Covers
Technical Ability
Section in Detail

disha

Basic Science & Engineering

for Indian Railways (RRB)

ASSISTANT LOCO PILOT

Exam 2018 Stage II

Covers :

- Basic Science & Engg.
- Electronics Engg.
- Electrical Engg.
- Mechanical/ Automobile Engg.
- Practice Exercises

Basic Science & Engineering

for Indian Railways (RRB)

ASSISTANT LOCO PILOT

Exam 2018 Stage II

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CHAPTER 1

Engineering Drawing

ENGINEERING DRAWING

Engineering drawing is a type of technical drawing, created within the technical drawing discipline, and is used to define the requirements for engineered items.

It is also a graphical language that communicates ideas and information from one mind to another.

The purpose of engineering drawing is to capture all the geometric features of a product or a component accurately and unambiguously. Its end goal is to convey the information that will allow a manufacturer to produce that component.

ENGINEERING DRAWINGS: COMMON FEATURES

Geometry- shape of the object ; represented as views and how the object will look when viewed from various standard directions , such as front , top , side, etc.

Dimensions - size of the object captured in accepted units .

Tolerances - allowable variations for every dimension .

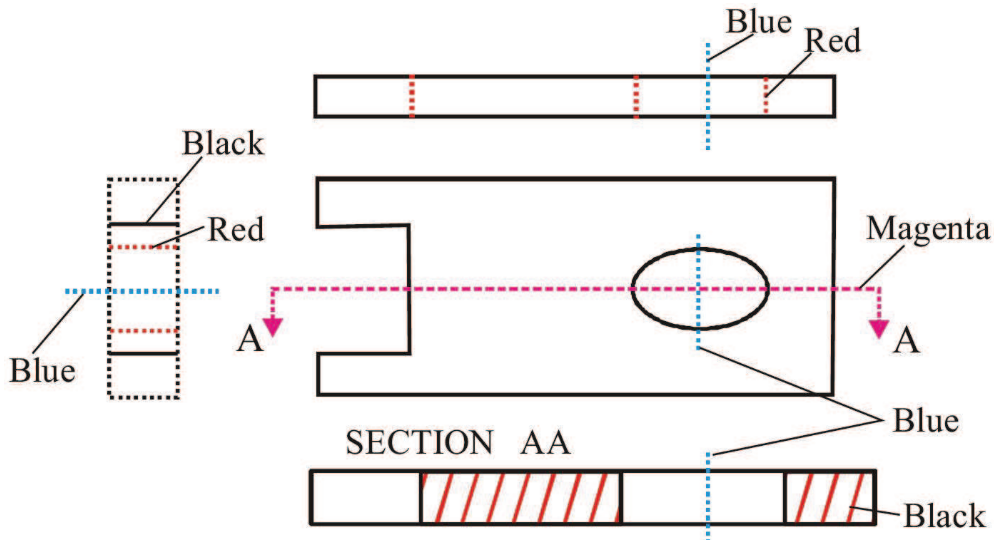
Material - represents what the item is made of .

Finish - specifies the surface quality of item, functional or cosmetic.

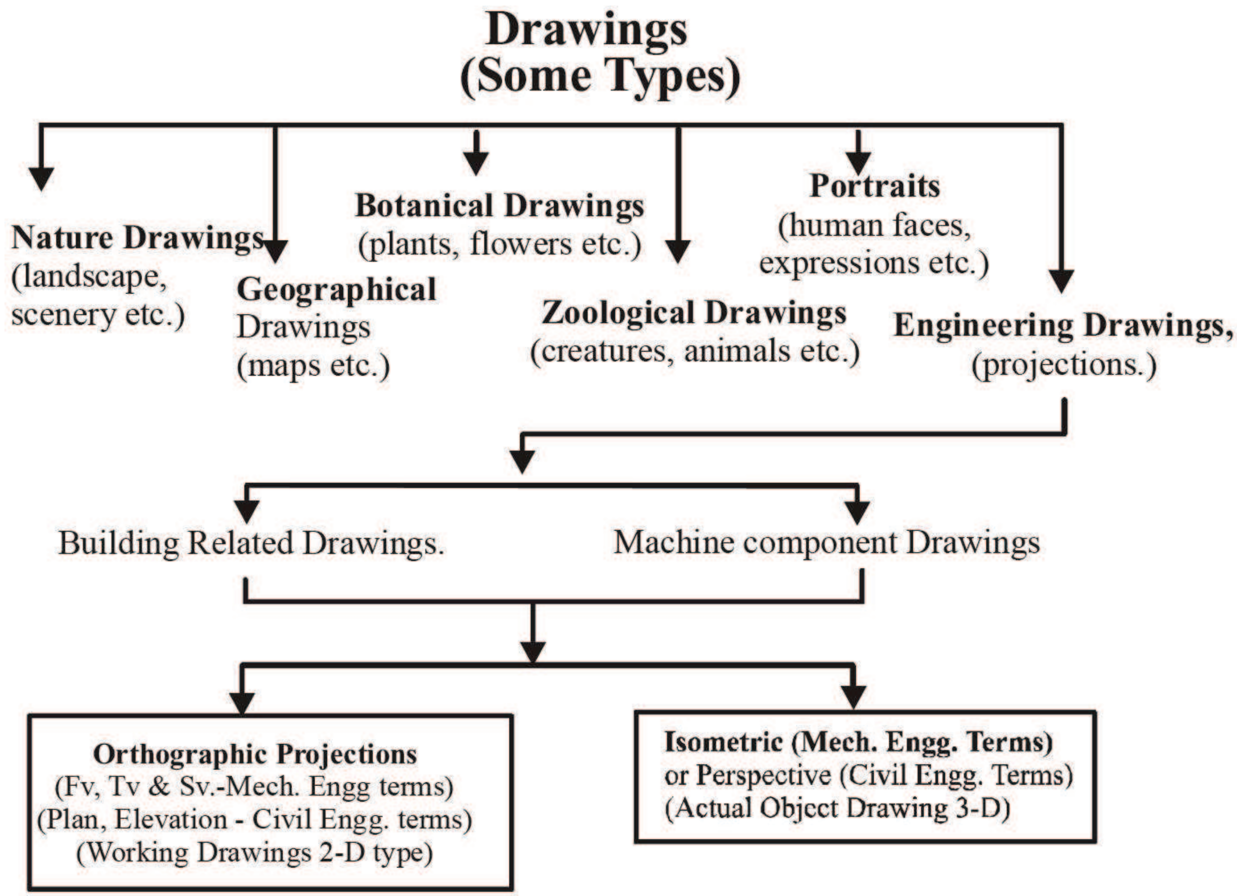
Example of an Engineering Drawing

Here is an **example** of an engineering drawing (an isometric view of the same object is shown bellow). The different line types are colored for clarity.

- Black = object line and hatching
- Red = hidden line
- Blue = center line of piece or opening
- Magenta = phantom line or cutting plane line



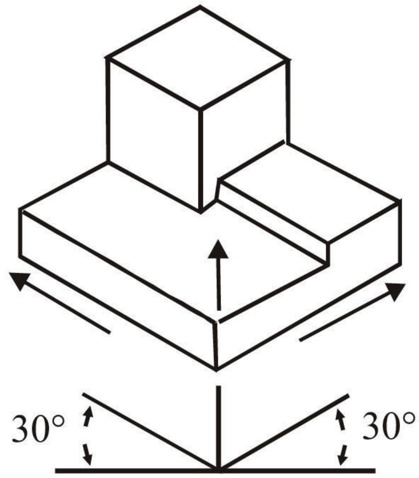
TYPES OF DRAWING



Isometric Drawing

Representation of the object in figure below is called an isometric drawing. This is one of a family of three-dimensional views called pictorial drawings. In an isometric drawing, the object's vertical lines are drawn vertically, and the horizontal lines in the width and depth planes are shown at 30 degrees to the horizontal. When drawn under these guidelines, the lines parallel to these three axes are at their true (scale) lengths. Lines that are not parallel to these axes will not be of their true length.

Figure An Isometric Drawing

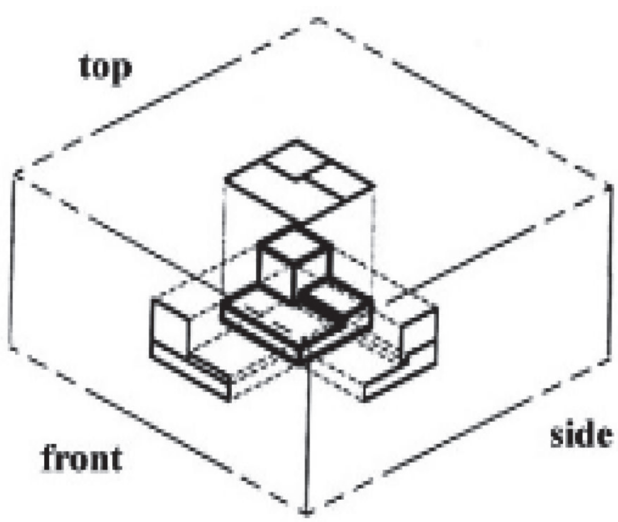


A engineering drawing should show everything because a complete understanding of the object should be possible from the drawing. If the isometric drawing can show all details and all dimensions on one drawing, it is ideal. One can pack a great deal of information into an isometric drawing. However, if the object in figure above had a hole on the back side, it would not be visible using a single isometric drawing. In order to get a more complete view of the object, an orthographic projection may be used.

