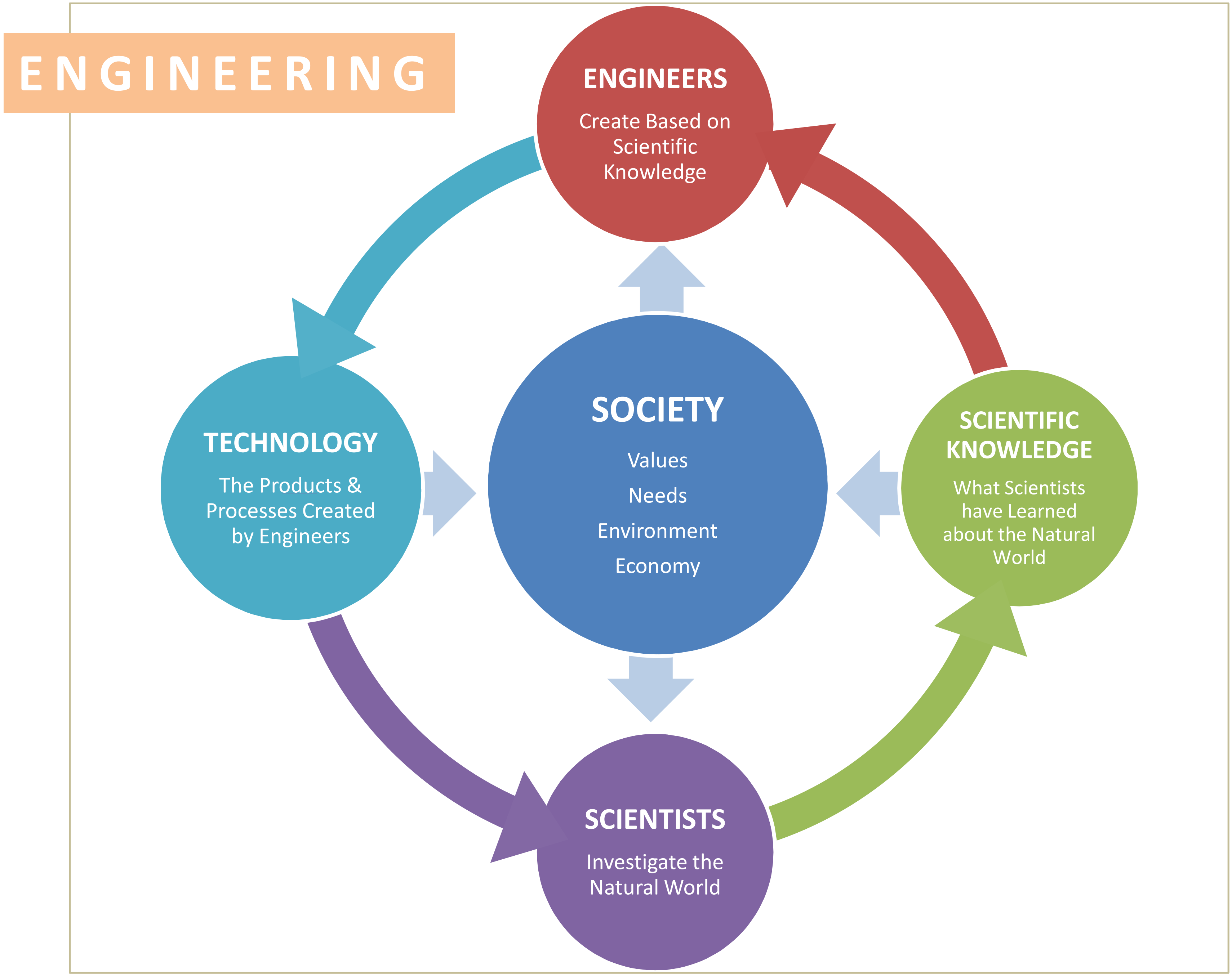
ENGINEERING GRAPHICS

BE 110

Department of Mechanical Engineering

RSET
RAJAGIRI SCHOOL OF ENGINEERING & TECHNOLOGY


ENGINEERING
ENGINEERS
Create Based on Scientific Knowledge
TECHNOLOGY
The Products & Processes Created by Engineers
SOCIETY
Values
Needs
Environment
Economy
SCIENTIFIC KNOWLEDGE
What Scientists have Learned about the Natural World
SCIENTISTS
Investigate the Natural World

