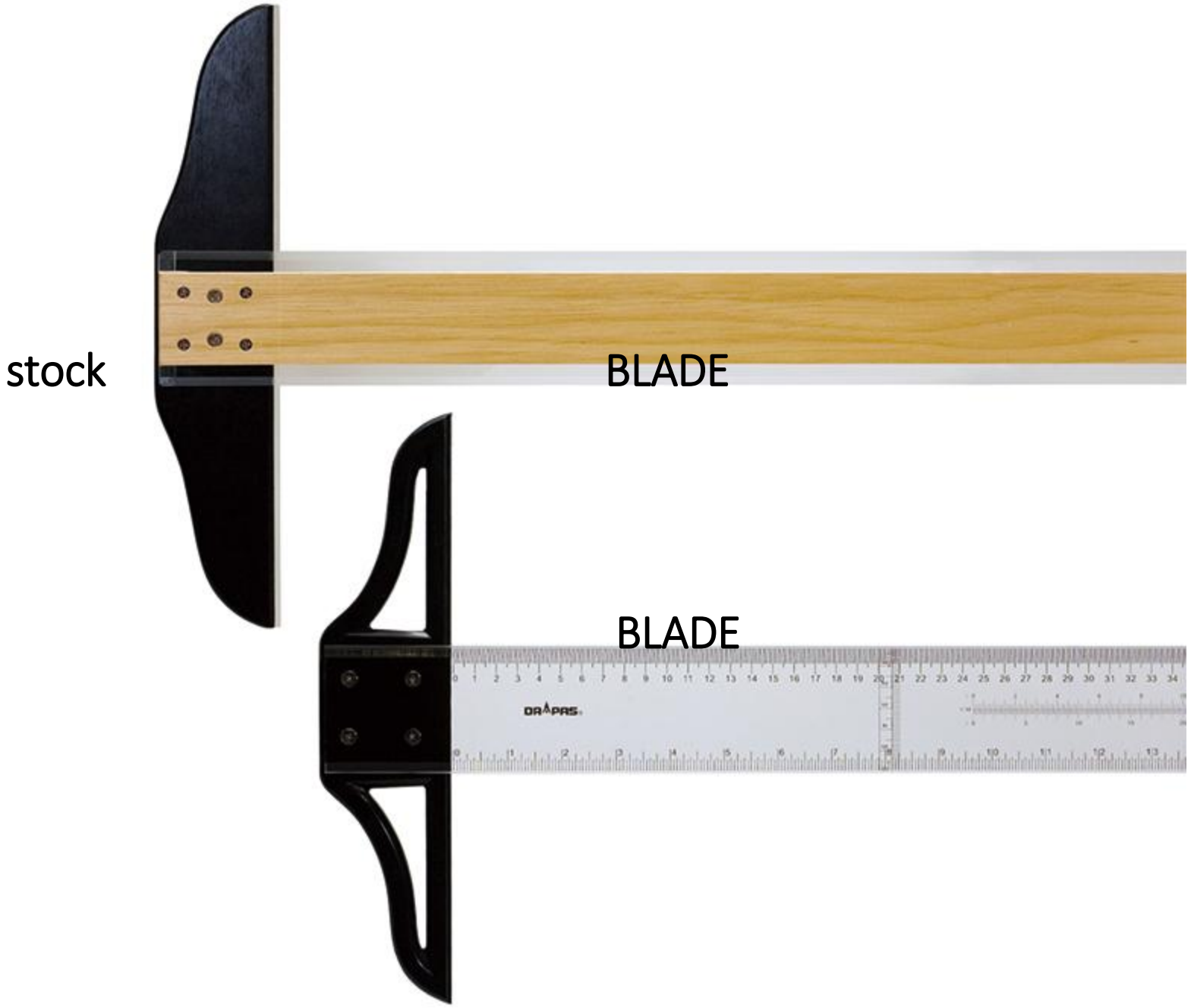
Is rectangular in shape made of soft wood or reinforced plastics . One of the edges of the board is used as the working edge . On which T square is made to slide this working edge is mostly the left side of the board . Also there is a portable boards but they used with the size of the A3 of the papers

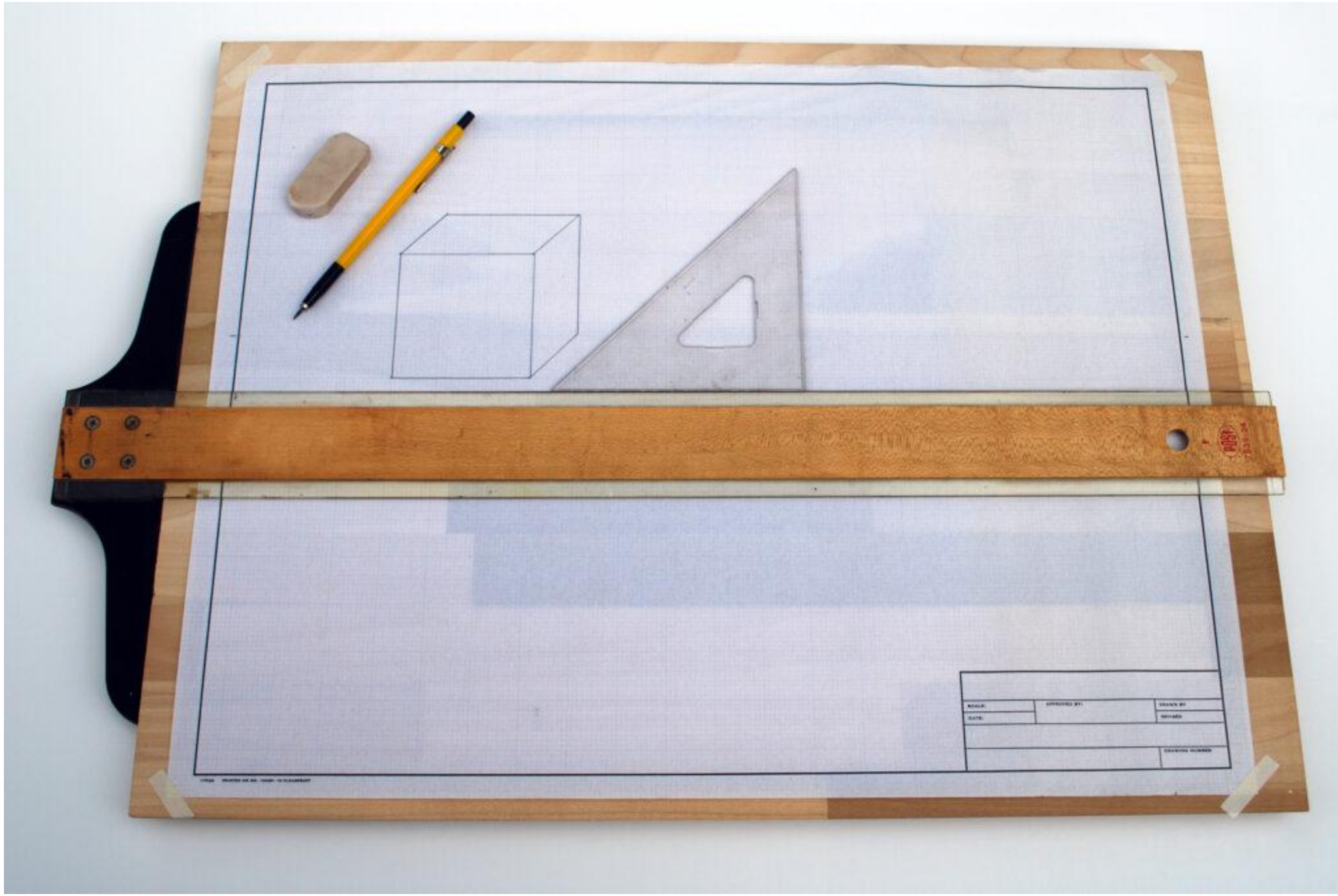
Portable board



T. Square:

A T-square is made up of hard-quality wood or plastic. It consists of two parts -the stock
and the blade -joined together at right angles to each other by means of screws and pins or slots by which blade can fixed with the stock. The stock is placed adjoining the working edge of the board and is made
to slide on it as and when required. The blade lies on the surface of the board. Its distant edge which is generally beveled, is used as the working edge and hence, it should be perfectly straight. The nearer edge of the blade is never used. The length of the blade is selected so as to suit the size of the drawing board. Now-a-days T-square is also available of celluloid or plastic with engraved scale.