Orthographic Drawing

Imagine that we have an object suspended by transparent threads inside a glass box, as in figure below.

Figure - The block suspended in a glass box



Then draw the object on each of three faces as seen from that direction. Unfold the box (figure below) and you have the three views. We call this an "orthographic" or "multi-view" drawing.

Figure - The creation of an orthographic or multi-view drawing

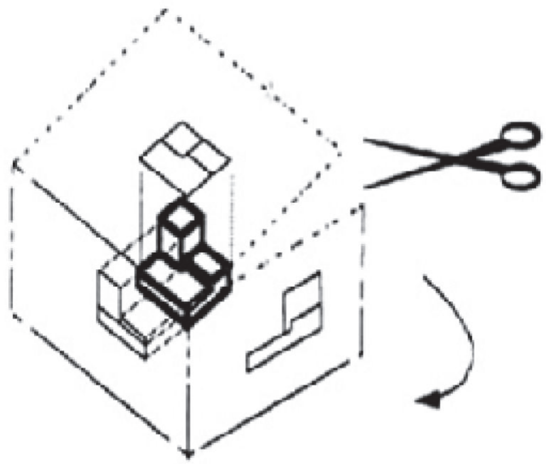
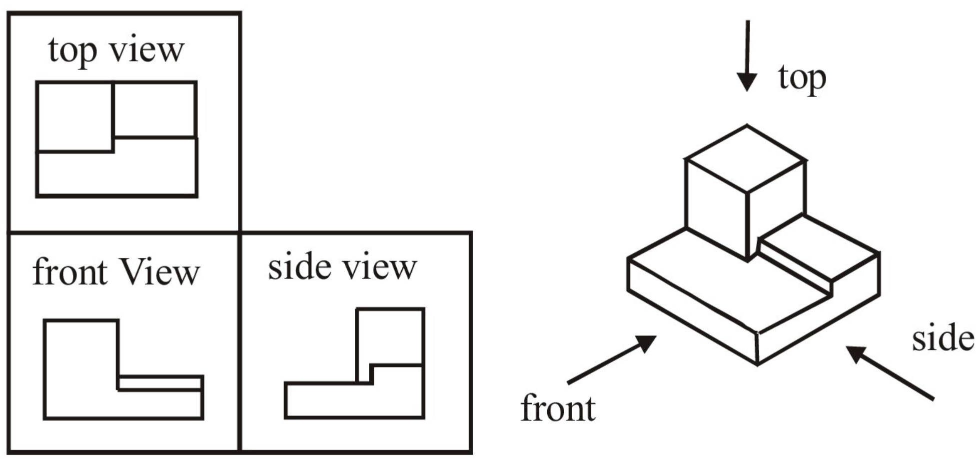


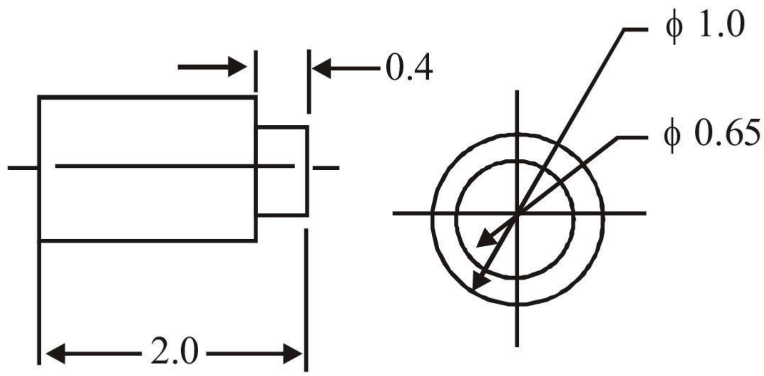
Figure below shows how the three views appear on a piece of paper after unfolding the box.

Figure - A multi-view drawing and its explanation



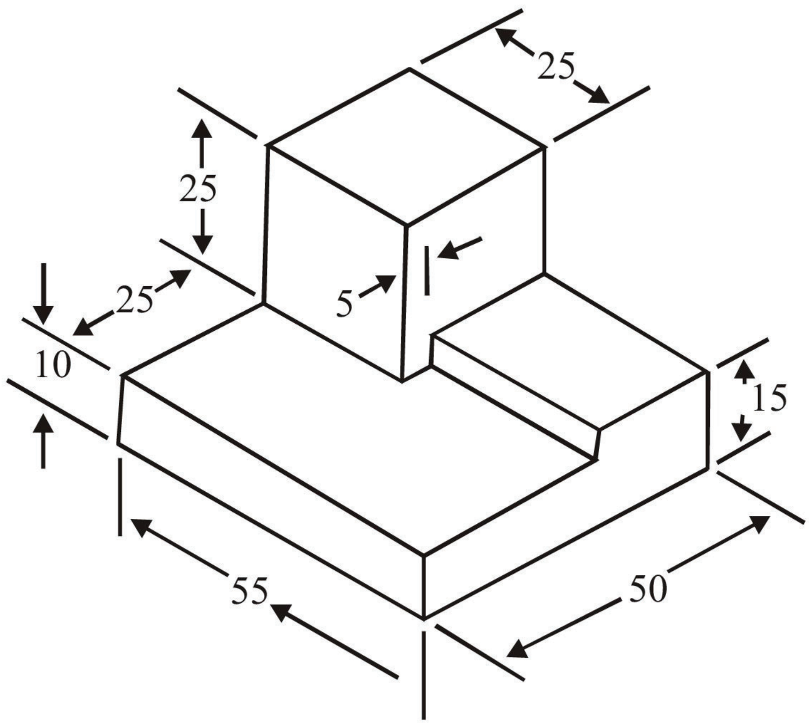
The views that reveal every detail about the object. Three views are not always necessary; we need only as many views as are required to describe the object fully. For example, some objects need only two views, while others need four. The circular object in figure below requires only two views.

Figure - An object needing only two orthogonal views



Dimensioning

Figure - An isometric view with dimensions



We have "dimensioned" the object in the isometric drawing in figure above. As a general guideline to dimensioning, try to think that we would make an object and dimension it in the most useful way. Put in exactly as many dimensions as are necessary for the crafts-person to make it -no more, no less. Do not put in redundant dimensions. Not only will these clutter the drawing, but if "tolerances" or accuracy levels have been included, the redundant dimensions often lead to

conflicts when the tolerance allowances can be added in different ways.
Repeatedly measuring from one point to another will lead to inaccuracies. It is often better to measure from one end to various points. That gives the dimensions a reference standard. It is helpful to choose the placement of the dimension in the order in which a machinist would create the part. So that convention may take some experience.

VIEWS OF ENGINEERING DRAWING:

Views

In engineering drawing there are six principle views of an object, front, top, L side, R side, rear, and back views. The three most commonly views drawn on a technical drawing are the front, back, and side views most other views are not needed. Other views may be needed in order for the person who is creating the Part, to better visualize it in order to properly manufacture it.
In most cases, a single view is not sufficient to show all necessary features, and several views are used such as:

Auxiliary views:

An auxiliary view is an orthographic view that is projected into any plane other than one of the six primary views. These views are typically used when an object contains some sort of inclined plane.
Using the auxiliary view allows for that inclined plane (and any other significant features) to be projected in their true size and shape. The true size and shape of any feature in an engineering drawing can only be known when the Line of Sight (LOS) is perpendicular to the plane being referenced. It is shown like a three-dimensional object. Auxiliary views tend to make use of axonometric projection. When

existing all by themselves, auxiliary views are sometimes known as pictorials.

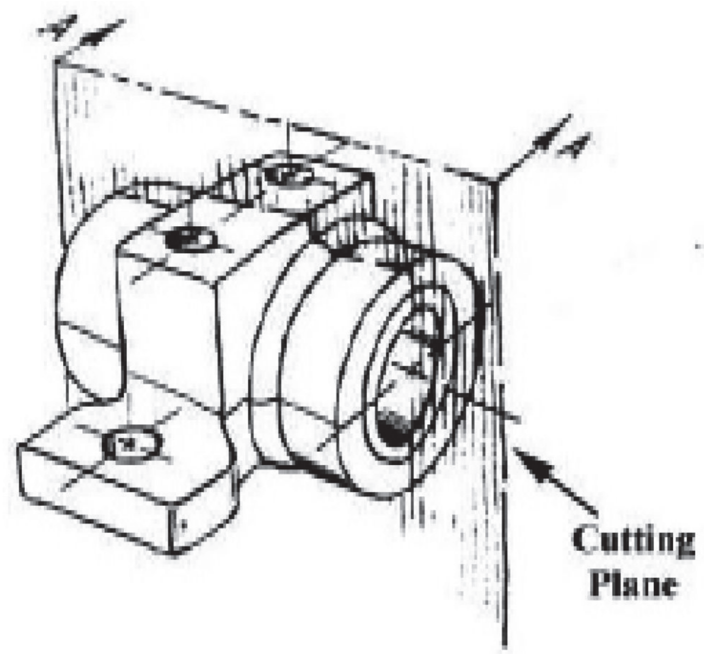
Section Views

Projected views (either Auxiliary or Multi-view) which show a cross section of the source object along the specified cut plane. These views are commonly used to show internal features with more clarity than may be available using regular projections or hidden lines. In assembly drawings, hardware components (e.g. nuts, screws, washers) are typically not sectioned.

