Dronacharya Group of Institutions, Greater Noida
Computer Aided Engineering Graphics (CAEG)
(NCE 151/251)
List of Drawing Sheets:

1. Letter writing & Dimensioning.
2. Projection of Points & Lines.
3. Projection of Planes.
4. Projection of Solids.
5. Projection of Section of Solids.
6. Development of Surfaces.
7. Isometric Projections.
8. Projection of Lines by AUTO CAD.
9. Projection of Planes by AUTO CAD.
10. Projection of Solids by AUTO CAD.

Engineering Drawing: - (Language of Engineer)

Engineering drawing is the graphical language of Engineers. It is used for effective communication among engineers to read drawings. Engineering drawing consist various standards rules and regulations set by Bureau of Indian standards (BIS).

Drawing instruments:

1. Drawing board
2. Mini drafter
3. Drawing pencil
4. Eraser
5. Compass
6. Protractor
7. Drawing sheet
8. Sharpener
9. A Scale
10. Drawing clip/ drawing pins

Drawing sheet: - The various size of the drawing sheet used for engineering drawing as per IS-1071-2001. Are listed in the table

SPECIFICATION	TRIMMED SHEET SIZE (MM)	DRAWING SPACE (MM)
Ao	841x1189	821 x1159
AI	594x841	574x811
A2	420x594	400x564
A3	297x420	277x390
A4	210x297	180x277

Line: - Various types of lines are used in general engineering drawing.

S. No.	Thickness of Lines	Pencil	Lines
1.	Thin	H	Centre Lines, Construction Lines, Dimension Lines, Leader Lines, Section Lines.
2.	Medium	HB	Outlines, Reference Lines in Projection Lines, Cutting Plane Lines (Thick at ends and change of direction). Dotted lines, Arrowheads.

TYPES OF LINES:-

1. CONSTRUCTION LINES:- These are used for construction of geometrical features. These are supporting lines and do not represent the main part or edge of the object.

2. **OUTLINES: -** Line drawn to represent visible edges and surface boundaries of objects are called out lines or principal lines .They are continuous thick lines.

3.PROJECT LINES:- These are used to project a view of the object.

4. **MARGIN LINES:**-They are continuous thick lines along which the prints are trimmed.

3.**DIMENSION LINES:-**These lines are continuous thin lines .They are terminated at the outer ends by pointed arrowheads touching the outlines, extension lines or center lines.

5. **EXTENSION OF PROJECTION LINES**:-These lines also are continuous thin lines. They extend by about 3 mm beyond the dimension lines.

6. **HATCHING OR SECTION LINES:**-These lines are drawn to make the section evident. They are continuous thin lines and are drawn to make the section evident. They are continuous thin lines and are drawn generally at an angle of 45^0 to the main outline of the section .They are uniformly spaced about 2-3 mm apart.

7. **LEADER OR POINTER LINES**:-Leader line is drawn to connect a note with the feature to which it applies .It is a continuous thin line.

8. **HIDDEN OR DOTTED LINES**:-Interior or hidden edges and surface are shown by hidden lines. They are of medium thickness and made up of short dashes of approximately equal lengths of about 3 mm spaced at equal. Distance of about 3 mm spaced at equal distance of about 1 mm.

9. **CENTER LINE:-** Centre line are drawn to indicate the axis of cylindrical conical or spherical objects or details and also to show the centers of circles and arcs .They are thin long chain lines composed of alternately long and short dashes spaced approximately 1 mm apart .The longer dashes are about 15 mm& the short dashes which are about 3 mm long .Center lines should extend for the a short distance beyond the outlines to which they refer for the purpose of dimensioning .

10. CUTTING PLANE LINES: - It is a long, thin, chain line, thick at ends only.

11. SHORT BREAK LINES: These lines are continuous, thin and wavy. They are drawn freehand and are used to show short break, or irregular boundaries.

12. LONG BREAK LINES: - These lines are thin ruled lines with short zigzag within them. They are drawn to show long breaks.

WRITING LETTER: - Writing of titles, dimension notes and other important particulars on a drawing is called lettering.