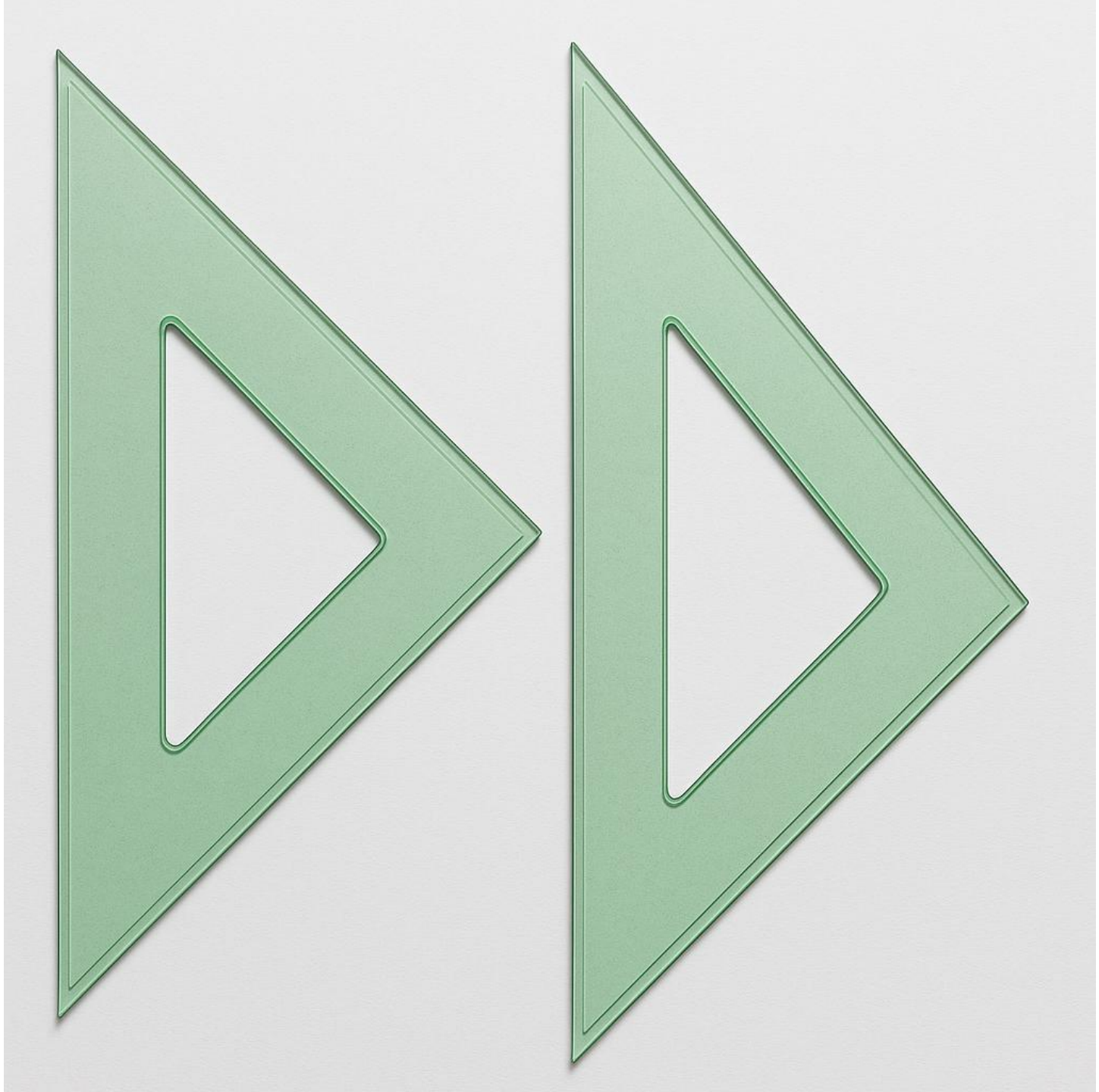

stock
BLADE
BLADE



Set squares:

The set-squares are made of wood, tin, celluloid or plastic. Those made of transparent celluloid or plastic are commonly used as they retain their shape and accuracy for a longer time. Two forms of set-squares are in general use. A set-square is triangular in shape with one of the angle as right angle. The 30°-60° set-square of 250 mm length and 45° set-square of 200 mm length are convenient sizes for use in colleges.

30 and 60-30 set- squares



Uses of set- squares:

Set-squares are used for drawing all straight lines except the horizontal lines which are usually drawn with the T-square. Vertical lines can be drawn with the T-square and the set-square.

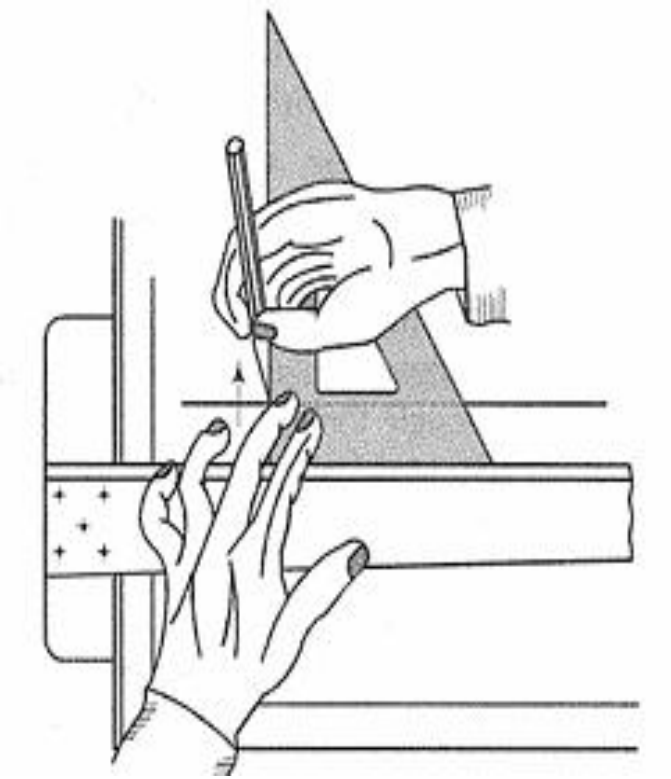
(ii)

In combination with the T-square, lines at 30° or 60° angle with vertical or horizontal lines can be drawn with 30°- 60° set-square and 45° angle with 45° set-square. The two set-squares used simultaneously along with the T-square will produce lines making angles of 15°, 75°, 105° etc.

(iii) Parallel straight lines in any position, not very far apart, as well as lines perpendicular to any line from any given point within or outside it, can also be drawn with the two set-squares.

(iv)

A circle can be divided in six, eight, twelve and twenty-four equal parts by using set-squares and T-square.