Cross-Sectional Views

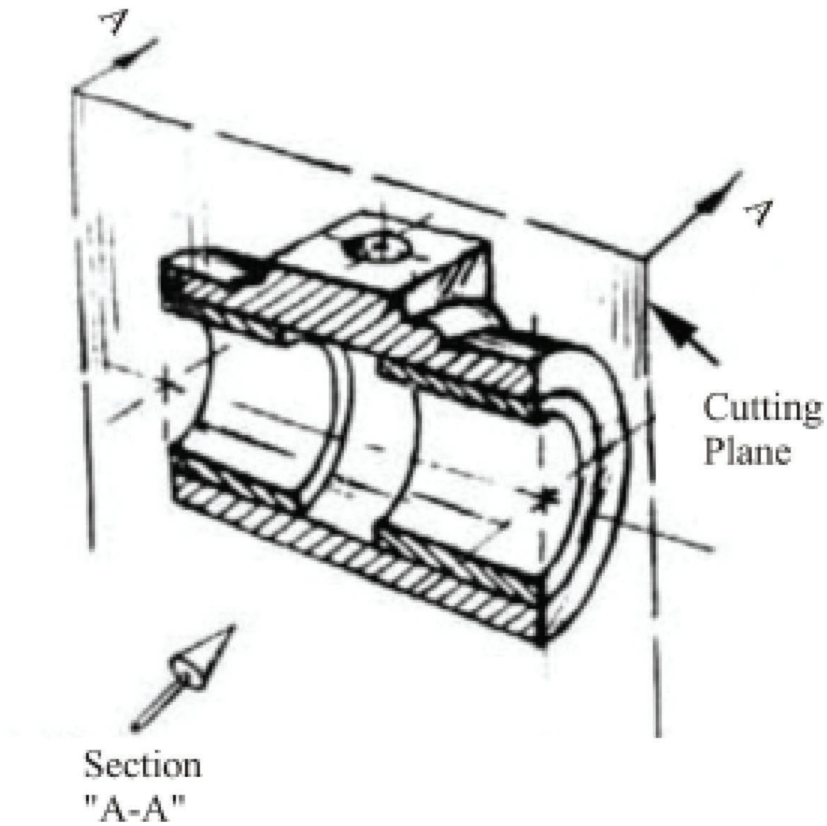
A cross-sectional view portrays a cut-away portion of the object and is another way to show hidden components in a device.
Imagine a plane that cuts vertically through the center of the pillow block as shown in figure below.

Figure - Pillow Block



Then imagine removing the material from the front of this plane, as shown in figure below:

Figure - Pillow Block



PROJECTIONS OF ENGINEERING DRAWING:

The projection is achieved by the use of imaginary "projectors". Graphical projection is a protocol, used in technical drawing, by which an image of a three-dimensional object is projected onto a planar surface without the aid of numerical calculation.

By this protocol the technician may produce the envisioned picture on a planar surface such as drawing paper. The protocols provide a uniform imaging procedure among people trained in technical graphics (mechanical drawing, computer aided design, etc.).

Types of projections:

- Orthogonal projection
- Auxiliary projection

- Isometric projection
- Oblique projection
- Perspective projection

Orthographic Projection:

Orthographic projection is a way of representing a 3-dimensional object in two dimensions. It is a form of parallel projection; here the view direction is orthogonal to the projection plane, resulting in each plane of the scene appearing in affine transformation on viewing surface. It is further divided into Multi-view Orthographic projections and axonometric projection.

A multi-view projection is a type of orthographic projection that shows the object as it looks from the front, right, left, top, bottom, or back (e.g. the primary views), and is typically positioned relative to each other according to the rules of either first-angle or third-angle projection.

First-angle projection

- In first-angle projection, the parallel projectors originate as if radiated from behind the viewer and pass through the 3D object to project a 2D image onto the orthogonal plane behind it.
- The 3D object is projected into 2D "paper" space as if we are looking at a radiograph of the object: the top view is under the front view; right view is at the left of the front view.

Third-angle Projection

- In third-angle projection, the parallel projectors originate as if radiated from the far side of the object and pass through the 3D object to project a 2D image onto the orthogonal plane in front of it.
- The views of the 3D object are like the panels of a box that envelopes the object and the panels pivot as they open up flat

into the plane of the drawing.

- Thus the left view is placed on the left and the top view on the top; and the features closest to the front of the 3D object will appear closest to the front view in the drawing.

Auxiliary Projections

The auxiliary view is an orthographic view that is projected into any plane other than one of the 6 principal views. The views are used when an object contains some sort of the inclined plane. Using the auxiliary view allows for inclined plane to be projected in true size and shape. The true size and shape of any feature in a technical drawing can only be known when the Line of Sight is perpendicular to the plane which is considered as reference.

Isometric projection

An isometric projection shows the object from angles in which the scales along each axis of the object are equal. Isometric projection corresponds to rotation of the object by ± 45° about the vertical axis, followed by rotation of approximately ± 35.264° [= arc-sin(tan(30°))] about the horizontal axis starting from an orthographic projection view. "Isometric" comes from the Greek for "same measure". One of the things that make isometric drawings so attractive is the ease with which 60° angles can be constructed with only a compass and straightedge.

Isometric projection is a type of axonometric projection. The other two types of axonometric projection are:

- Di-metric projection
- Tri-metric projection

Oblique projection:

An oblique projection is a simple type of graphical projection used for producing pictorial, two-dimensional images of three-dimensional objects:

- It projects an image by intersecting parallel rays (projectors)
- From the three-dimensional source object with the drawing surface (projection plan).

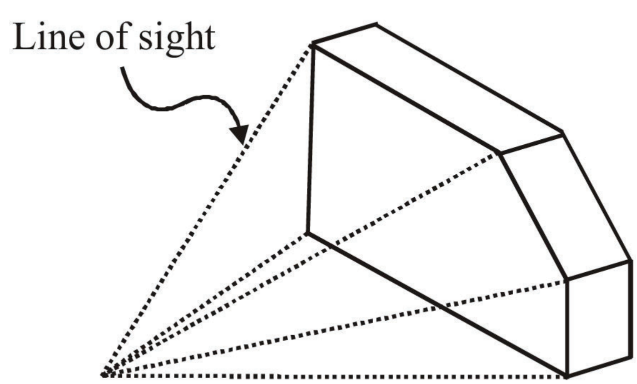
In both oblique projection and orthographic projection, parallel lines of the source object produce parallel lines in the projected image.

Perspective projection:

Perspective is an approximate representation on a flat surface, of an image as it is perceived by the eye. The two most characteristic features of perspective are that objects are drawn:

- Smaller as their distance from the observer increases
- Foreshortened: The sizes of an object's dimensions along the line of sight are relatively shorter than dimensions across the line of sight.

Perspective projection



DRAWING INSTRUMENTS

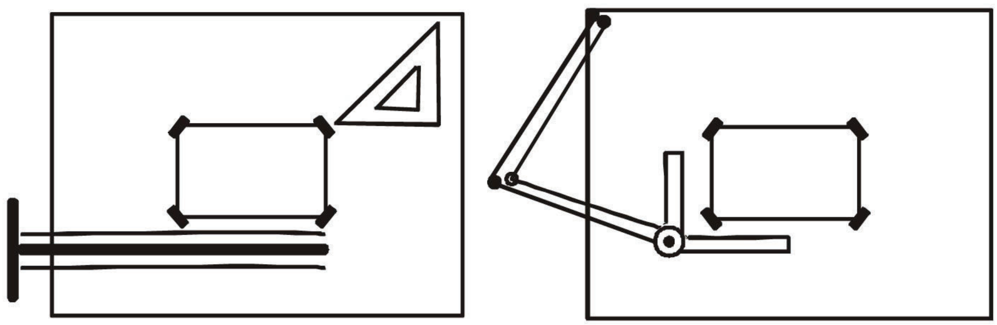
Drawing instruments are used to draw straight lines, circles, and curves accurately concisely.

The drawing tools are like drawing board, mini drafter, instrument box containing compass, divider, Set squares, protractor, French curves, drawing sheet, pencils, and erasers.

Drawing Tools

To prepare a drawing, one can use manual drafting instruments (figure below) or computer-aided drafting or design, or CAD. The basic drawing standards and conventions are the same regardless of what design tool we use to make the drawings. In learning drafting, we will approach it from the perspective of manual drafting. If the drawing is made without either instruments or CAD, it is called a freehand sketch.