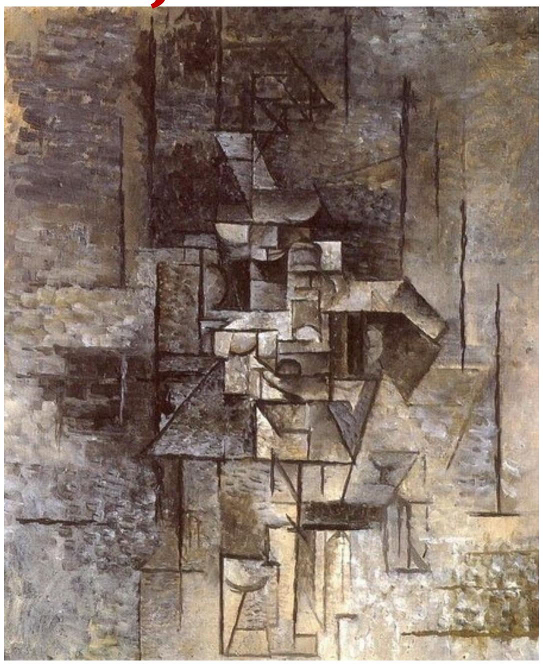
GRAPHICS

from Greek graphikos

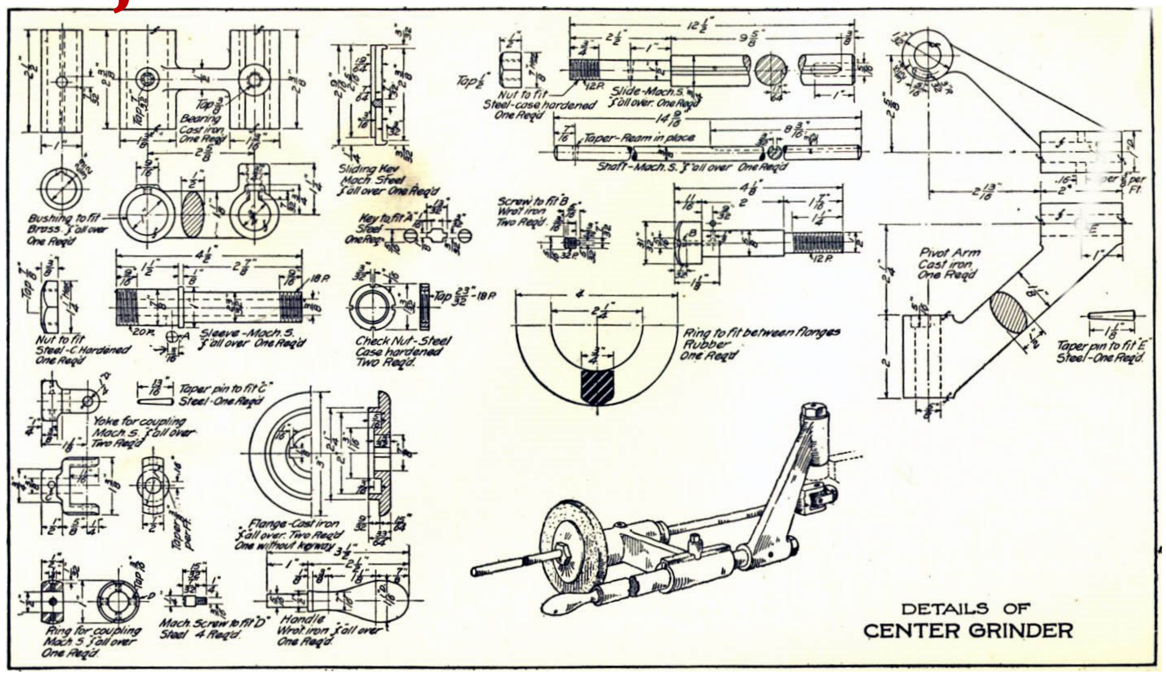
the art or science of drawing a representation of an object on a two-dimensional surface according to mathematical rules of projection

40,000 years of drawing

Subjective



Objective



Graphics: *a language*

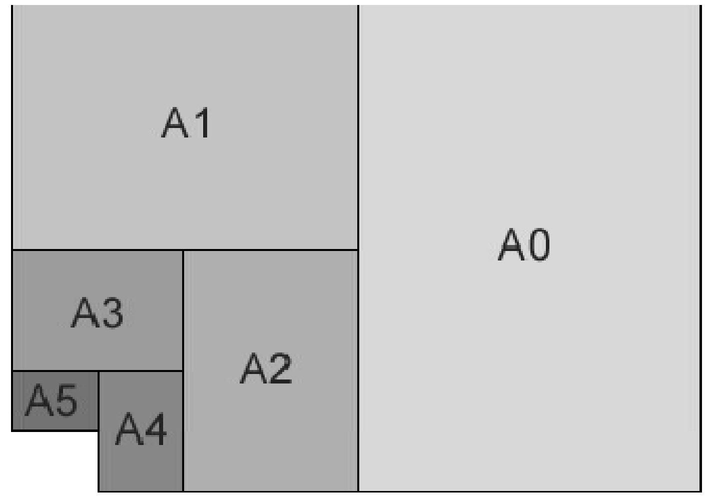
- Language → Grammar
- Rules/Standards of engineering drawing (in India) are set by

Bureau of Indian Standards (B.I.S.)