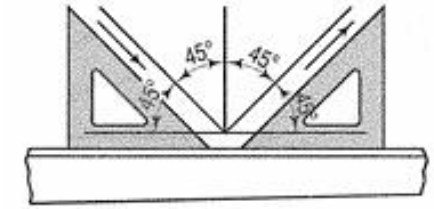


FIG. 1-7

FIG. 1-8

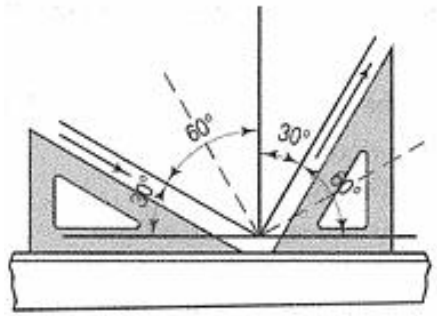


FIG. 1-9

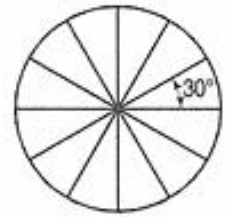
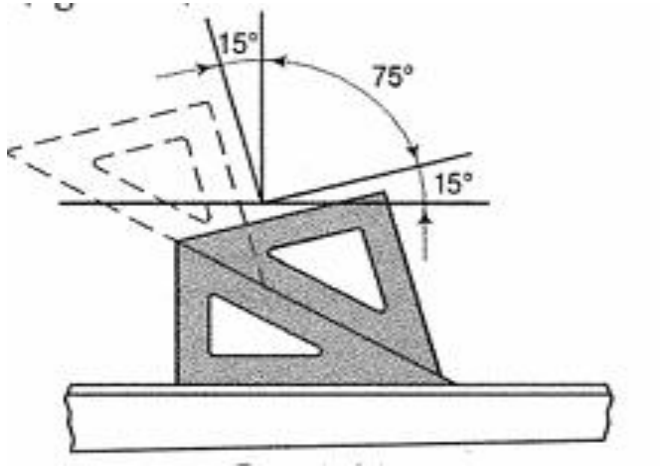
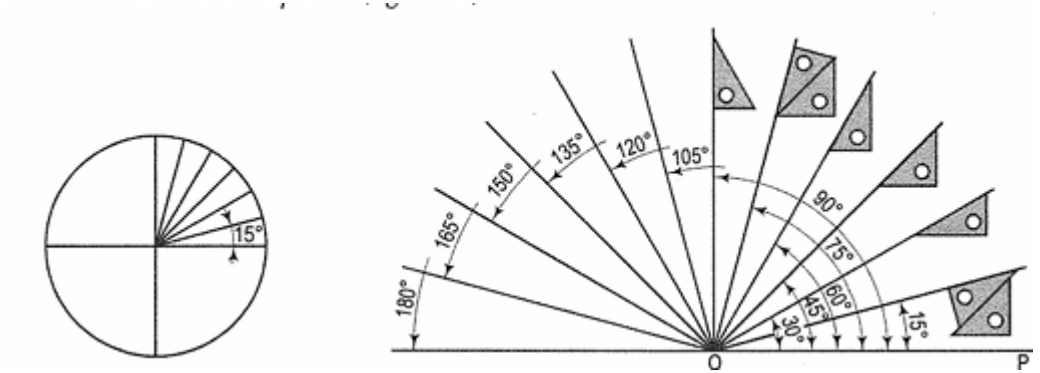
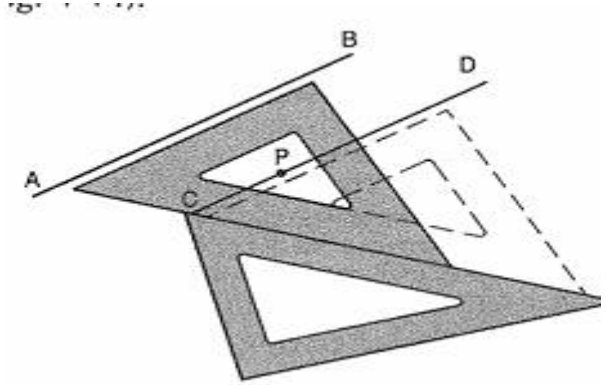
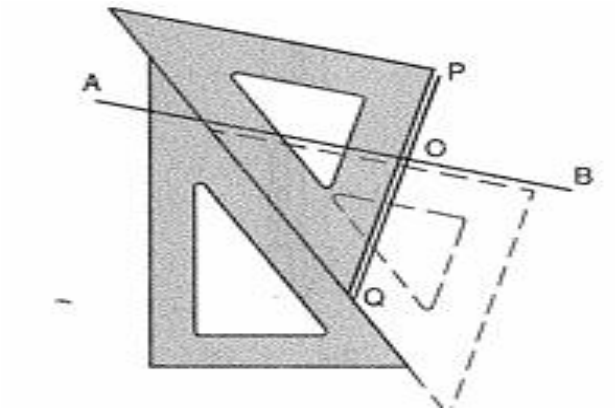


FIG. 1-10


15°
75°
15°


15°
180°
165°
150°
135°
120°
105°
90°
75°
60°
45°
30°
15°
O
P

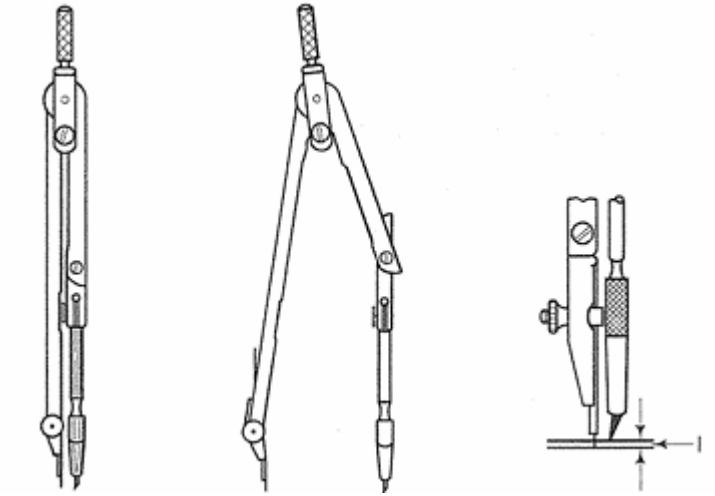

B
D
A
P
C


A
P
O
B
Q

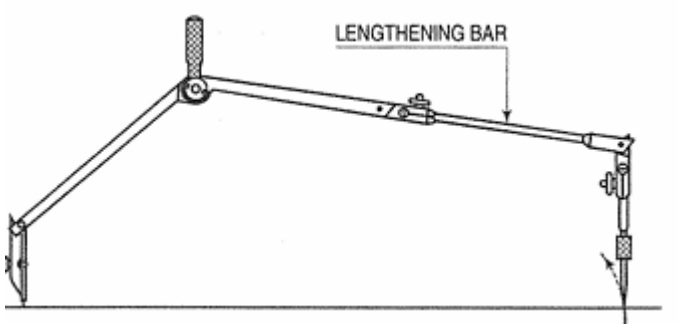
Compasses

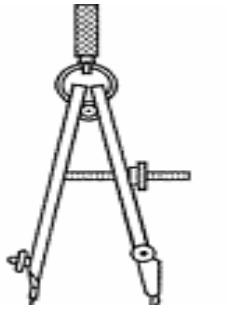
(1) large-size compass with interchangeable pencil and pen legs (fig. 1)

The compass is used for drawing circles and arcs of circles. It consists of two legs hinged together at its upper end. A pointed needle is fitted at the lower end of one leg, while a pencil lead is inserted at the end of the other leg. The lower part of the pencil leg is detachable and it can be interchanged with a similar piece containing an inking pen. Both the legs are provided with knee joints. Circles upto about 120 mm diameter can be drawn with the legs of the compass kept straight. For drawing larger circles, both the legs should be bent at the knee joints so that they are perpendicular to the surface of the paper



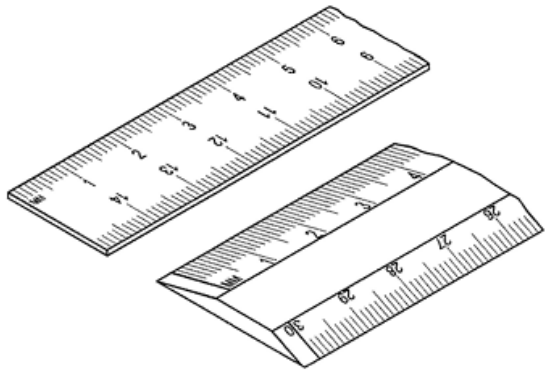
Curves drawn with the compass should be of the same darkness as that of the straight lines. It is difficult to exert the same amount of pressure on the lead in the compass as on a pencil.
It is, therefore, desirable to use slightly softer variety of lead (about one grade lower, HB or HJ in the compass than the pencil used for drawing straight lines, to maintain uniform darkness in all the lines.





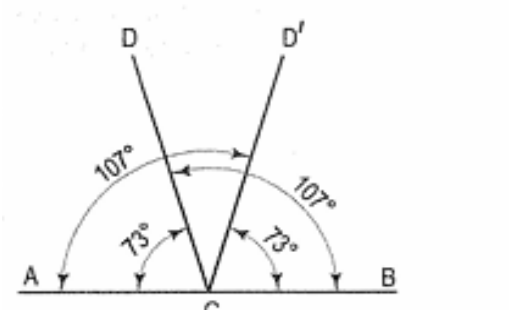
Scales :

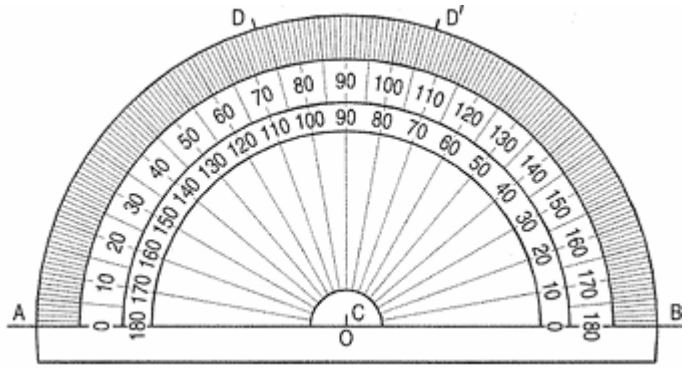
Scales are made of wood, steel, celluloid or plastic or card board. Stainless-steel scales are more durable. Scales may be flat or of triangular cross-section. 15 cm long and 2 cm wide or 30 cm long and 3 cm wide flat scales are in common use. They are usually about 1 mm thick. Scales of greater thickness have their longer edges beveled. This helps in marking measurements from the scale to the drawing paper accurately. Both the longer edges of the scales are marked with divisions of centimeters, which are sub-divided into millimeters.