Single Stroke Letters: - **These** are the simplest forms of letters and are usually employed in most of the engineering drawings. The word single –stroke should not be mean that the letter should be made in one stroke without lifting the pencil. It actually means that the thickness of the line of the letter should be such as is obtained in one stroke of the pencil. According to the height of letter, they are classifieds:

(i) Lettering 'A' (Refer to Table 1)

(ii) Lettering 'B' (Refer to Table 2)

Table 1

Characteristic	**Ratio**	**Dimensions(mm)**			
Lettering height ,Height of capital letter (h)	(14/14) h	10	14	20	
Height of Lower case letters (c)	(10/14) h	7	10	14	
Spacing between characteristic(a)	(2/14) h	1.4	2	2.8	
Minimum spacing of base lines(b)	(20/14) h	14	20	28	
Minimum spacing between words(e)	(6/14) h	4.2	6	8.4	
Thickness o0f lines(d)	(1/14) h	0.7	1	1.4	
Width of Capital Letter	(5/6) h			16.6	

Height of Lower case letters = 1: 1 =c: c

GOTHIC LETTERS: - Stems of single stroke letters if given more thickness form what are known as gothic letter. These are mostly used for main titles of ink drawings.

DIMENSIONING TERMS AND NOTATIONS:-

{A}.**DIMENSION LINE**:-dimension line is a thin continuous line .It is terminated by arrowheads touching the outlines extension lines or center lines.

{B} EXTENSION LINE-An extension line is also a thin continuous line drawn in extension of an outline. The B. I. S. had recommended that a gap of about 1 mm should be kept between the extension line and an outline by about 3 mm beyond the dimension line.

{**C}ARROWHEAD** :-The length of the arrowhead should be about three times its maximum width .It is drawn freehand with two strokes made in the direction of its pointed end the space between them is nearly filled up.

{D}**LEADER:** -A leader or a pointer is a thin continuous line connecting a note or a dimension figure with the feature to which it applies.

PLACING OF DIMENSIONS: The two systems of placing dimension are:-

1. ALIGNED SYSTEM **2. UNIDIRECTIONAL SYSTEM.**

{1} **ALIGNED SYSTEM**:-In the aligned system the dimension is placed perpendicular to the dimension line in such a away that it may be read from the bottom edge or the right hand edge of the drawing sheet .The dimension should be placed near the middle and above but near the dimension lines.

{2} **UNIDIRECTIONAL SYSTEM :-** In unidirectional system all dimension are so placed that they can be read from the bottom edge of the drawing sheet .The dimension lines are broken near the middle for inserting the dimensions .

UNIT OF DIMENSIONING: As far as possible, all dimensions should be given in millimeters, omitting the abbreviation mm. Even when it is used, only the dimension figures are written. But foot notes such as all dimensions are in centimeters' is inserted in prominent place near the title block.

GENERAL RULES FOR DIMENSIONING:-

{1} Dimensioning should be done so completely that further calculation or assumption of any dimension or direct measurement from the drawing is not necessary.
(2) Every dimension must be given; none should be given more than once.
(3) A dimension should be placed on the view where its use is shown more clearly.
(4) Dimensions should be placed outside the views, unless they are clearer and more easily read inside.
(5) Mutual crossing of dimension lines and dimensioning between hidden lines should be avoided .Dimension lines should not crass any other line of the drawing.
(6) An outline or a centre line should never be used as a dimension line.

Scales:-

1	Reducing Scales	1:2; 1:20
2.	Enlarging Scale	5:1; 50:1
3.	Full size scales	1:1

It may not always be possible to prepare full size drawings. They are therefore drawn proportionately smaller or larger. When drawings are drawn smaller than the actual size of the objects the scale used is said to be a reducing scale. Drawing of small machine parts mathematically instruments, watches etc. are made larger than their real size. These are said to be drawn on an enlarging scale.

Geometrical Construction:-

To construct regular polygons (General Method)

Problem:-To construct a regular polygon of any no. of sides.
Method:-
1. Draw a line AB equal to the given length.
2. At B, draw a line BP perpendicular and equal to AB.
3. Draw a line joining A with P.
4. With centre B and radius AB, draw the quadrant AP.
5. Draw the perpendicular bisector of AB to intersect the straight line AP in 4 and arc in 6.
Ex: 1 A square of a side equal to AB can be inscribed in the circle drawn with center 4 and radius A4.
Ex: 2 A regular hexagon of a side equal to AB can be inscribed in the circle drawn with center 6 and radius A6.
Ex: 3 The mid –point 5 of the line 4-6 is the center of the circle of the radius A5 in which a regular pentagon of a side equal to AB can be inscribed.
Ex.4 To locate centre 7 for the regular heptagon of side AB, step-off a division 6-7 equal to division 5-6.

(a) With centre 7 and radius equal to A7, draw a circle.
(b) Starting from B, cut it in seven equal divisions with radius equal to AB.
(c) Draw lines BC, CD, etc. and complete the heptagon.