Drawing Accessories

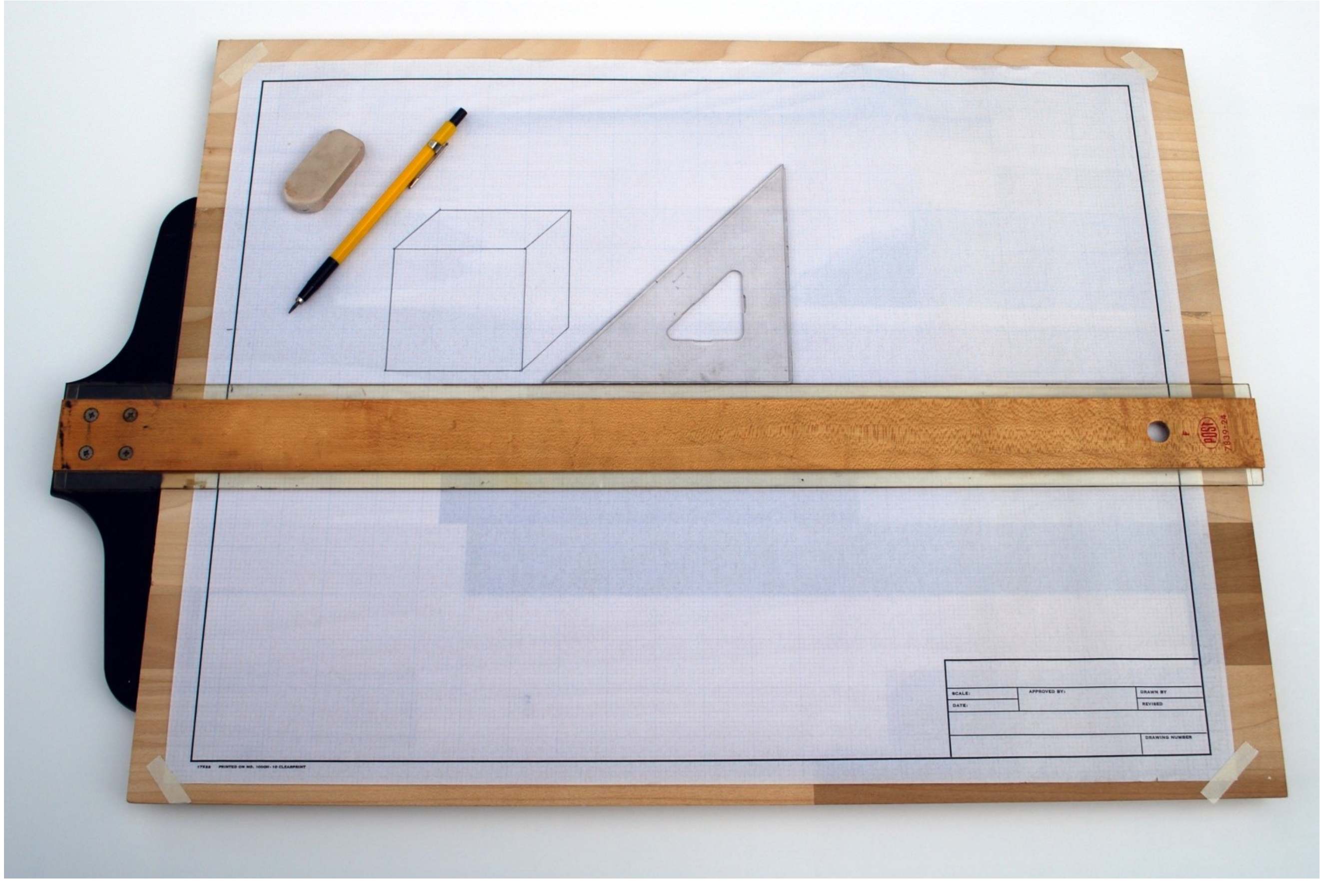
- Drawing Board
- Drawing Sheet
- T-square / Mini-drafter *(Roll and Draw)*
- Set Squares
- Large Compass & Divider
- Protractor *(pro-circle)*
- Mechanical Pencil
- Eraser

Drawing Boards & Drawing Sheets



Sl. No.	Drawing Boards		Drawing Sheets	
	Designation	size	Designation	size
1	D0	1500 x 1000 x 25	A0	841x1189
2	D1	1000 x 700 x 25	A1	594 x 841
3	D2	700 x 500 x 15	A2	420 x 594
4	D3	500 x 350 x 15	A3	297 x 420