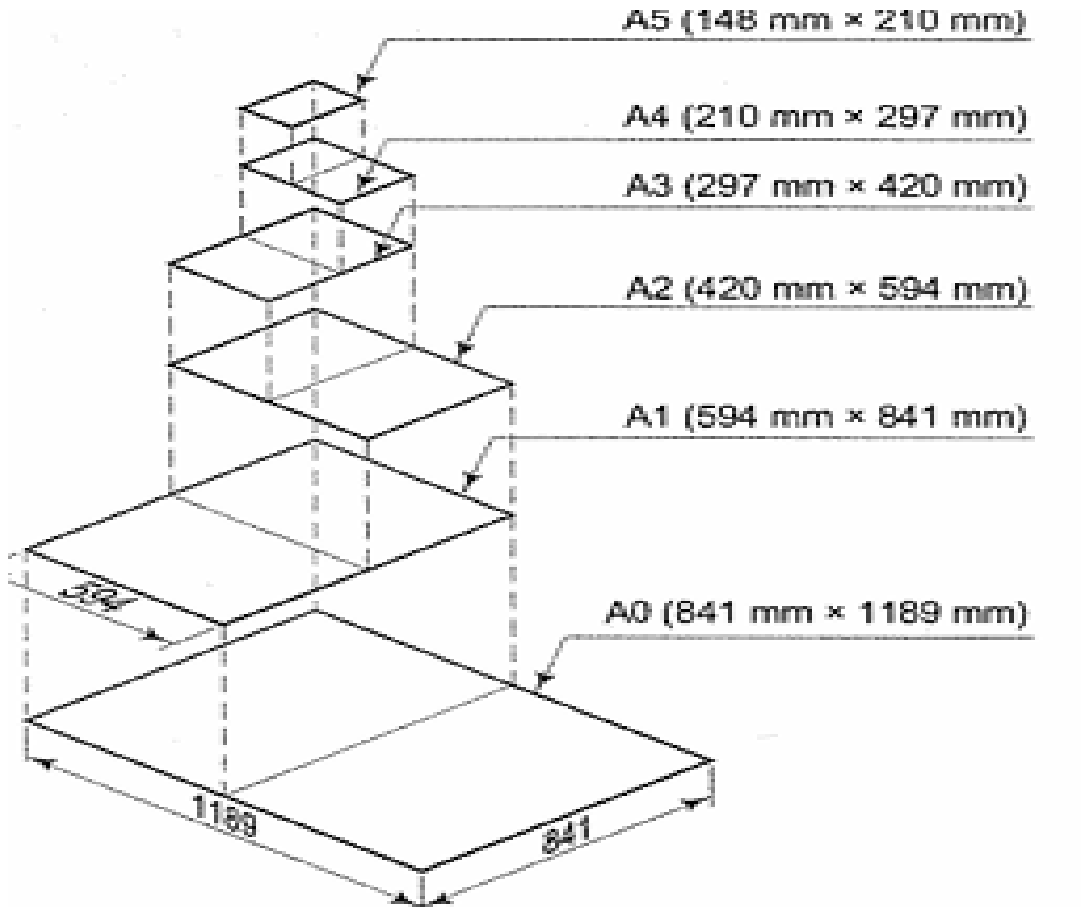
Protractor:

Protractor is made of wood, tin or celluloid. Protractors of transparent celluloid are in common use. They are flat and circular or semi-circular in shape. The commonest type of protractor is semi-circular and of about 100 mm diameter. Its circumferential edge is graduated to 1 ° divisions, is numbered at every 10° interval and is readable from both the ends. The diameter of the semi-circle (viz. straight line 0-180°) is called the base of the protractor and its centre O is marked by a line perpendicular to it.





Drawing Papers : Drawing papers are available in many varieties. For ordinary pencil-drawings, the paper selected should be tough and strong. It should be uniform in thickness and as white as possible. When the rubber eraser is used on it, its fibres should not disintegrate. Good quality of paper with smooth surface should be selected for drawings which are to be inked and preserved for a long time. It should be such that the ink does not spread. Thin and cheap quality paper may be used for drawings 1 from which tracings are to be prepared.~~ The standard sizes of drawing papers are given in table. Surface area of AO size is one square metre. Successive format sizes (from AO to AS) are obtained by halving along the length or doubling along the width. The areas of the two subsequent sizes are in the ratio 1 :2. See fig.


A5 (148 mm × 210 mm)
A4 (210 mm × 297 mm)
A3 (297 mm × 420 mm)
A2 (420 mm × 594 mm)
A1 (594 mm × 841 mm)
A0 (841 mm × 1189 mm)
1189
841

Drawing Pencils

The accuracy and appearance of a drawing depend very largely on the quality of the pencils used. With cheap and low-quality pencils, it is very difficult to draw lines of uniform shade and thickness. The grade of a pencil lead is usually shown by figures and letters marked at one of its ends. Letters HB denote the medium grade. The increase in hardness is shown by the value of the figure put in front of the letter H, viz. 2H, 3H, 4H etc. Similarly, the grade becomes softer according to the figure placed in front of the letter B, viz. 2B, 3B, 4Betc. Beginning of a drawing should be made with H or 2H pencil using it very lightly, so that the lines are faint, and unnecessary or extra lines can be easily erased. The final fair work may be done with harder pencils, e.g. 3H and upwards. Lines of uniform thickness and darkness can be more easily drawn with hard grade pencils. H and HB pencils are more suitable for lettering and dimensioning. For freehand sketching, where considerable erasing is required to be done, soft-grade pencils such as HB should be used.

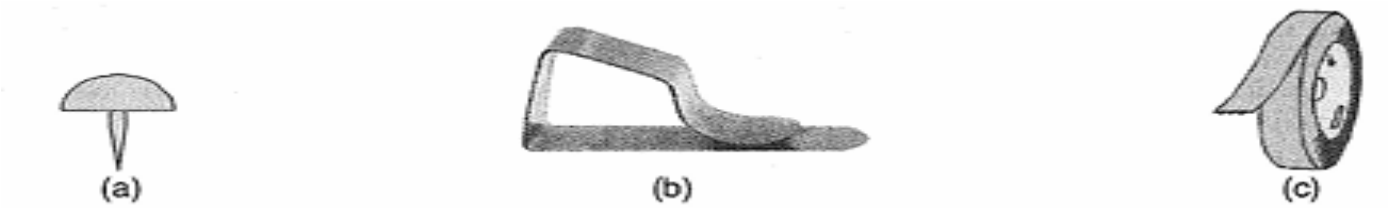
Different types of drawing pencils:

Eraser:

Soft rubber is the most suitable kind of eraser for pencil drawings. It should be such as not to spoil the surface of the paper. Frequent use of rubber should be avoided by careful planning.

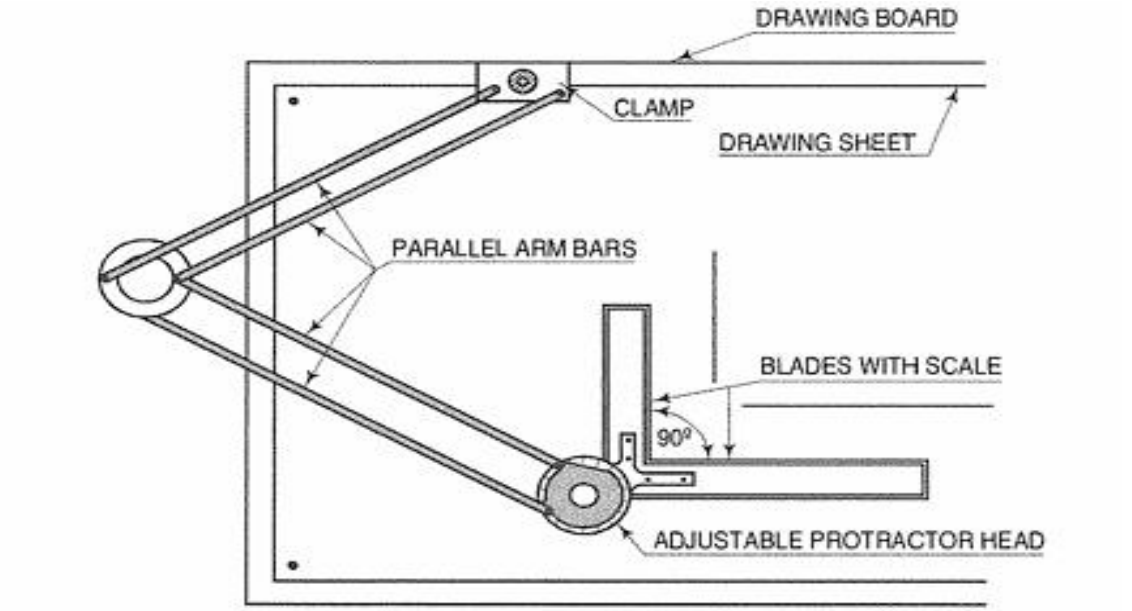
Drawing Pins, Clips or Adhesive tape:

These are used to fix the drawing paper on the drawing board. The needle part of the pin (a) is generally made of steel, while the head may be of plated mild steel or brass. Pins of about 15 mm to 20 mm diameter and about 1 mm thick flat heads made of brass are quite convenient, as they do not rust. Pins should be so inserted that the heads sit on the surface of the paper. Clips (b) or adhesive tapes (c) are often used instead of the pins.



Drafting Machine:

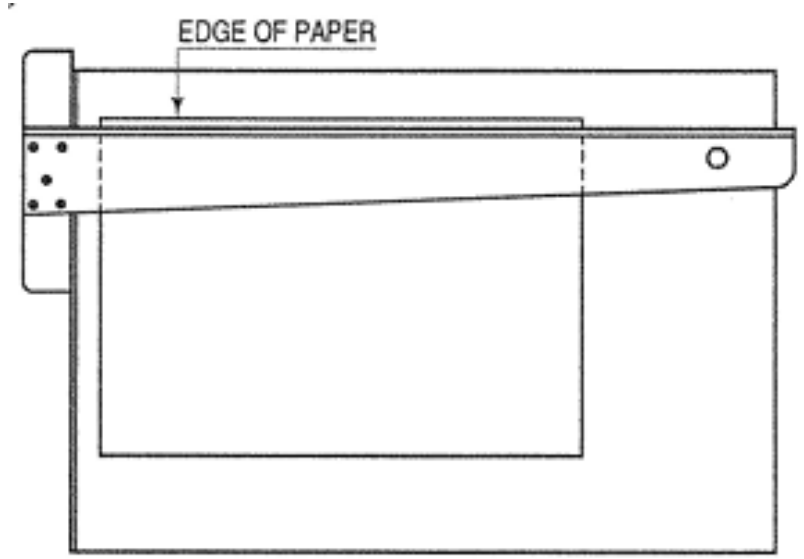
he uses and advantages of the T-square, set-squares, scales and the protractor are combined in the drafting machine. Its one end is clamped by means of a screw, to the distant longer edge of the drawing board. At its other end, an adjustable head having protractor markings is fitted. Two blades of transparent celluloid accurately set at right angles to each other are attached to the head.



General Suggestion for Drawing aSheet

(1) Cleaning the instruments: Clean the drawing board and the T-square and place them on the table, with the working edge of the board on your left-hand side and the stock of the T-square attached to that working edge. Clean all other instruments and materials and place them on a neat piece of paper by the side of the board. When a drafting machine is used, clean the drafting machine before fixing on drawing board.

(2) Pinning the paper to the drawing board: Place the paper at about equal distances from the top and bottom edges of the board and one of its shorter edges at about 25 mm from the working edge of the board. When the paper is a much smaller size than that of the board, it may be placed with its lower edge at about 50 mm from the bottom edge of the board. Insert a pin in the left hand top corner of the paper and at about 10 mm from its edges. Adjust the paper with the right hand, bringing its upper edge in line with the working edge of the T-square (fig.).



Line Types and Their Uses in Engineering Drawing

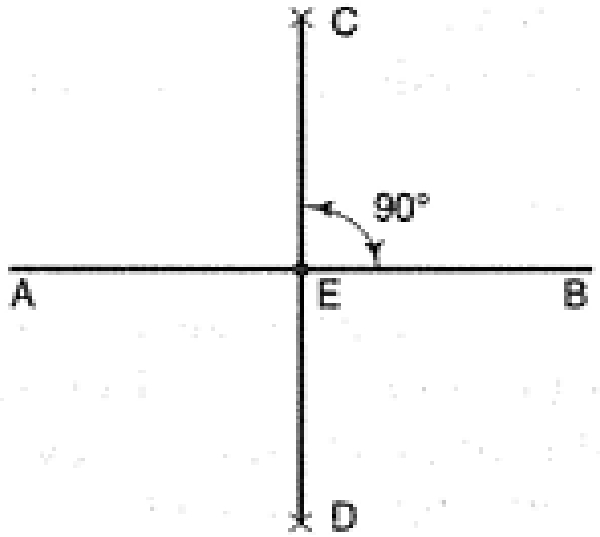
Line Type	Appearance	Use / Purpose
Continuous Thick	———————	Visible outlines and edges of objects
Continuous Thin	——————— (thin)	Dimension lines, projection lines, leader lines, hatching
Dashed Thin	- - - - - - - - -	Hidden edges or features not visible in the current view
Chain Thin (Long dash + dot)	– – – · – – – · – – –	Center lines of circles, arcs, or symmetrical parts
Chain Thick (Long dash + dot)	– – – · – – – · – – – (thicker)	Cutting plane lines in section views
Continuous Thin with Zigzag	———/\/\/\/———	Long breaks in an object (to shorten a view)

Geometry :

We shall deal with problems on geometrical construction which are mostly based on plane geometry and which are very essential in the preparation of engineering drawings. They are described as under: (1) Bisecting a line (2) To draw perpendiculars (3) To draw parallel lines (4) To divide a line (5) To divide a circle (6) To construct regular polygons (7) Special methods of drawing regular polygons (8) Regular polygons inscribed in circles (9) To draw regular figures using T-square and set-squares (10) To draw tangents contact.

1- Bisecting Aline

:i-Let AB be the given line. With center A and radius greater than half AB, draw arcs on both sides of AB. Fig 1

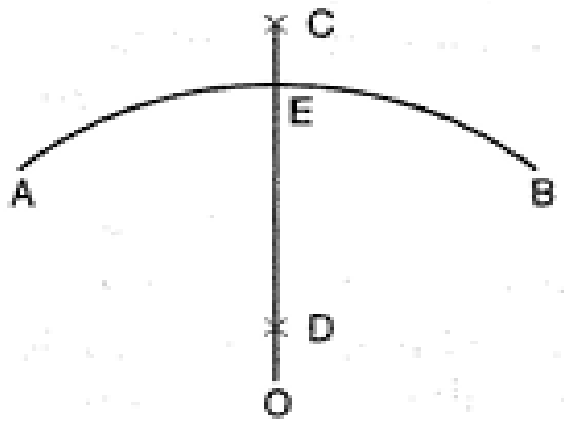


(ii) With center B and the same radius, draw arcs intersecting the

previous arcs at C and D. (iii) Then AE = EB = 2 AB. Draw a line joining C

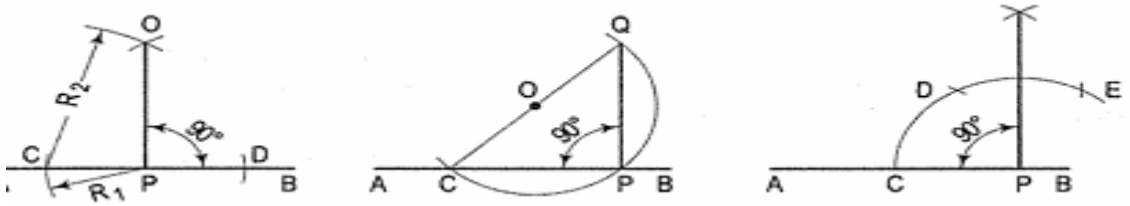
and D and cutting AB at E. 1 Further, CD bisects AB at right angles..