Alternative Method:

1. On AB as diameter, describe a semi-circle.
2. With either A or B as centre and AB as radius, describe an arc on the same side as the semi circle.
3. Draw a perpendicular bisector of AB cutting the semi circle at a point 4 and arc at point 6.
4. Obtain points 5, 7, 8 etc. as explained in previous method.

Projections: If straight lines are drawn from various points on the contour of an object to meet a plane, the object is said to be projected on that plane, the figure formed by joining in correct sequence, the points at which these lines meet the plane is called the projection of the object. The lines from the object to the plane are called projections.

Methods of projection: - In engineering drawing following four methods of projections are commonly used:
1. Orthographic projection 2. Isometric projection
3. Oblique projection 4. Perspective Projection

Orthographic projection: When the projection projectors are parallel to each other and also perpendicular to the plane, the projection is called orthographic projection.

Planes of projections: The two planes employed for the purpose of orthographic projections are called reference planes or principle planes of projections. These are horizontal planes (H.P.) and vertical Planes (V.P.) The Line in which they intersect is termed the reference line and is denoted by the letters xy. The projection on the V.P. called the front view or the elevation of the object. The projection on the H.P. is called the top view or plan.

Four Quadrants: - When the planes of projections are extended beyond the line of intersection, they form four quadrants. The object may be situated in any one of the quadrants, its position relative to the planes being described as above or below the H.P. and in front of or behind the V.P.

Difference between First angle projection method and Third angle projection

S. No.	First angle projection method	Third angle projection method.
1	The object is kept in the first quadrant	The object is assumed to be kept in the third quadrant.
2.	The object lies between the observer and plane of projection	The plane of projection is in between the observer and the object.
3.	The plane of projection is assumed to be non transparent	The plane of projection is assumed to transparent
4.	In this method when the views are drawn in their relative positions, the Top view comes below the xy line and front view comes above the xy line. LSV comes on right side of front side and vice versa.	In this method when the views are drawn in their relative positions, the Top view comes above the xy line and front view comes below the xy line. LSV comes on left side of front side and vice versa.

Symbol of method of projection:-

Projection of points:- A point may be situated in space in any one of the four quadrants formed by the two principal planes of projection or may lie in any one or both of them. Its projections are obtained by extending projectors perpendicular to planes.

Q: Draw the projection of following points on the same ground line keeping the projection 25 mm apart.

(A) In the H.P. & 20 mm behind the V.P.
(B) 40 mm above the H.P. & 25 mm in front of V.P.
(C) In the V.P. & 40 mm above the H.P.
(D) 25 mm below the H.P. & 25 mm behind the V.P.
(E) 15 mm above the H.P. & 50 mm behind the V.P.
(F) 40 mm below the H.P. & 25 mm in front of the V.P.
(G) In both the H.P. & V.P.

Projection of Straight Lines: - A straight line is the shortest distance between two points. Hence the projection of a straight line may be drawn by joining the respective of its ends which are points.

Line inclined to both Planes: - When a line is inclined to both the panes its projection are shorter than the true length and inclined to xy at angles greater than the true inclinations. These angles viz α and β are called apparent angles of inclinations.

Trace of a line: - When a line is inclined to a plane, it will meet that plane, produced if necessary. The point in which the line or line produced meets the plane is called its trace.

The point of intersection of the line with the H.P. is called the horizontal trace, usually denoted as H.T. and that with the V.P. is called the vertical trace or V.T.

Q: Draw the projections of a 80 mm long straight line in the following positions:

(A) Parallel to both H.P. & the V.P. & 25 mm away from each.
(B) Parallel to & 30 mm above the H.P. in the V.P.
(C) Parallel to & 40 mm in front of the V.P. in the H.P.
(D) Perpendicular to the H.P. 20 mm in front of V.P. & its one end 15 mm above the H.P.
(E) Perpendicular to the V.P.; 25 mm above the H.P. & its one end in the V.P.
(F) Perpendicular to H.P.; in the V.P. & its one end in the H.P.
(G) Inclined at 45 º to the V.P in the H.P. & its one end in the V.P.
(H) Inclined at 30 º to the H.P. & its one end 20 mm above it; parallel to & 30 mm in front of V.P.
(I) Inclined at 60 º to V.P. & its one end 15 mm in front of it; parallel to & 25 mm above the H.P.
(J) A 100 mm long straight line is parallel to & 40 mm above the H.P. Its two ends ore 25 mm & 50 mm in front of V.P. respectively. Draw its projection & Find its inclinations with the V.P. & Also find its traces.