Figure- Drawing Tools



LINE

Line is the most basic design 'tool' on which almost every piece of art relies. A line has length, width, tone, and texture. It may divide space, define a form, describe contour, or suggest direction.

Types of lines

There are mainly four types of lines are present in engineering drawing:

- **Visible line**: represent features that can be seen in the current view.
- **Dimension line:** It is also known as extension line or leader line and it indicate the sizes and location of features
- **Hidden line:** represent features that cannot be seen in the current view.
- **Center line:** represents symmetry, path of motion, centers of circles, axis of symmetrical parts.

Which are used in the representation of the diagrams are of mainly 4 types they are

Style \ Thickness	Thick	Thin
Continuous	Visible line	1. Dimension line 2. Extension line 3. Leader line
Dash		Hidden line
Chain		Center line

Classification of Lines

Lines can also be classified by a letter classification in which each line is given a letter.

- **Type A** lines show the outline of the feature of an object. They are the thickest lines on a drawing and done with a pencil softer than HB.
- **Type B** lines are dimension lines and are used for dimensioning, projecting, extending, or leaders. A harder pencil should be used, such as a 2H pencil.
- **Type C** lines are used for breaks when the whole object is not shown. These are freehand drawn and only for short breaks. 2H pencil
- **Type D** lines are similar to Type C, except these are zigzagged and only for longer breaks. 2H pencil
- **Type E** lines indicate hidden outlines of internal features of an object. These are dotted lines. 2H pencil
- **Type F** lines are Type F-lines, except these are used for drawings in electro-technology. 2H pencil
- **Type G** lines are used for centre lines. These are dotted lines, but a long line of 10-20 mm, then a 1 mm gap, then a small line of 2 mm. 2H pencil
- **Type H** lines are the same as type G, except that every second long line is thicker. These indicate the cutting plane of an object. 2H pencil

- **Type U** lines indicate the alternate positions of an object and the line taken by that object. These are drawn with a long line of 10-20 mm, then a small gap, then a small line of 2 mm, then a gap, then another small line. 2H pencil.

Scale

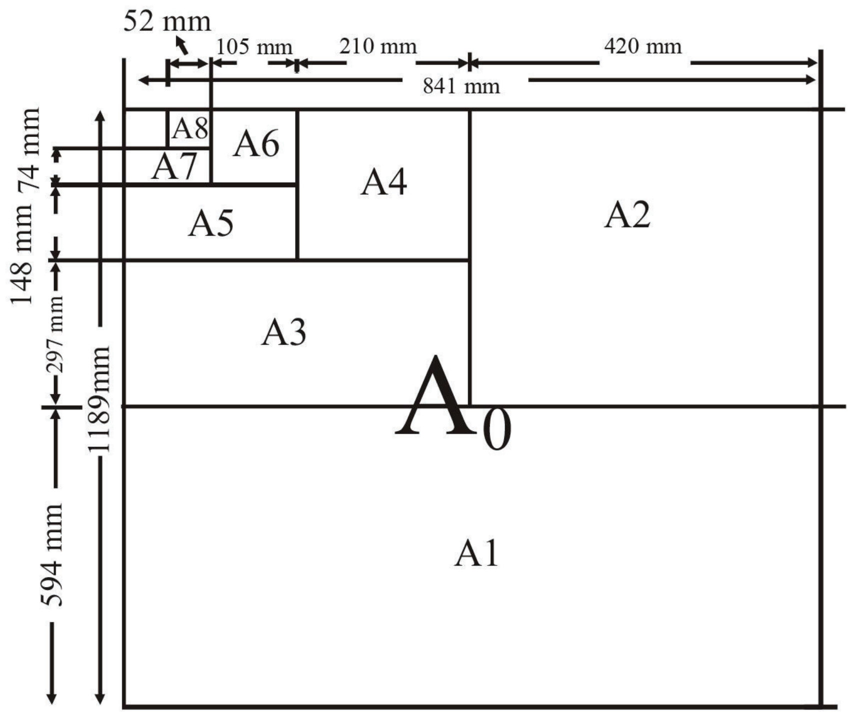
Plans are usually "scale drawings", meaning that the plans are drawn at specific ratio relative to the actual size of the place or object. Various scales may be used for different drawings in a set. For example, a floor plan may be drawn at 1:50 (1:48 or V_4 "= 1′ 0") whereas a detailed view may be drawn at 1:25 (1:24 or V_2 "= 1′ 0"). Site plans are often drawn at 1:200 or 1:100.

Drawing Standards

Drawing standards are set of rules that govern how the technical drawings are represented. These are used so that everyone can commonly understand the meaning of drawn picture.

Drawing Sheet

We have many types and sizes of drawing sheets such as: A4, A3, A2, A1, A0 etc.



Standard sheet size (JIS)

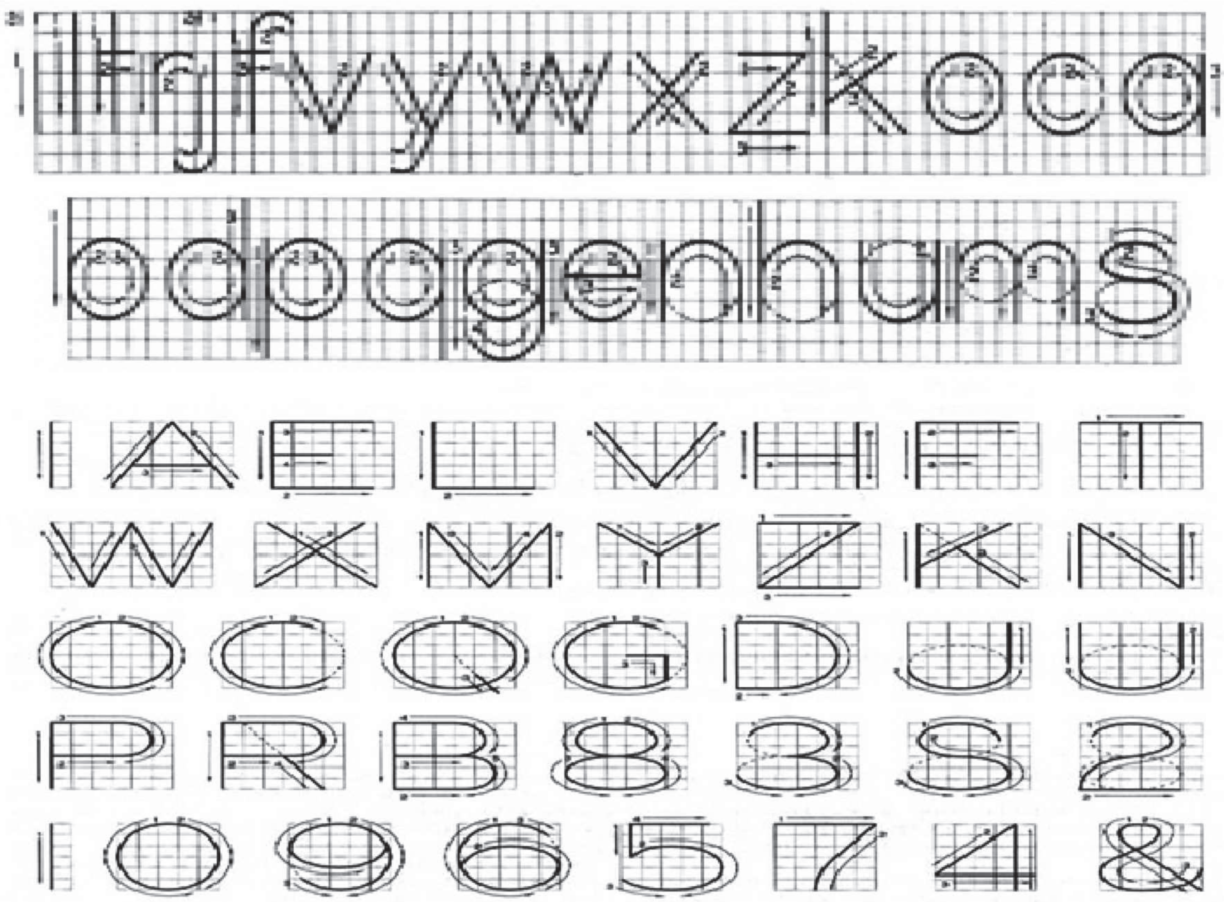
A4	210 × 297
A3	297 × 420
A2	420 × 594
A1	594 × 841
A0	841 × 1189

TECHNICAL LETTERING

Technical lettering is the process of forming letters, numerals, and other characters in technical drawing. It is used to describe, or provide detailed specifications for, an object. With the goals of legibility and uniformity, styles are standardized and lettering ability has little relationship to normal writing ability. Engineering drawings use a Gothic sans-serif script, formed by a series of short strokes. Lower case letters are rare in most drawings of machines.

Lettering and numbering should be in a perfect manner.

For example in figure below the upper and lower case letters are neatly drawn.