To bisect a given Arc :



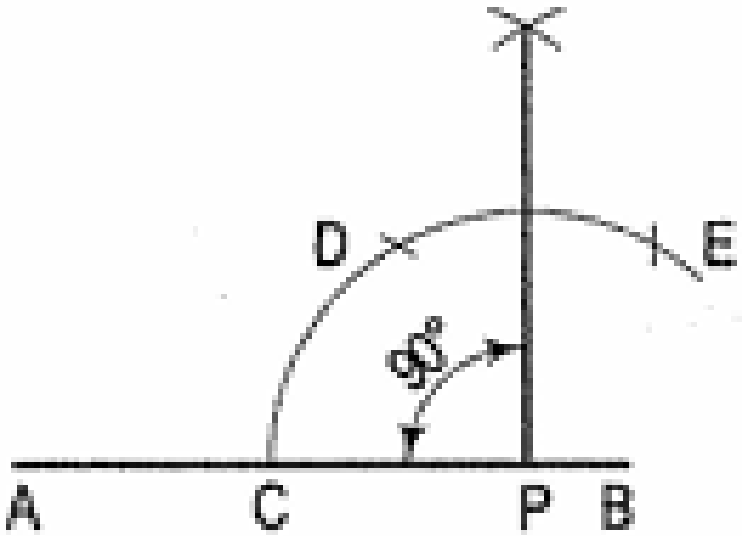
Let AB be the arc drawn with centre O. Adopt the same method as shown in problem. The bisector CD, if produced, will pass through the centre 0.

To Draw A perpendicular to a given line from a point within it



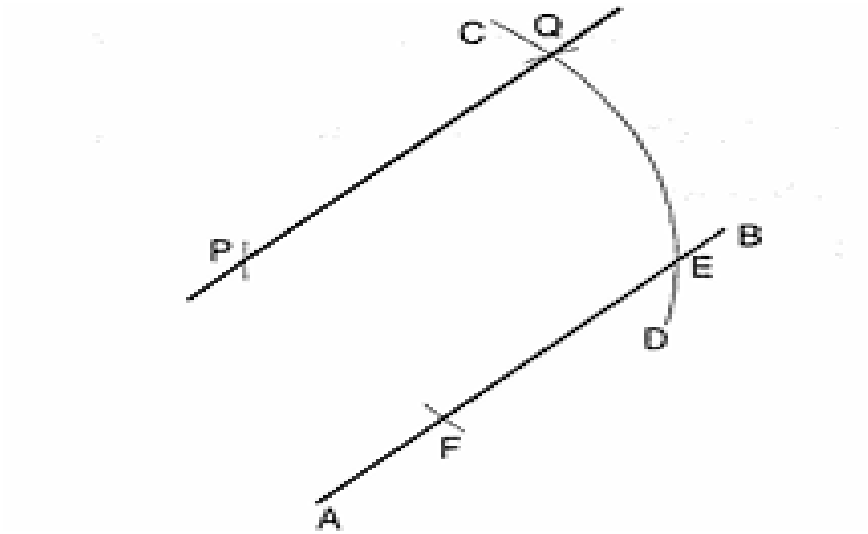
(a) When the point is near the middle of the line. Let AB be the given line and P the point in it. With Pas centre and any convenient radius R1, draw an arc cutting AB at C and D. With any radius R2 greater than R1 and centres C and D, draw arcs intersecting each other at 0. Draw a line joining P and 0. Then PO is the required perpendicular. (b) When the point is near an end of the line. Let AB be the given line and P the point in it. With any point O as centre and radius equal to OP, draw an arc greater than the semi-circle, cutting AB at C. Draw a line joining C and 0, and produce it to cut the arc at Q. Draw a line joining P and Q. Then PQ is the required perpendicular.

(iii) With P as center and any convenient radius, draw an arc cutting AB at C. With the same radius cut (from the arc) two equal divisions CD and DE. Again, with the same radius and centres D and E, draw arcs intersecting each other at Q. Draw a line joining P and Q. Then PQ is the required perpendicular.



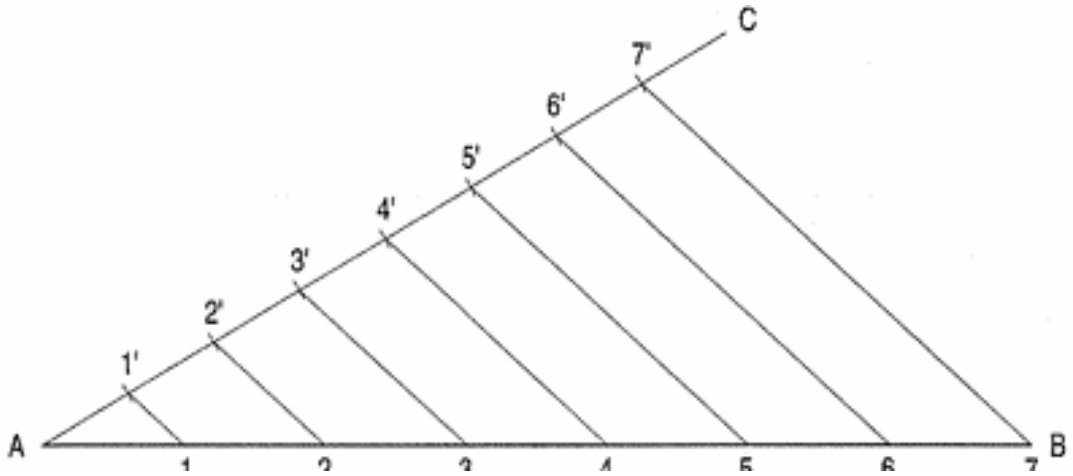
To draw parallel lines

To draw a line through a given point, parallel to a given straight line (i) Let AB be the given line and P the point. With center P and any convenient radius, draw an arc cutting AB at E. With center E and the same radius, draw an arc cutting AB at F. With center E and radius equal to FP, draw an arc to cut arc C at Q. Draw a straight line through P and Q. Then this is the required line.



To divide Straight line to equal parts :

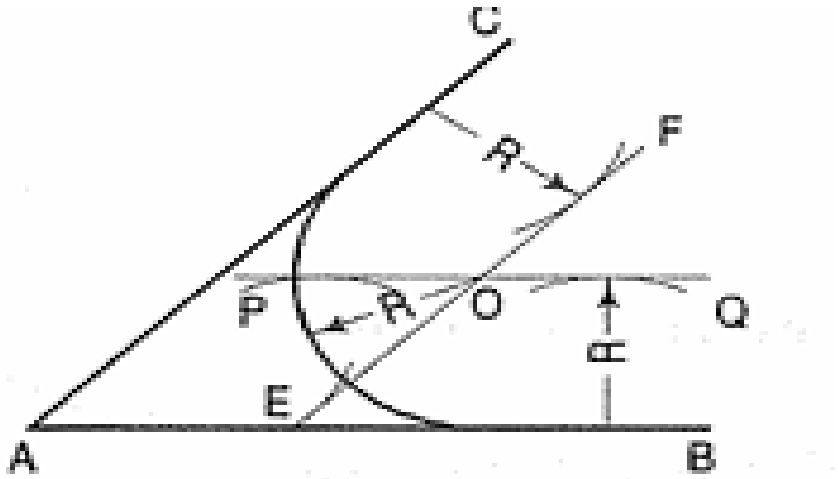
Let AB be the given line to be divided into say, seven equal parts. Draw the line AB of given length. Draw another line AC making an angle of less than 30° with AB. With the help of dividers mark 7 equal parts of any suitable length on line AC and mark them by points 1 ', 2', 3', 4', 5', 6' and 7' as shown. Join the last point 7' with point B of the line AB. Now, from each of the other marked points 6', 5' 4', 3', 2' and 1 ', draw lines parallel to 7'B cutting the line AB at 6, 5, 4, 3, 2 and 1 respectively. Now the line AB has been divided into 7 equal parts. You can verify this by measuring the lengths.



To draw a Fillet Radii :

i- when the angle is acute angle

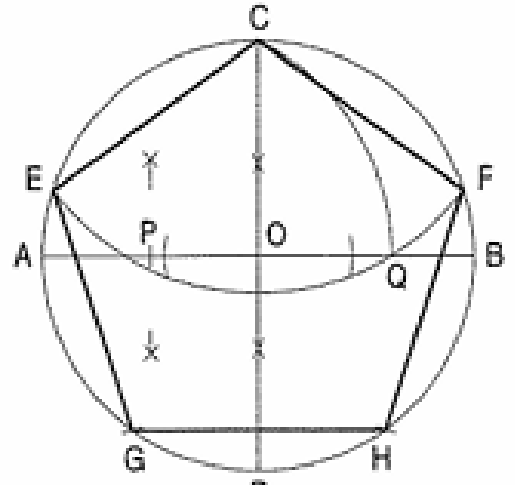
- draw an acute angle BAC
- Draw line EF with a suitable radius parallel to AC
- Then draw line PQ parallel to AB with the same radius
- the intersecting of these to lines which is O is the center of the arc
- From O with the same R draw the fillet arc
-



Regular Polygons :
a- Pentagon
b- Hexagon
C- General Rule

1- Regular Pentagon Inside a known Circle

a- draw the known circle from center o
b- bisect the radius to get point p
c- from point P as a center and with radius PC draw an arc to get point Q
d- take point C as center and with distance CQ as radiu sdraw arc to get points E and F
e- the distance CE or CF IS the length of the pentagon side
f- take either of these distances with compass and get the points G and H
g- join these points to get the regular pentagon.