Projection of Planes: -
Plane figure or surface have only two dimensions viz. Length and breadth. They do not have thickness. A Plane figure may be assumed to be contained by a plane and its projections can draw if the position of that plane with respect to the principal planes of projection is known.

Types of Planes: Planes may be divided into two main types.

1. Perpendicular planes. 2. Oblique planes.

Traces of Planes: - A plane extended if necessary, will meet the reference planes in lines unless it is parallel to any one of them. These lines are called the traces of the plane. The line in which the plane meets the H.P. is called the horizontal trace or the H.T. of the plane. The Line in which it meets the V.P. is called is called its vertical trace or the V.T. A plane is usually presented by its traces.

Q: Draw the projections of Planes

(A) *An equilateral triangle of 50 mm side has its V.T. parallel to & 25 mm above xy. It has no H.T. Draw its projection when one of its sides is inclined at 45 ^{o} to the V.P.*

(B) *A regular pentagon of 25 mm side has one side on the ground. Its plane is inclined at 45 ^{o} to H.P. & perpendicular to the V.P. Draw its projections & show in traces.*

(C) *Draw the projection of a circle of 5 cm diameter having its plane vertical & inclined at 30 ^{o} to the V.P. its centre is 3 cm above the H.P. & 2 cm in front of V.P. Show also its traces.*

(D) *Draw the projection of a regular hexagon of 25 mm side having one of its sides in the H.P. & inclined at 60 ^{o} to the V.P & its surface making an angle of 45 ^{o} with the H.P.*

(E) *A square lamina of sides 35 mm lies with one of its corner on the ground (H.P.) n& the corner opposite to it is 43 mm above the ground. Draw the plane & elevation of the lamina in said position & determine the inclination of the lamina to the ground also.*

Projection of Solids: -

Solid has three dimensions viz length breadth and thickness. To represent a solid on a flat surface having only length and breadth at least two orthographic views are necessary. Sometimes additional views projected on auxiliary planes become necessary to make the description of a solid complete.

Types of solids: - Solids may be divided into two main groups

(i) Polyhedral (ii) Solids of revolution

Polyhedron: A polyhedron is defined as a solid bounded by planes called faces. When all the faces are equal and regular, the polyhedron is called to be regular.

Tetrahedron: Four equal faces, each an equilateral triangle.

Cube or Hexahedron: six equal faces, all equal squares.

Octahedron: Eight equal equilateral triangles as faces.

Dodecahedron: Twelve equal and regular pentagons.

Icosahedrons: Twenty equal faces, all equal equilateral triangles.

Prism: This is a polyhedron having two equal and similar faces called its ends or bases, parallel to each and joined by other faces which are parallelograms. The imaginary line joining the centers of the bases is called the axis.

Pyramid: This is a polyhedron having a plane figure as base and a number of triangular faces meeting at a point called the vertex or apex. The imaginary line joining the apex with the centre of the base is it axis.

A right and regular prism or pyramids have its axis perpendicular to the base while oblique prism or pyramid have its axis inclined to its base.

Solids of Revolution:-

(a) **Cylinder**: A right circular cylinder is a solid generated by the revolution of a rectangle about one of its sides which remains fixed. It has two equal circular bases. The line joining the centers of bases in the axis. It is perpendicular to the bases.

(**b) Cone:** A right circular cone is a solid generated by the revolution of a right angled triangle about one of its perpendicular sides which is fixed. Straight lines drawn from the apex to the circumference of the circle are all equal and are called generators of the cone. The length of the generator is the slant height of the cone.

(c) Sphere: A sphere is a solid generated by the revolution of a semi circle about its diameter as the axis .The mid point of the diameters is the center of the sphere. All Points on the surface of the sphere equidistant from its center. Oblique cylinders and cones have their axis inclined to their bases

FRUSTUM: when a pyramid or a cone is cut by a plane parallel to its base thus removing the top portion the remaining portion is called its frustum

TRUNCATED: When a solid is cut by a plane inclined to the bases it is solid to be truncated

Q: Draw the Projections of Solids:

(A) Draw the projection of a pentagonal pyramid base 30 mm edge & axis 50 mm long having its base on the H.P. & an edge of base parallel to the V.P.

(B) A square pyramid base 40 mm side & axis 65 mm long , has its base in the V.P. one edge of the base is inclined at 30 º to the H.P. & a corner contained by that edge is on the H.P. Draw its projections.

(C) Draw the projections of pentagonal prism base 30 mm side & axis 50 mm long resting on one of its rectangular faces on the H.P. with the axis inclined at 45 º the V.P.

(D) Draw the projection of a cone, base 75 mm diameter & axis 100 mm long. Lying on the H.P. on one of its generators with axis parallel to the V.P.