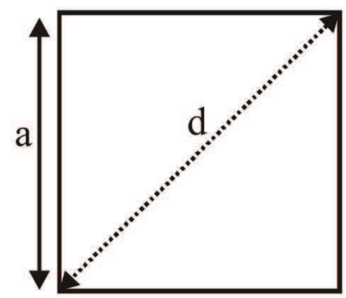
GEOMETRIC FIGURE

Geometric shapes are found everywhere. Take a moment to analyze products or objects we use every day. Geometric shapes and solids are the basis of these products. Engineers who have a strong understanding of these shapes, solids, and other geometric relationships can help designers develop and create solutions to a variety of problems. As designers progress through the design process and these design solutions are formalized, the level of accuracy and precision in the design specifications must increase. Conceptual sketches are converted to computer models and formal drawings, which include annotations describing the size and characteristics of the design features. A strong understanding of shapes and other geometric relationships is necessary to effectively and efficiently develop these computer and graphic representations.

Types of geometric shape:

There are many types of geometric shapes:

Square

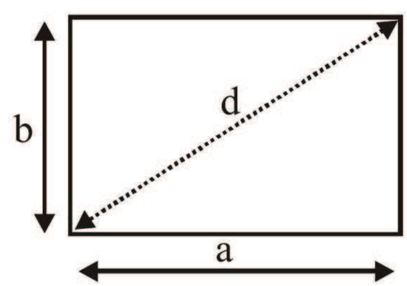


The area of a square can be calculated as $A = a^2$

The side of a square can be calculated as $a = A^{1/2}$

The diagonal of a square can be calculated as $d = a\sqrt{2}$

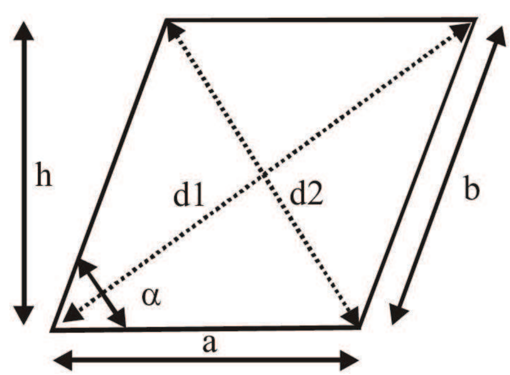
Rectangle



The area of a rectangle can be calculated as $A = a\,b$

The diagonal of a rectangle can be calculated as $d = (a^2 + b^2)^{1/2}$

Parallelogram



The area of a parallelogram can be calculated as $A = a\,h = a\,b \sin \alpha$

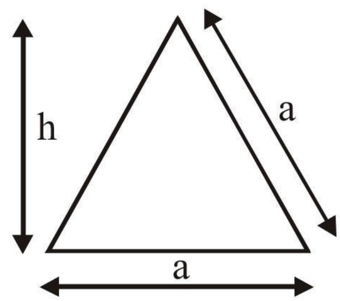
The diameters of a parallelogram can be calculated as

$d_1 = ((a + h \cot \alpha)^2 + h^2)^{1/2}$

$d_2 = ((a - h \cot \alpha)^2 + h^2)^{1/2}$

Equilateral Triangle

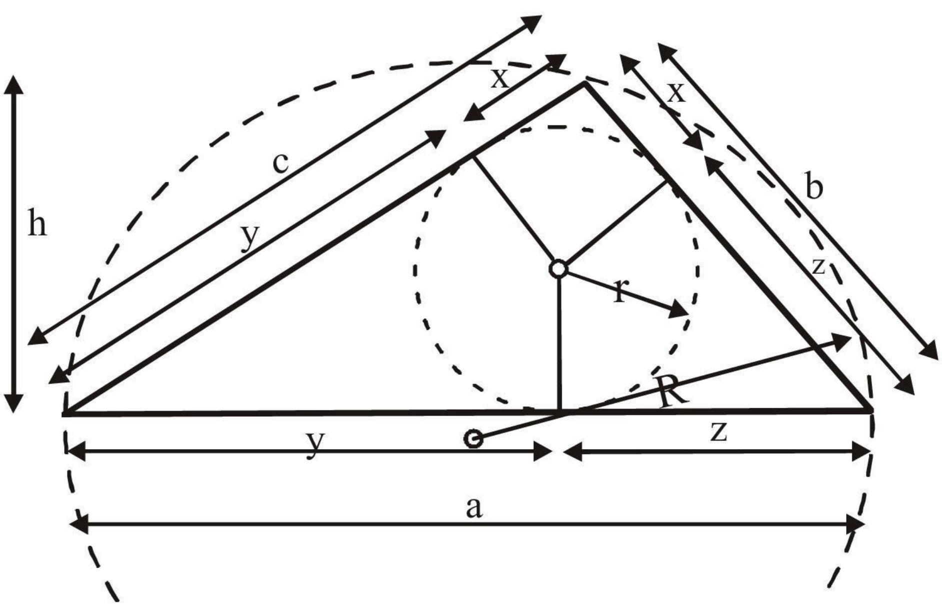
An equilateral triangle is a triangle in which all three sides are equal.



The area of an equilateral triangle can be calculated as $A = (a^2/3)\, 3^{1/2}$

The area of an equilateral triangle can be calculated as $h = a/2\; 3^{1/2}$

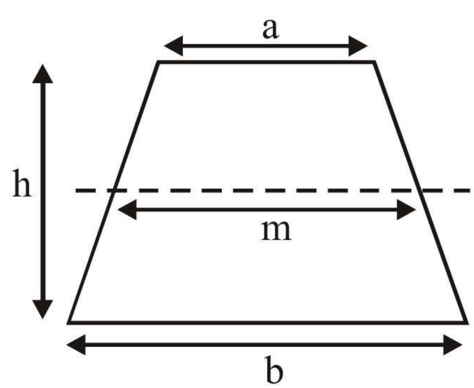
Triangle



The area of a triangle can be calculated as

$A = a\,h / 2 = r\,s$
$r = a\,h / 2s$
$R = b\,c / 2\,h$
$s = (a + b + c) / 2$
$x = s - a$
$y = s - b$
$z = s - c$

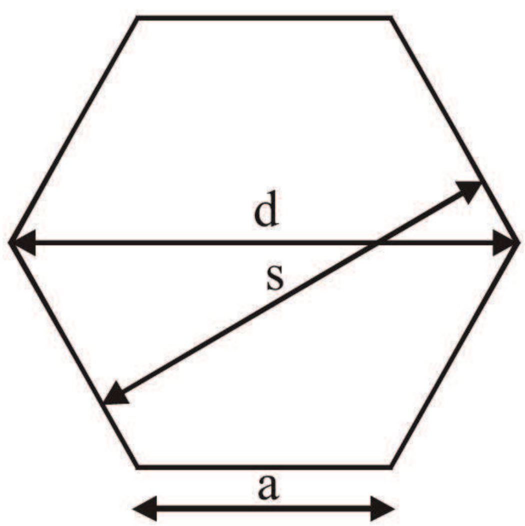
Trapezoid



The area of a trapezoid can be calculated as $A = 1/2\,(a + b)\,h = m\,h$

$m = (a + b) / 2$

Hexagon



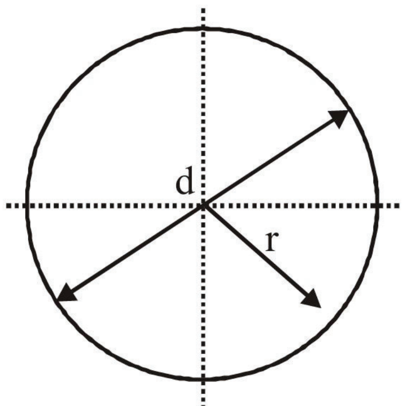
The area of a hexagon can be calculated as

$A = 3/2\,a^2\,3^{1/2}$
$d = 2\,a$

$$= \frac{2}{\sqrt{3s}} = 1.1547005\ s$$

$$s = \sqrt{3} / 2d = 0.866025\ d$$

Circle



The area of a circle can be calculated as

$$A = \pi/4\ d^2 = \pi\ r^2 = 0.785..\ d^2$$

$$C = 2\ \pi\ r = \pi\ d$$

where

C = circumference

Sector of Circle

Area of a sector of circle can be expressed as

$A = 1/2\ \theta_r\ r^2$

$= 1/360\ \theta_d\ \pi r^2$

where

θ_r = angle in radians

θ_d = angle in degrees

Segment of Circle

Area of a segment of circle can be expressed as

$A = 1/2\ (\theta_r - \sin\theta_r)\ r^2$

$= 1/2\ (\pi\ \theta_d/180 - \sin\theta_d)\ r^2$

Right Circular Cylinder

Lateral surface area of a right circular circle can be expressed as

$A = 2 \pi r h$

where

h = height of cylinder (m, ft)

r = radius of base (m, ft)

Right Circular Cone

Lateral surface area of a right circular cone can be expressed as

$A = \pi r l$

$= \pi r (r^2 + h^2)^{1/2}$

where

h = height of cone (m, ft)

r = radius of base (m, ft)

l = slant length (m, ft)

Sphere

Lateral surface area of a sphere can be expressed as

$A = 4 \pi r^2$

Where

r = radius of base (m, ft)

SYMBOLIC REPRESENTATION:

Drawing Symbols provide a convenient way to draw geometrical shapes. To draw a geometrical shape, such as a pentagon or hexagon, select an appropriate symbol from the menu, specify the size of the symbol, and it is drawn at the indicated point.