T- Square



Mini-Drafter

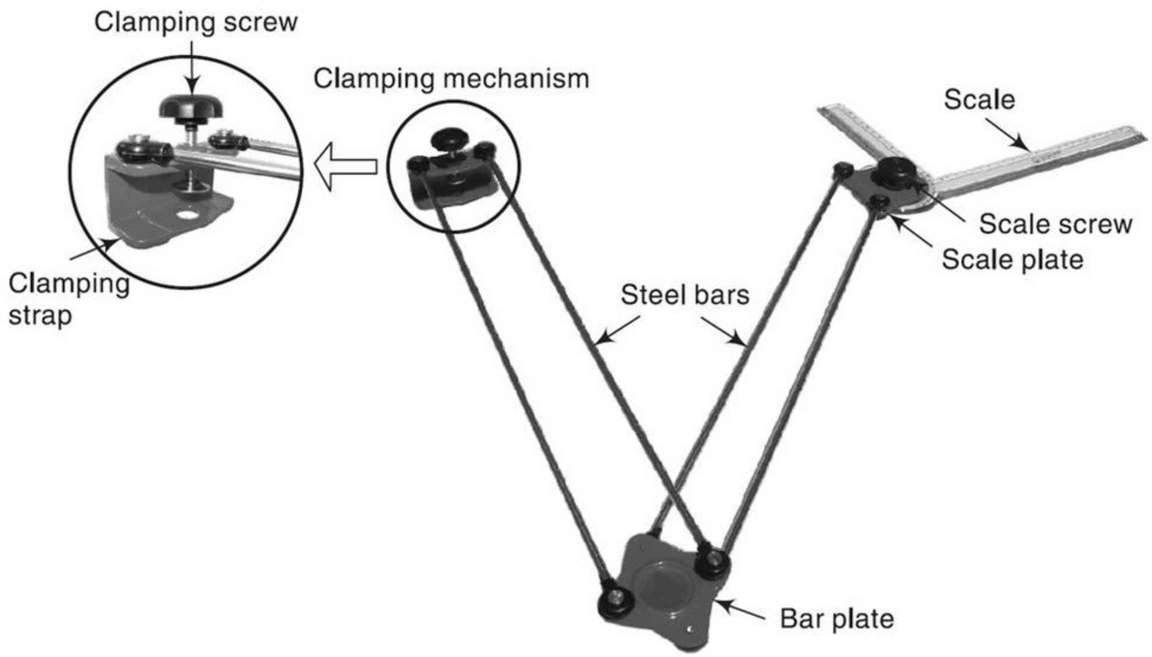
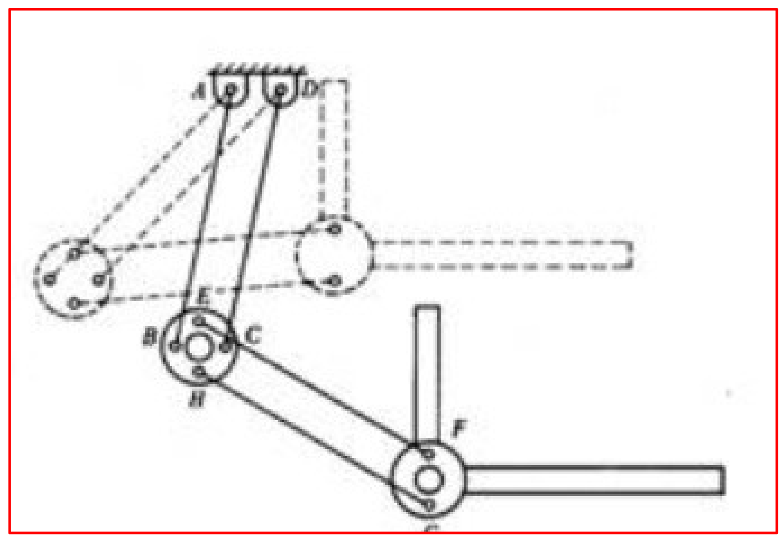


Fig. 1.3 Mini drafter



Drawing Accessories

- Drawing Board
- Drawing Sheet
- T-square / Mini-drafter *(Roll and Draw)*
- Set Squares
- Large Compass & Divider
- Protractor *(pro-circle)*
- Mechanical Pencil
- Eraser

*As this course is practical oriented, the evaluation is different from other lecture based courses.

Points to note:

(1) End semester examination will be for 50 marks and of 2 hour duration.
(2) End semester exam will include all modules except Module IV.
(3) 100 marks are allotted for internal evaluation: first internal exam 40 marks, second internal exam 40 marks and class exercises 20 marks.
(4) The first internal exam will be based on modules I and II and the second internal exam will be a practical exam based on Module IV alone.

Course Objectives

To enable the student to be able to effectively communicate basic designs through graphical representations as per standards.

Syllabus

Introduction to Engineering Graphics; Orthographic projections of lines and solids, Isometric projection, Freehand sketching, Introduction to CAD, Sections of solids, Development of surfaces, Perspective projection.