Sections of Solids:

Invisible features of on object are shown by dotted lines in their projected views. But when such features are too many these lines make the views more complicated and difficult to interpret. In such cases it is customary to imagine the object as being cut through or sectioned by planes. The part of the object between the cutting plane and the observer is assumed to the removed and the view is then shown in section .The imaginary plane is called a section plane or a cutting plane .The surface produced by cutting the object by the section plane is called the section. It is indicated by thin section lines uniformly spaced and inclined at 45 ^{o}.

TRUE SHAPE OF A SECTION: The projection of the section on a plane parallel to the section plane will show the true shape of the section. Thus when the section plane is parallel to the H P or the ground the true shape of the section will be seen in sectional top view. When it is parallel to the VP the true shape will be visible in the sectional front view.

Q: Draw the Projections of section of Solids:

(A) A cube of 35 mm long edges is resting on the H.P. on one of its faces with a vertical face inclined at 30 ^{o} to the V.P. It is cut by a section plane parallel to the V.P. & 9 mm away from the axis & furthers away from the V.P. Draw its sectional front view & the top view.

(B) A pentagonal pyramid base 30 mm side & axis 65 mm long has its base horizontal & an edge of the base parallel to the V.P. A horizontal section plane cuts it at a distance of 25 mm above. Draw its front view & sectional top view.

(C) A Hexagonal pyramid base 30 mm side & axis 65 mm long is resting on its base on the H.P. with two edges parallel to the V.P. It is cut by a section plane, Perpendicular to the V.P. inclined at 45 o to the H.P. & intersecting the axis at a point 25 mm above the base. Draw the front view, sectional top view.

(D) A cone base 75 mm diameter & axis 80 mm long is resting on its base on the H.P. It is cut by a section plane perpendicular to the V.P. inclined at 45 ^{o} to the H.P. & cutting the axis at a point 35 mm from the apex. Draw its front view, sectional top view, and sectional side view & true shape of section.

Development of Surfaces:

Let a solid is enclosed in a wrapper of thin material, such as paper. In this covering is opened out & laid on a flat plane the flattened out paper is the development of solid.

The surface of a solid are laid out on a plane, the figure is called its development.

Q: Draw the development of surfaces of given Solids:

(A) Draw the development of the surface of the part P of the cube, the front view of which is shown in figure.

(B) Draw the development of the lateral surface of the part P of the cylinder shown in figure.

(C) Draw the development of the lateral part of the part P of the surface as shown in figure.

(D) Draw the development of the lateral surface of the truncated cone as shown in figure.

ISOMETRIC PROJECTION:

Isometric projection is a type of pictorial projection in which the three dimensions of a solid are not only shown in one view but their actual sizes can be measured directly from it.

If a cube is placed on one of its corners on the ground with a solid diagonal perpendicular to the V.P, The front view is the isometric projection of the cube.

ISOMETRIC AXES, LINES AND PLANE: The three lines CB,CD and CG meeting at the point C and making 120 º angle witch each other are termed isometric axes, The lines parallel to these axes are called isometric lines , The planes representing the face of the cube as well as other planes parallel to these planes are called isometric planes.

Isometric Scales: - As all the edges of the cube are equally foreshortened, the square faces are seen as rhombus. The rhombus ABCD show the isometric projection of the top square face of the cube in which BD is the true length of the diagonal.

Construct a square BQDP around BD as a diagonal. Then BP shows the true length of BA

In triangle ABO, BA / BO = 1 / Cos 30 º = 2 / √3

In triangle PBO, BP / BO = 1 / Cos 45 º = √2 / 1

BA / BP = 2/√3 X 1 / √2 = √2 /√3 = 0.815

The ratio, Isometric length / True length = BA / B P = √2/√3 = 0.815 or 9 / 11.

Thus, the isometric projection is reduced in the ratio 9/11of the true length.

Isometric Drawing or Isometric View: - If the foreshortened of isometric lines in an isometric projections is disregarded and instead, the true lengths are marked the view obtained will be exactly of the same shape but larger in proportion than that obtained by the use of the isometric scale. Due to the ease in construction and the advantage of measuring the dimension directly from the drawing, it has become a general practice to use the true scale instead of the isometric scale. To avoid confusion, the view drawn with the true scale is called isometric drawing or isometric view. While that drawn with the use of isometric scale is called isometric projection.

Isometric Graph:-

An isometric graph as shown in facilitates the drawing of isometric view of an object. Students are advised to make practice for drawing of isometric view using such graphs.