Example:

Arrows (or pointers) in a drawing are commonly used to specify a direction for any reason. There are several arrow styles available in CADD programs. We can choose from simple two-point arrows to arrows passing through a number of points, and from simple to fancy arrow styles. To draw an arrow, we need to indicate the points through which the arrow will pass.

EXERCISE

1. The following is not included in title block of drawing sheet.
   (a) Sheet No
   (b) Scale
   (c) Method of Projection
   (d) Size of sheet
2. Which of the following is not a pictorial drawing?
   (a) isometric
   (b) multiview
   (c) perspective
   (d) axonometric
3. Which of the following represent reducing scale?
   (a) 1 : 1
   (b) 1 : 2
   (c) 2 : 1
   (d) 10 : 1
4. Which of the following projection methods does not use projectors perpendicular to the projection plane?
   (a) isometric
   (b) orthographic
   (c) oblique
   (d) axonometric
5. In first angle projection method, object is assumed to be placed in
   (a) First quadrant
   (b) Second quadrant
   (c) Third Quadrant
   (d) Fourth quadrant
6. A circle will appear on an isometric drawing as a(n) __________ .
   (a) ellipse
   (b) cycloid
   (c) circle
   (d) parabola

7. The following line is used for visible outlines
   (a) Continuous thick
   (b) Continuous thin
   (c) Chain thin line
   (d) Short zigzag thin
8. An axonometric drawing which has two axes divided by equal angles is:
   (a) dimetric
   (b) trimetric
   (c) orthographic
   (d) isometric
9. The dotted lines represents
   (a) Hidden edges
   (b) Projection line
   (c) Centre line
   (d) Hatching line
10. When you want to make the letters of a line of text narrower, you would set its:
   (a) aspect
   (b) scale
   (c) alignment
   (d) font
11. In aligned system of dimensioning, the dimensions may be read from
   (a) Bottom or right hand edges
   (b) Bottom or left hand edges
   (c) Only from bottom
   (d) Only from left side
12. In an axonometric drawing, the projection rays are drawn _____ to each other and ____ to the plane of projection.
   (a) Parallel...oblique
   (b) oblique...parallel
   (c) parallel...perpendicular
   (d) parallel...parallel
13. The Length: Width in case of an arrow head is
   (a) 1 : 1

(b) 2 : 1
(c) 3 : 1
(d) 4 : 1

14. Which tool can be used to draw a 90 degree angle?
    (a) 30/60 triangle
    (b) protractor
    (c) drafting machine
    (d) all of these

15- The internal angle of regular pentagon is ___ degree.
    (a) 72
    (b) 108
    (c) 120
    (d) 150

16. In an oblique sketch of a cube:
    (a) the frontal face appears in its true shape
    (b) both receding axes are at 30 degrees to the horizontal
    (c) all faces are equally distorted
    (d) the depth distances must be reduced

17. The following line is used for dimension line
    (a) Continuous thick
    (b) Continuous thin
    (c) Chain thin line
    (d) Short zigzag thin

18. What is the major difference(s) between perspective and parallel projection?
    (a) Parallel projection can only be used with objects containing parallel edges.
    (b) Perspective projection gives a more realistic representation of an object.
    (c) Parallel projection is equivalent to a perspective projection where the viewer is standing infinitely far away.
    (d) Both B and C

19. A line of 1 meter is shown by 1cm on a scale. Its Representative fraction (RF) is
    (a) 1
    (b) 100

(c) 1/100
(d) 1/50

20. Which statement(s) is true about the precedence of lines?
    (a) a hidden line has precedence over a center line
    (b) a center line has precedence over a visible line
    (c) a visible line has precedence over a miter line
    (d) all of the above
21. The side view of an object is drawn in
    (a) Vertical plane
    (b) Horizontal plane
    (c) Profile plane
    (d) Any of the above
22. Which type of line has precedence over all other types of lines?
    (a) a hidden line
    (b) a center line
    (c) a visible line
    (d) none of the above
23. The following is the method for development of a right regular prism.
    (a) Parallel line method
    (b) Radial line method
    (c) Triangulation method
    (d) Approximate method
24. In an oblique drawing, all of the following angles are commonly used for drawing the depth axis, except:
    (a) 30°
    (b) 45°
    (c) 60°
    (d) 90°
25. The following method(s) is used to find the true length and true inclination of a line when its front view and top view are given
    (a) Rotation method
    (b) Trapezoidal method
    (c) Auxiliary plane method
    (d) All of the above
26. Which set of lead grades has a grade out of sequence?

(a) H, HB, B, 3B
(b) 7B, H, F, 3H
(c) 6B, B, H, 4H
(d) 9H, HB, B, 2B

27. Hatching lines are drawn at ___ degree to reference line
(a) 30
(b) 45
(c) 60
(d) 90

28. What type of sketch shows the front in true shape?
(a) isometric
(b) perspective
(c) oblique
(d) axonometric

29. When the line is parallel to VP and perpendicular to HP, we can get its true length in
(a) Front view
(b) Side view
(c) Both 'a' and 'b'
(d) Top view

30. Which type of line is part of a dimension?
(a) break lines
(b) phantom lines
(c) extension lines
(d) cutting plane lines

31. The following are the Polyhedron except
(a) Prism
(b) Pyramid
(c) Cube
(d) Cylinder

32. What type of sketch incorporates convergence?
(a) isometric
(b) perspective
(c) oblique
(d) multiview

33. When the line is parallel to both Horizontal Plane (HP) and Vertical Plane (VP), we can get its true length in
    (a) Front view
    (b) Top view
    (c) Both 'a' and 'b'
    (d) Side view
34. Which line type is thin and light?
    (a) Visible lines
    (b) center lines
    (c) construction lines
    (d) all of the above
35. The internal angle of regular hexagon is ___ degree.
    (a) 72
    (b) 108
    (c) 120
    (d) 150
36. What type of sketch uses a miter line?
    (a) a two-view multiview
    (b) an isometric pictorial
    (c) a three-point perspective pictorial
    (d) a three-view multiview
37. The front view of a rectangle, when its plane is parallel to HP and perpendicular to VP, is
    (a) Rectangle
    (b) Square
    (c) Line
    (d) Point
38. Which type of line is particular to section drawings?
    (a) break lines
    (b) phantom lines
    (c) extension lines
    (d) cutting plane lines
39. Which of the following position is not possible for a plane?
    (a) Perpendicular to both HP and VP
    (b) Parallel to both HP and VP
    (c) Perpendicular to HP and parallel to VP

(d) Perpendicular to VP and parallel to HP

40. In an oblique drawing, the projection rays are drawn ___ to each other and ____ to the plane of projection.
    (a) oblique.....oblique
    (b) oblique.....parallel
    (c) parallel.....oblique
    (d) parallel....parallel

41. The following are the Solids of revolution except
    (a) Prism
    (b) Sphere
    (c) Cone
    (d) Cylinder

42. Which design process involves responding to the emotional needs of the consumer?
    (a) aesthetic design
    (b) functional design
    (c) systems design
    (d) e-business

43. If a solid is cut by a cutting plane parallel to the base of the solid and top part is removed, the remaining part is called
    (a) Frustum of a solid
    (b) Truncated solid
    (c) Oblique solid
    (d) None of the above

44. Which line type is thick and black?
    (a) Visible lines
    (b) center lines
    (c) construction lines
    (d) all of the above

45. A right regular hexagonal prism in resting on HP on its base, its top view is a
    (a) Square
    (b) Rectangle
    (c) Hexagon
    (d) Pentagon

46. In an isometric sketch of a cube:

(a) the frontal face appears in its true shape
(b) the receding axes are at 45 degrees to the horizontal
(c) all faces are equally distorted
(d) only the depth distances must be reduced

47. Which of the following position is not possible for a right solid?
(a) Axis perpendicular to HP and parallel to VP
(b) Axis parallel to VP and perpendicular to HP
(c) Axis parallel to both VP and HP
(d) Axis perpendicular to both VP and HP

48. Where do the projection lines converge in a perspective sketch?
(a) the vanishing point
(b) the ground line
(c) the horizon line
(d) the eye point

49. The top view of a right cylinder resting on HP on its base rim is
(a) Ellipse
(b) Circle
(c) Rectangle
(d) Square

50. In isometric drawings:
(a) Two axes are perpendicular
(b) True measurements can be made only along or parallel to the isometric axes
(c) All faces are unequally distorted
(d) None of the above