Expected outcome

Upon successful completion of this course, the student would have accomplished the following abilities and skills:

1. Fundamental Engineering Drawing Standards.
2. Dimensioning and preparation of neat drawings and drawing sheets.
3. Interpretation of engineering drawings
4. The features of CADD software

References Books:

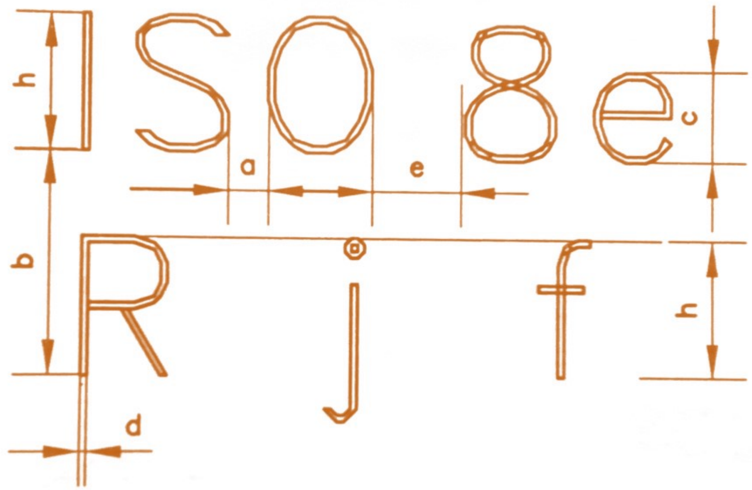
- Agrawal, B. and Agrawal, C. M., Engineering Drawing, Tata McGraw Hill Publishers
- Anilkumar, K. N., Engineering Graphics, Adhyuth Narayan Publishers
- Benjamin, J., Engineering Graphics, Pentex Publishers
- Bhatt, N., D., Engineering Drawing, Charotar Publishing House Pvt Ltd.
- Duff, J. M. and Ross, W. A., Engineering Design and Visualization, Cengage Learning, 2009
- John, K. C., Engineering Graphics, Prentice Hall India Publishers
- Kulkarni, D. M., Rastogi, A. P. and Sarkar, A. K., Engineering Graphics with AutoCAD, PHI 2009
- Luzadder, W. J. and Duff, J. M., Fundamentals of Engineering Drawing, PHI 1993
- Parthasarathy, N. S., and Murali, V., Engineering Drawing, Oxford University Press
- Varghese, P. I., Engineering Graphics, V I P Publishers
- Venugopal, K., Engineering Drawing & Graphics, New Age International Publishers

Types of Lines

Line	Description	General Applications
A	Continuous thick	A1 Visible out lines A2 Visible edges
B	Continuous thin (straight or curved)	B1 Imaginary lines of intersection B2 Dimension lines B3 Projection lines B4 Leader lines B5 Hatching lines B6 Outlines of revolved sections in place B7 Short centre lines
C	Continuous thin freehand **	C1 Limits partial or interrupted views and sections if the limit is not a chain thin
D **	Continuous thin (straight) with zig-zags	D1 line
E	Dashed thick **	E1 Hidden outlines E2 Hidden edges
F	Dashed thin	F1 Hidden outlines F2 Hidden edges
G	Chain thin	G1 Centre lines G2 Lines of symmetry G3 Trajectories
H	Chain thin, thick at ends and changes of direction	H1 Cutting planes
J	Chain thick.	J1 Indication of lines or surfaces to which a special requirement applies
K	Chain thin double- dashed	K1 Outlines of adjacent parts K2 Alternative and extreme positions of movable parts K3 Centroidal lines K4 Initial out lines prior to forming K5 Parts situated in front of the cutting plane

Lettering

1. Legibility
2. Uniformity
3. Rapidity of Execution
4. Suitability for Reproduction



Lettering A (d=h/14)

Characteristic		Ratio
Lettering height (height of capitals)	*h*	(14/14) *h*
Height of lower- case letters (without stem or tail)	*c*	(10/14) *h*
Spacing between characters	*a*	(2/14)*h*
Minimum spacing of base lines	*b*	(20/14)*h*
Minimum spacing between words	*e*	(6/14)*h*
Thickness of lines	*d*	(1/14)*h*

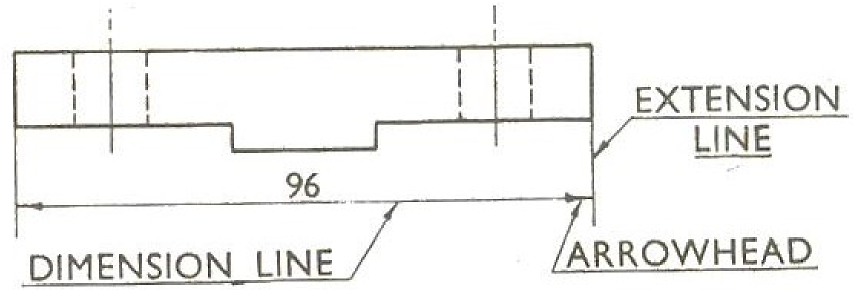
Lettering B (d=h/10)