2- Regular Hexagon knowing distance across corners (A/C)

a- distance across corners is the distance between any two opposite corners.

b- take this distance as a diameter of a circle

c- then with half of A/C distance as radius draw circle from center O

d- with the compass at the ends of the horizontal diameter and with distance equal to R draw arcs to get points P1, P2, P4 P6, and the two end of the horizontal diameter are points P5 and P9.

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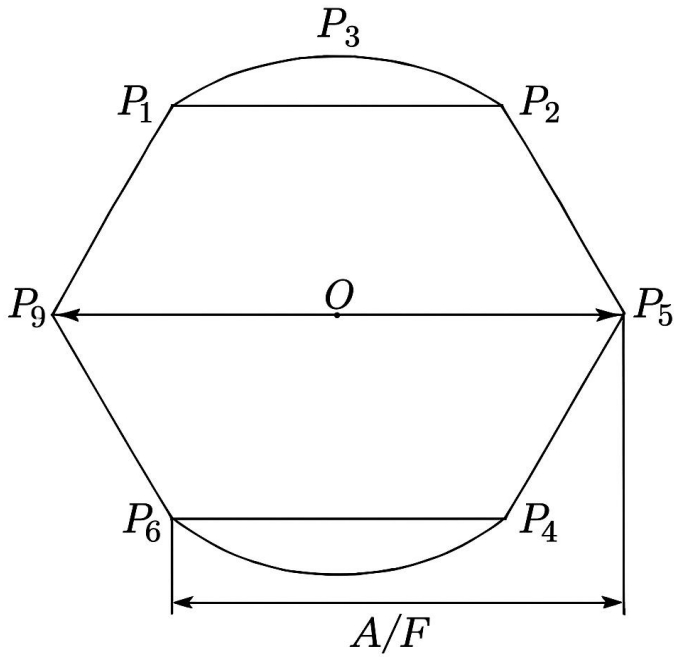
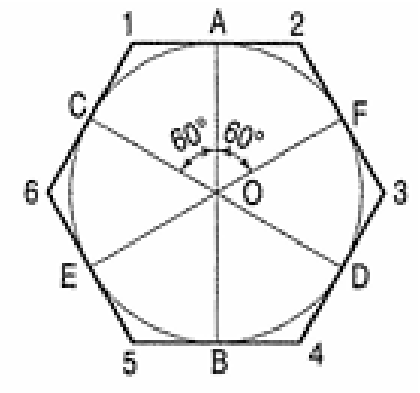


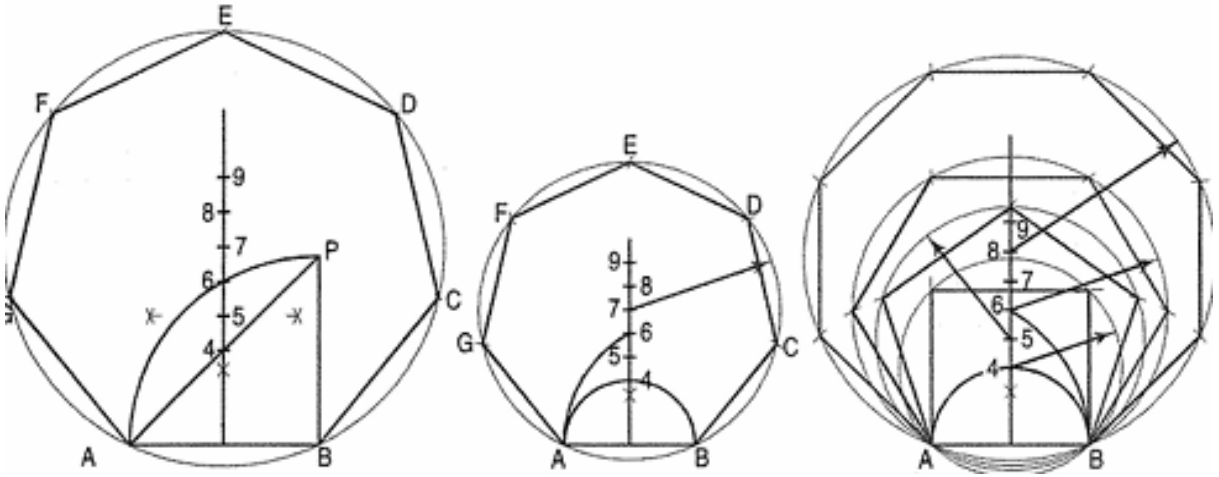
3- Regular Hexagon with a give distance Across Flats (A/F)

a- distance across flats is the distance between any two sides of the polygon
b- consider this A/F distance as diameter of a circle and draw the circle
c- with the T square and 60°set-square draw the side of the polygon tangent to the circumference of the circle.



General method of drawing any polygon knowing the length of the polygon side:

a- Draw line AB equal to the given length
b- at B draw line BP perpendicular and equal to AB
c- draw line joining A with P
d- with center B and radius A P draw a quadrant AP
e- draw the perpendicular bisector of AB to intersect the line AP in 4 and the quadrant in 6
f- at the mid of the distance 4-6 we get point 5
g- this distance by which we marks points7, 8,…….etc.
h- any point represent center of a circle with radius equal to the distance from the point to A
i- then to take the length AB and mark on circumference of the circle , ang joining these points to get the required polygon



Line tangent to two circles of different diameter

a-state the center o1

b- find the center of the other circle o2

c- then draw the tow circles

d- bisect the distance btn. The two centers to get M

e- take M as center and with radius MO draw circle

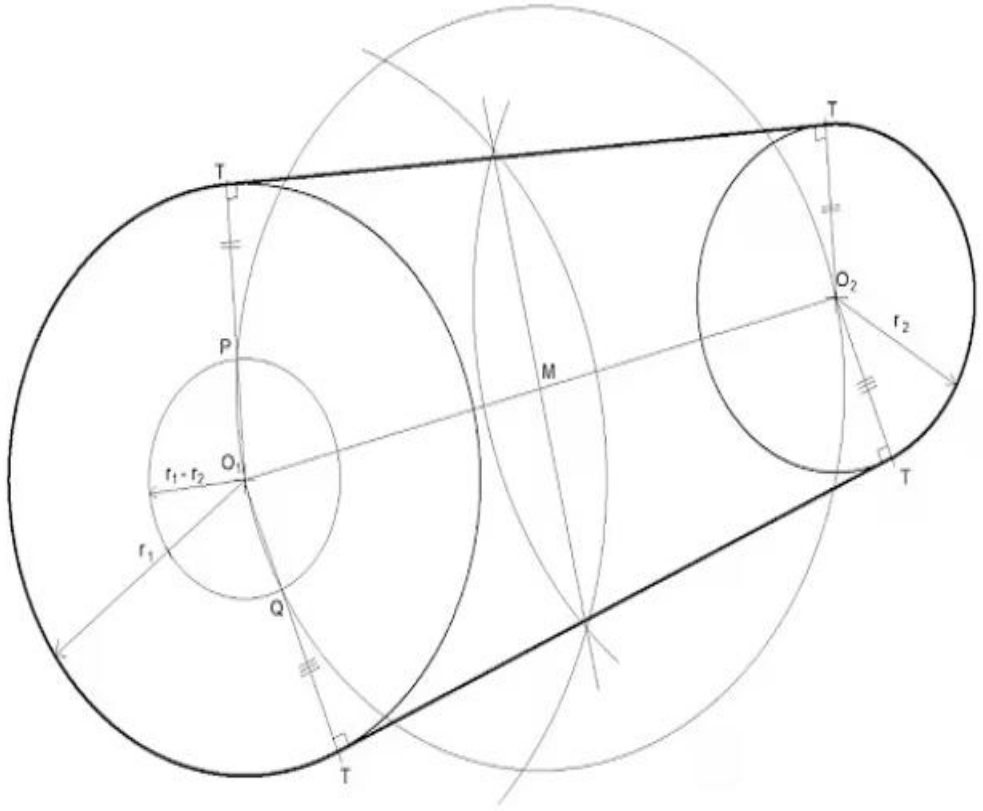
f- at center O2 and radius (R1 – R2) draw internal cirle intersect at P and Q with the central circle