ANSWER KEYS

1	(d)	2	(b)	3	(b)	4	(c)	5	(a)	6	(a)	7	(a)	8	(a)	9	(a)	10	(a)
11	(a)	12	(c)	13	(c)	14	(d)	15	(a)	16	(a)	17	(b)	18	(d)	19	(c)	20	(a)
21	(c)	22	(c)	23	(a)	24	(d)	25	(d)	26	(b)	27	(b)	28	(c)	29	(c)	30	(c)
31	(d)	32	(b)	33	(c)	34	(c)	35	(a)	36	(d)	37	(c)	38	(d)	39	(b)	40	(c)
41	(a)	42	(a)	43	(a)	44	(a)	45	(c)	46	(c)	47	(d)	48	(a)	49	(b)	50	(b)

CHAPTER

2

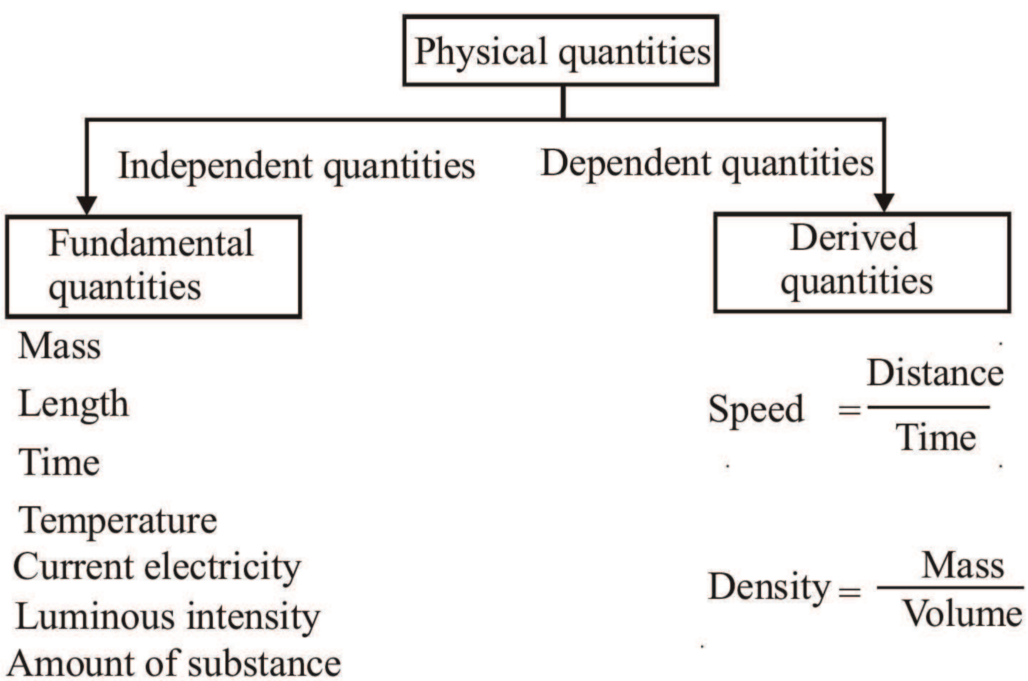
Unit and Measurements

PHYSICAL QUANTITIES

Those quantities which can describe the laws of physics and possible to measure are called physical quantities.
A physical quantity is that which can be measured.
Physical quantity is completely specified;
If it has

- → only numerical value (ratio) Ex. Refractive index, dielectric constant etc.
- → only magnitude (scalar) Ex. Mass, charge etc.
- → magnitude and direction (vector) Ex. Displacement, torque etc.

Types of Physical Quantities



The physical quantities which do not depend upon other physical quantities are called **fundamental quantities**.

In M.K.S. System the fundamental quantities are mass, length and time.

In Standard International (S.I.) system the fundamental quantities are mass, length, time, temperature, illuminating power (or luminous intensity), current and amount of substance.

The physical quantities which depend on fundamental quantities are called **derived quantities** e.g. speed, acceleration, force, etc.

UNITS

The **unit** of a physical quantity is the reference standard used to measure it.

For the measurement of a physical quantity a definite magnitude of quantity is taken as standard and the name given to this standard is called unit.

Properties of Unit

(a) The unit should be well-defined.
(b) The unit should be of some suitable size.
(c) The unit should be easily reproducible.
(d) The unit should not change with time.
(e) The unit should not change with physical conditions like pressure, temperature etc.
(f) The unit should be universally acceptable.

Types of Units

1. Fundamental Units

The units defined for the fundamental quantities are called fundamental or base units.

Base quantities and their SI unit

- Unit of **mass** = **kilogram**

One kilogram is defined as the mass of a platinum – iridium cylinder kept in National Bureau of Weights and Measurements, Paris.

- Unit of **length** = **metre**

  The distance travelled by light in vacuum in 1/299,792,458 second or it is equal to 1650763.73 wavelength emitting from Kr^{86}.

- Unit of **time** = **second**

  The time interval in which Cesium-133 atom vibrates 9,192,631, 770 times.

- Unit of **temperature** = **kelvin**

  It is defined as the (1/273.16) fraction of thermo dynamic temperature of triple point of water.

  Triple Point of Water is the temperature at which ice, water and water vapours co-exist.

- Unit of **electric current** = **ampere**

  The amount of current which produces a force of 2×10^{-7} N per unit length acts between two parallel wires of infinite length and negligible cross-section area placed at 1m distance in vacuum.

- Unit of **luminous intensity** = **candela**

  The amount of intensity on 1/60000 m^2 area of blackbody in the direction perpendicular to its surface at freezing point of platinum 2042K at pressure of 101325 N/m^2.

- Unit of **quantity of substance** = **mole**

  It is the amount of a substance which has same number of elementary entities as in 12 gm of carbon-12.

2. Derived Units

The units defined for the derived quantities are called derived units.

Unit of speed

$$\text{(Speed/velocity)} = \frac{\text{Distance (displacement)}}{\text{Time}}$$

⇒ (Unit of speed/velocity) = $\frac{\text{metre}}{\text{sec.}}$ =ms^{-1}

Unit of acceleration

Acceleration; $a = \frac{v}{t}$

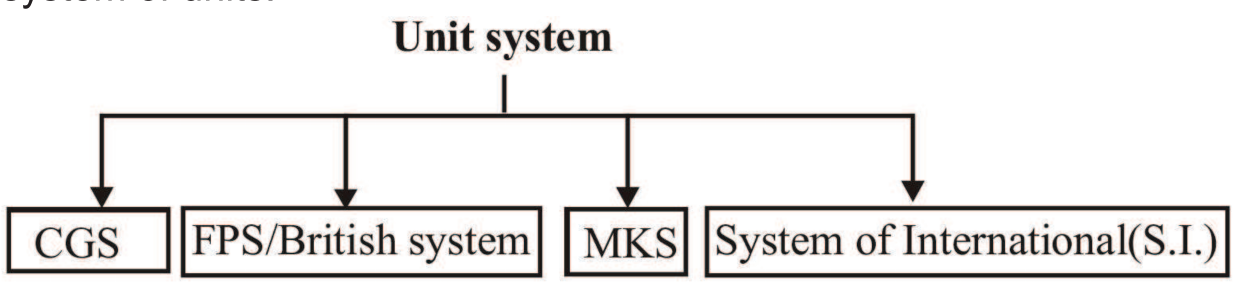
⇒ Unit of 'a' = $\frac{m/s}{s}$ = m/s^2

Unit of force

Force F = ma ⇒ Unit of force = kg m/s^2 = newton

System of Units

A complete set of fundamental and derived units is known as the system of units.



Fundamental	Name of system of unit		
quantity	**C.G.S.**	**F.P.S.**	**M.K.S.**
Length	centimetre	foot	metre
Mass	gram	pound	kilogram
Time	second	second	second

S.I. Prefixes of power 10

Perfix	Symbol	Power of 10
exa	E	10^{18}

peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	K	10^{3}
hecto	h	10^{2}
deca	da	10^{1}
metre	m	$10^{\circ} = 1$
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}

Practical units of length

- 1 light year = 9.46×10^{15} m
- 1 parsec = 3.084×10^{16} m
- 1 fermi = 10^{-15} m
- 1 angstrom (A°) = 10^{-10} m
- 1 astronomical unit (A.U.) = 1.496×10^{11} m

MEASUREMENT OF LARGE DISTANCE

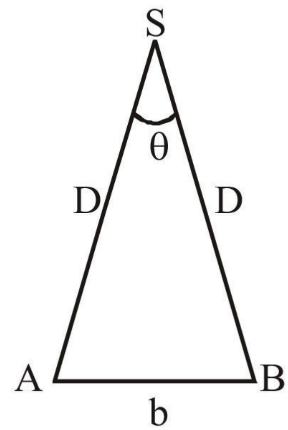
Parallax method : It is used to measure large distances such as the distance of a planet or a star.

If, S is the position of a planet, A and B arethe positions of eyes observing planet S from two different positions on the earth called basis.

Angle, θ is called the **Parallax angle** or **Parallactic angle.**

Distance between A and B = b

Therefore, the distance of the planet 'S' from the earth, $D = \frac{b}{\theta}$



ACCURACY, PRECISION AND ERRORS IN MEASUREMENT

Accuracy of measurement : It depends upon the number of significant figures in it. The higher the accuracy, the higher the number of significant figures.