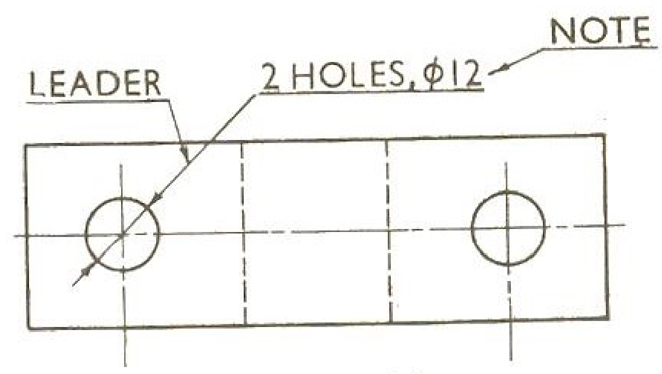
Characteristic		Ratio
Lettering height (height of capitals)	*h*	(10/10) *h*
Height of lower- case letters (without stem or tail)	*c*	(7/10) *h*
Spacing between characters	*a*	(2/10)*h*
Minimum spacing of base lines	*b*	(14/10)*h*
Minimum spacing between words	*e*	(6/10)*h*
Thickness of lines	*d*	(1/10)*h*

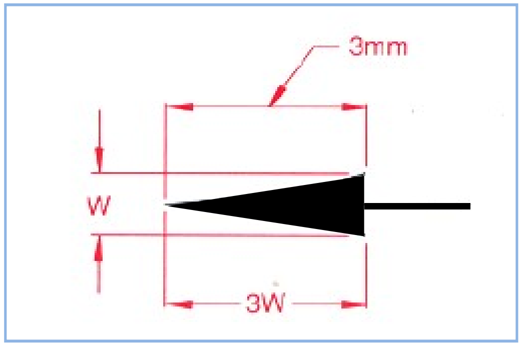
Characteristic		Ratio	mm
Lettering height (height of capitals)	*h*	(10/10) *h*	5
Height of lower- case letters (without stem or tail)	*c*	(7/10) *h*	3.5
Spacing between characters	*a*	(2/10)*h*	1
Minimum spacing of base lines	*b*	(14/10)*h*	7.00
Minimum spacing between words	*e*	(6/10)*h*	3
Thickness of lines	*d*	(1/10)*h*	0.5

DIMENSIONING

- Projection Line (Extension Line)
- Dimension Line
- Leader Line
- Dimension Line Termination (Arrow Head)
- Origin Indication
- Dimension