g- draw line from O2 passing through P to cut the circle at T

h- also the same to get T

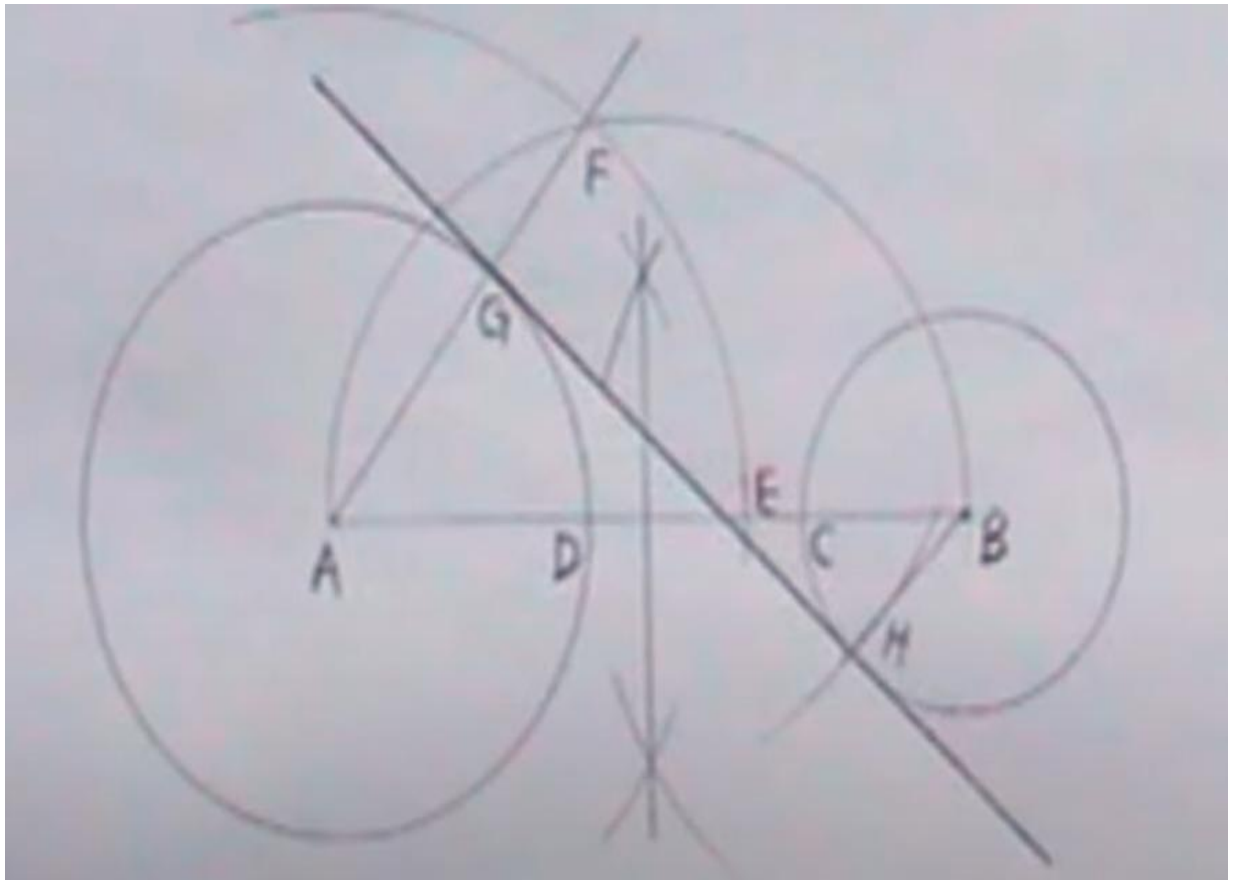
I then transfer these tow lines to the other circle with paralle to get T

i- these points t are the tangency points , then connect them shown.



Internal line tangency to two un equal circles:

a- given centers of circles A, B and distance between the two centers
b- draw the two circles
c- bisect the distance between two circles, draw semi circle where the bisecting point is the center
c- draw quadrant with center Aand radius (RA+RB) we get points F and E
d- draw line from A to intersect the semi circle at F
e- the intersecting of this line with the circle is point G which is the tangent point
f- transferline AG parallel to other circle to find the tangent point H
g- draw the tangent line GH.



Internal and external ar tangents to an equal circles:

a- given the dimensions draw the tow circles

b- the external tangent radius is 32, the internal one is 110

c- the un known is the centers of the two tangents

d- to find the center of the external tangent

1- add 32+35 and with the center of the big circle draw an arc

2- similarly add 32+20 and with center of the small circle draw an arc

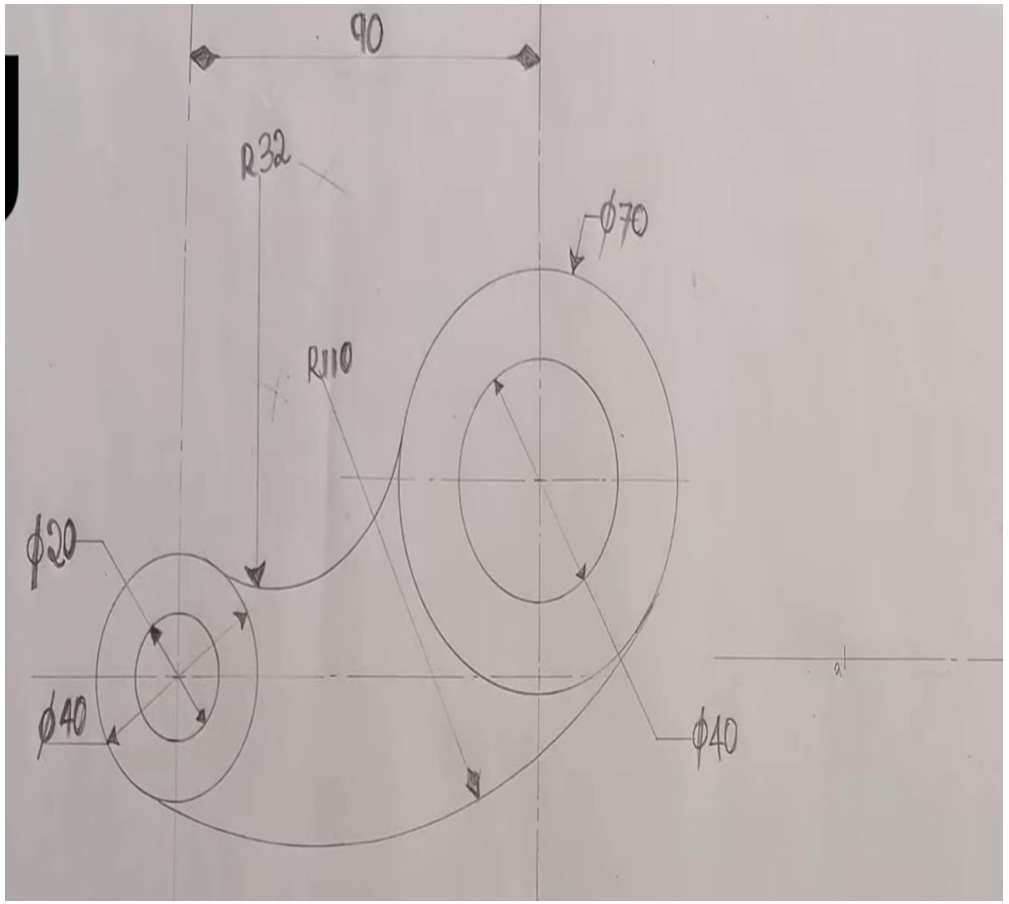
3- the intersection of these two arcs is the center of the tangent

4- with this center and 32 r draw the external tangent

e- for the internal tangent de the same steps but instead of addition you have to substract

R of tangent which is110, then (110- 35) and (110- 20) to find the center of the external tangent and with the radius of the tangent draw the internal tangent

N.B the distance between the two horizontal axis is 30.



An internal external tangent to tow an equal circle:

a- this tangent is internal to circle O1, and external to circle O2

b- to find the center of tangent you have to add for external and with O2draw the curve,

c- and for internal you have to substract and and from point O1 draw the curve to get center of the tangent O3

then draw the tangent with radius = 75