Precision of measurement : It depends upon the least count of the measuring instrument. The smaller the least count, the more precise the measurement.

Errors in measurement : It is the difference in the true value and the measured value of the quantity.

Least count error : It is the smallest value that can be measured by the measuring instrument.

Absolute error : It is the difference in the true value or mean value and measured value of a quantity.

Suppose, a_1, a_2, a_3 ....a_n are the measured value then,

True value or mean value $a_m = \frac{a_1 + a_2 + a_3 + ... + a_n}{n}$

where n is the number of observations.

Absolute error = $\Delta a_1 = a_m - a_1$

$$\Delta a_2 = a_m - a_2$$

....

$$\Delta a_n = a_m - a_n$$

Relative error : It is the ratio of mean absolute error to the mean value of quantity measured.

i.e., Relative error = $\frac{Mean\ absolute\ error\ (\Delta\overline{a})}{Mean\ value\ (a_{mean})}$

Percentage error (δa): When the relative error is expressed in per cent it is called percentage error.

Percentage error = $\frac{Mean\ absolute\ error\ (\Delta\overline{a})}{Mean\ value\ (a_{mean})} \times 100\%$

Combination of Errors

(a) **Error of a sum or a difference :** In sum or difference of quantities the absolute error in final result is the sum of the absolute errors in the individual quantities.

i.e., $\Delta Z = \Delta A + \Delta B$

(b) **Error of a product or a quotient :** In multiplication or division, the relative error in the result is equal to the sum of the relative errors in the measured quantities.

i.e., $\frac{\Delta Z}{Z} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$

(c) **Error in quantity raised to some power :** The relative error in a physical quantity raised to the power p is the p times the relative error in the measured quantity.

i.e., $\frac{\Delta Z}{Z} = P\frac{\Delta A}{A}$

SIGNIFICANT FIGURES

Significant figures are the number of digits upto which we are sure about their accuracy.

In the measured quantity significant figures are those digits which are known reliably plus the first digit that is uncertain.

Rules in counting the number of significant figures in a given measured quantity :

(i) All non-zero digits are significant.

(ii) All zeroes occuring between two non-zero digits are sigificant.

(iii) All zeroes to the right of a decimal point and to the left of a non-zero digit are not significant.

(iv) All zeroes to the right of the last non-zero digit are not significant. On the other hand, all zeroes to the right of the last non-zero digit are significant provided they come from a measurement.

(v) Power of ten are not counted in significant figures.
e.g. 2.5×10^{-29} has only 2 significant figures.

ROUNDING OFF

Rules of Rounding off Uncertain Digits

(a) The preceding digit is raised by 1 if the uncertain digit to be dropped is more than 5 and is left unchanged if the latter is less than 5.

Example : $x = 5.68\underline{6}$ is rounded off to 5.69 (as 6 > 5)
$x = 3.46\underline{2}$ is rounded off to 3.46 (as 2 < 5)

(b) If the uncertain digit to be dropped is 5, the preceeding digit raised by 1 if it is odd and is left unchanged if it is even digit.
Example : 7.735 is rounded off to three significant figures becomes 7.74 as preceeding digit is odd.
7.745 is rounded off to 7.74 as preceeding digit is even.

DIMENSIONS OF PHYSICAL QUANTITIES

The limit of a derived quantity in terms of necessary basic units is called dimensional formula and the raised powers on the basic units are **dimensions**.

Force is the product of mass and acceleration

Force = mass × acceleration
= mass × (length) / $(\text{time})^2$

Dimensions of force are

$[M]\,[L]/\,[T]^2 = [MLT^{-2}]$

i.e. 1 in mass, 1 in length and 2 in time.

DIMENSIONAL FORMULAE AND DIMENSIONAL EQUATIONS

The expression which shows how and which fundamental quantities represent the dimensions of a physical quantity is known as **dimensional formula**.

Ex. The dimensional formula of force is $[MLT^{-2}]$

When a dimensional formula is equated to its physical quantity then the equation is called **dimensional equation.**

Ex. Dimensional equation of force :

By F = ma

$\Rightarrow$ Dimension equation of force, $F = [M^1] [L^1 T^{-2}]$

$= [MLT^{-2}]$

Ex. Dimensional equation of energy :

By E = W = force × displacement

Dimensional equation of energy, $E = [M^1 L^1 T^{-2}] [L^1]$

$= [M L^2 T^{-2}]$

Dimensions of physical quantities in mechanics

Physical quantity	**Dimensions**	**Physical quantity**	**Dimensions**
Distance Displacement, Length/depth/thickness, wavelength	$[M^0LT^0]$	Force, Weight Tension Centripetal force	$[MLT^{-2}]$
Mass, Inertia, Intertial mass, Gravitational mass	$[ML^0T^0]$	Work Energy Torque Moment of couple Heat	$[ML^2T^{-2}]$

Speed, Velocity	$[M^0LT^{-1}]$	Linear momentum Impulse	$[MLT^{-1}]$
Acc.(a) Acc. due to gravity(g)	$[M^0LT^{-2}]$	Surface tension	$[ML^0T^{-2}]$
Angular velocity, Velocity gradient, Decay constant (λ) Linear frequency	$[M^0L^0T^{-1}]$	Pressure, Coefficient of elasticity Young's modulus Bulk modulus Stress	$[ML^{-1}T^{-2}]$
Wave number Propagation constant (K) Ridburg constant	$[M^0L^{-1}T^0]$	Plank's constant, Angular momentum	$[ML^2T^{-1}]$
Gravitational constant (G)	$[M^{-1}L^3T^{-2}]$	Coefficient of viscosity	$[ML^{-1}T^{-1}]$

Dimensions In heat

Physical quantity	**Dimensions**
Temperature	$[M^0 L^0 T^0 \theta]$
Latent heat	$[M^0 L^2 T^{-2} \theta^0]$
Specific heat	$[M^0 L^2 T^{-2} \theta^{-1}]$
Coefficient of thermal	$[M^0 L^0 T^0 \theta^{-1}]$

expansion	
Coeff. of thermal conductivity	$[ML T^{-3} \theta^{-1}]$
Mechanical equivalent of heat (J)	$[M^0 L^0 T^0]$
Stephan constant	$[ML^0 T^{-3} k^{-4}]$
Wien's constant	$[M^0 L T^0 \theta]$
Boltzmann constant	$[ML^2 T^{-2} \theta^{-1}]$

Dimensions in electricity

Physical quantity	**Dimensions**	**Physical quantity**	**Dimensions**
Charge	$[M^0L^0AT]$	Electric permittivity	$[M^{-1} L^{-3} T^4 A^2]$
Current	$[M^0L^0T^0A]$	Resistance Reactance Impedance	$[ML^2 T^{-3} A^{-2}]$
Potential gradient Electric field Intensity of electric field	$[M L T^{-3}A^{-1}]$	Electrical conductance Admittance Susceptance	$[M^{-1}L^{-2} T^3A^2]$
Potential difference			
Potential	$[ML^2 T^{-3}A^{-1}]$	Electric flux	$[ML^3 T^{-3} A^{-1}]$

Potential energy Electromotive force			
Electrical capacitance	$[M^{-1} L^{-2} T^4 A^2]$	Specific resistance	$[ML^3 T^{-3} A^{-2}]$

Dimensions of magnetic quantities

Physical quantity	**Dimensions**
Magnetic induction	$[M L^0 T^{-2} A^{-1}]$
Permeability of magnet (μ)	$[M L T^{-2} A^{-2}]$
Self inductance or Mutual inductance	$[M L^2 T^{-2} A^{-2}]$
Bohr magneton (μ_B)	$[M^0 L^2 T^0 A]$

Dimensionless quantity

1. Efficiency (η)
2. Coefficient of amplification (μ)
3. Q-factor
4. Power coefficient
5. Relative electric permittivity ($\in_r$)
6. Magnetic permeability (μ)
7. Refractive index (η)
8. Mechanical equivalent of heat (J)
9. Poison's ratio
10. Strain
11. Angular displacement
12. Plane angle/solid angle

Principle of Homogeneity

The dimensions of both sides i.e. dimensions of left side of physical quantity and right side of physical quantity in an equation are same.

Ex. $s = ut + \frac{1}{2}gt^2$

L.H.S. R.H.S

$[L] = [LT^{-1} . T] + [LT^{-2} . T^2]$

$[L] = [L] + [L]$

APPLICATIONS OF DIMENSIONAL ANALYSIS

1. Conversion of one system of unit into another
2. To check the accuracy of a formula
3. To derive the formula by dimensional analysis method

Limitations of Dimensional Analysis

(i) While deriving a formula the proportionality constant cannot be found.

(ii) The formula for a physical quantity depending on more than three other physical quantities cannot be derived. It can be checked only.

The equations of the type $v = u \pm at$ cannot be derived. They can be checked only.

(iii) The equations containing trigonometrical functions

(sin θ, cos θ, etc), logarithmic functions (log x, log x^3, etc) and exponential functions (e^x, e^{x^2}, etc) cannot be derived. They can be checked only.