- Chain, Parallel, Superimposed Dimensioning
- Dimension by Coordinates

- Methods
  - Aligned
  - Unidirectional

- Shape indication

  Φ – Diameter

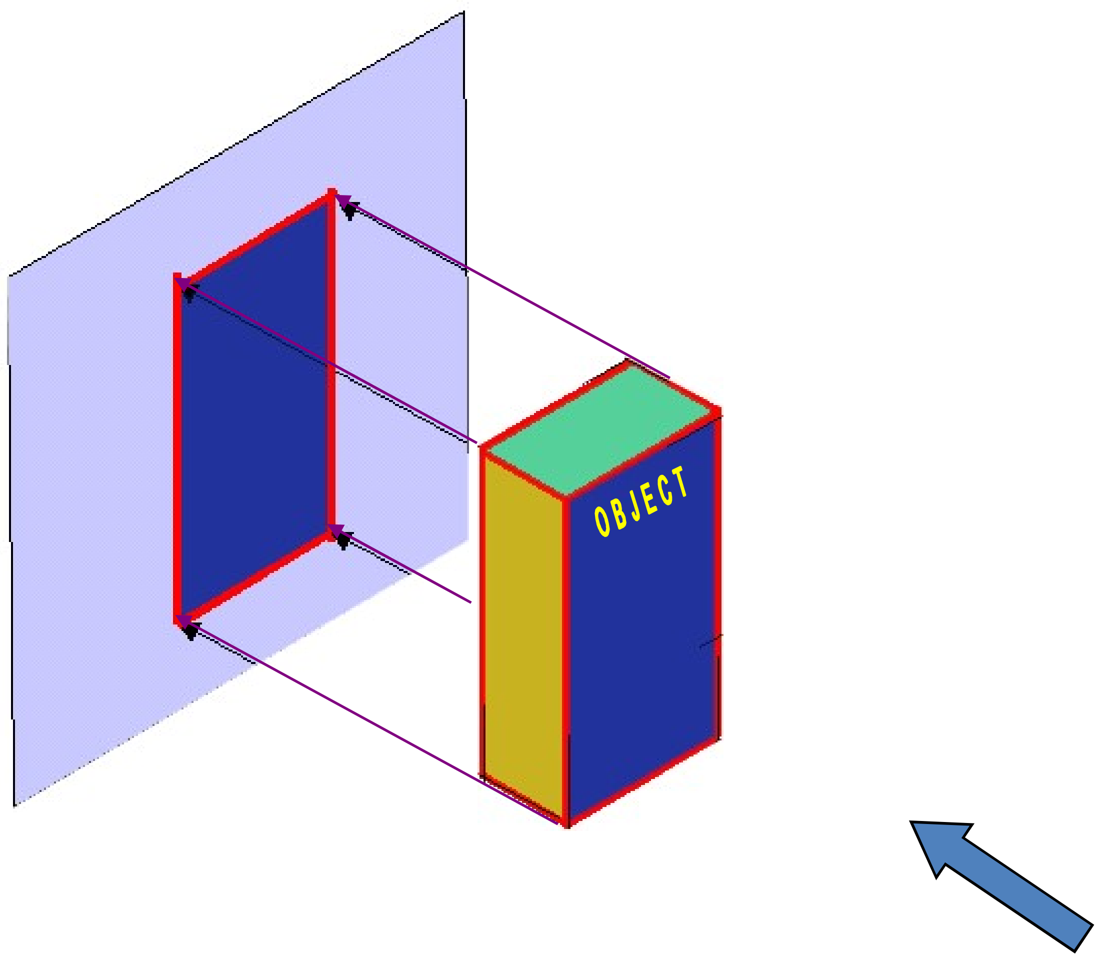
  R – Radius

  □ – Square

  SΦ – Spherical Diameter

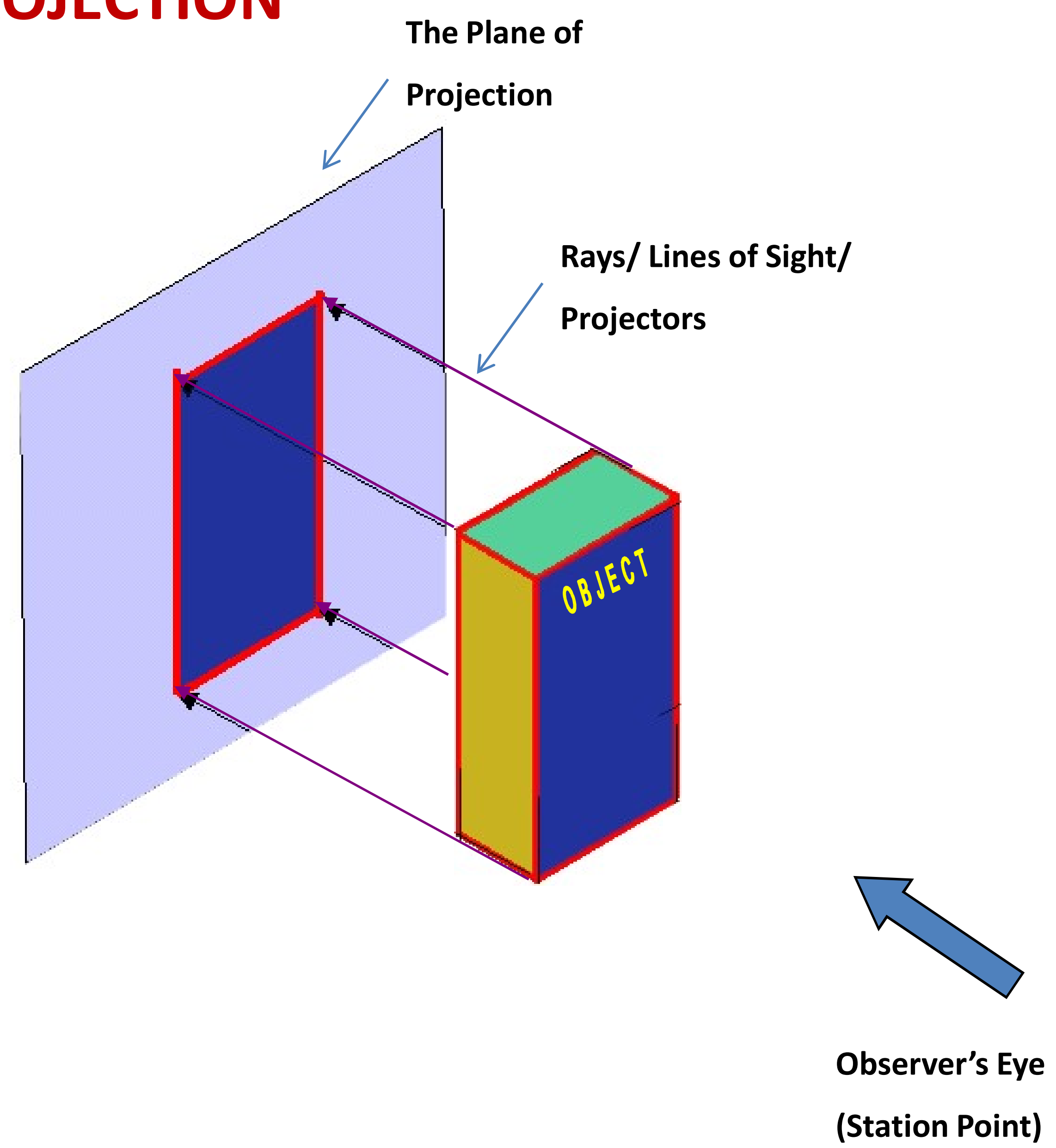
  SR – Spherical Radius

PROJECTION

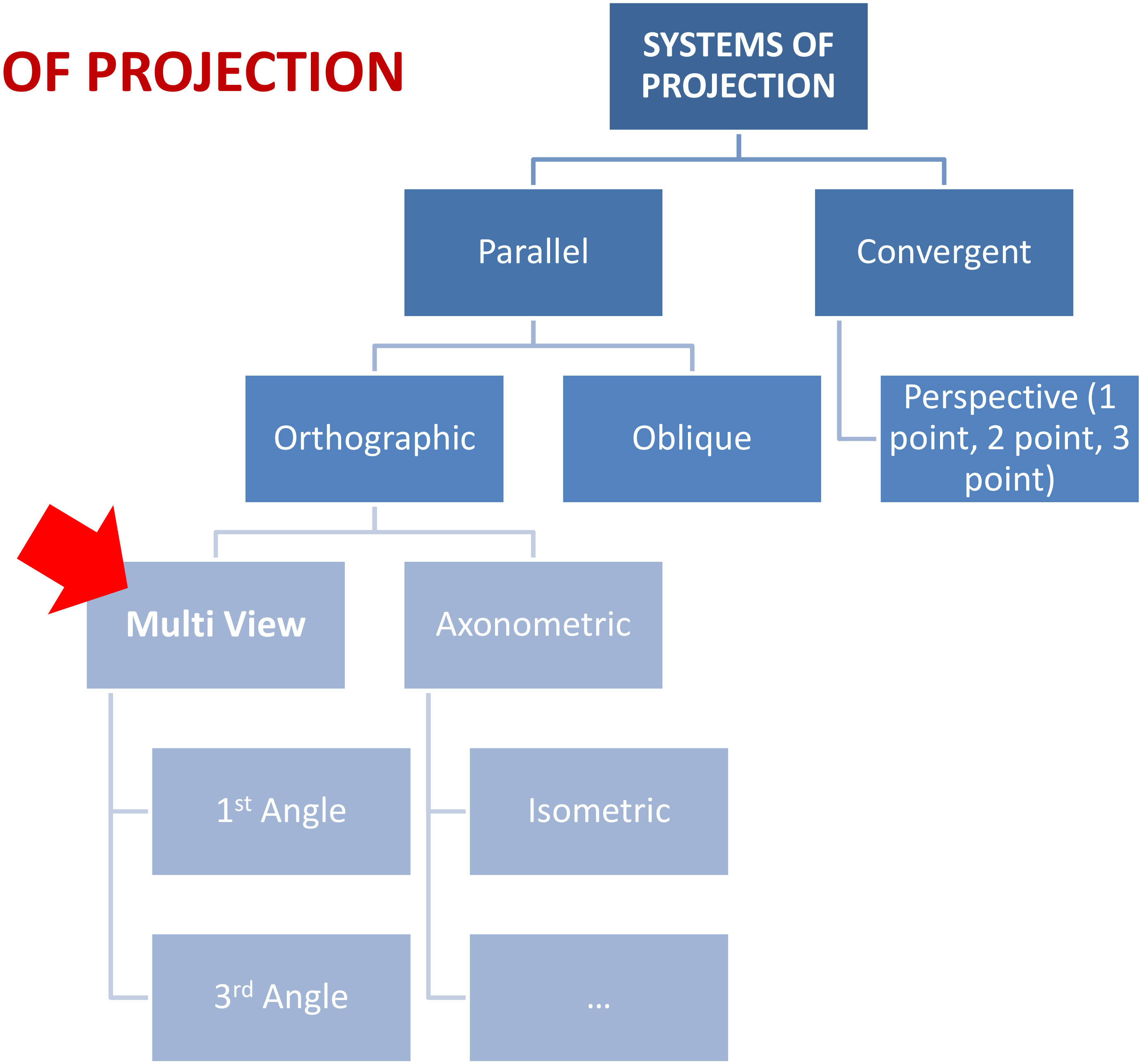


COMPONENTS OF PROJECTION

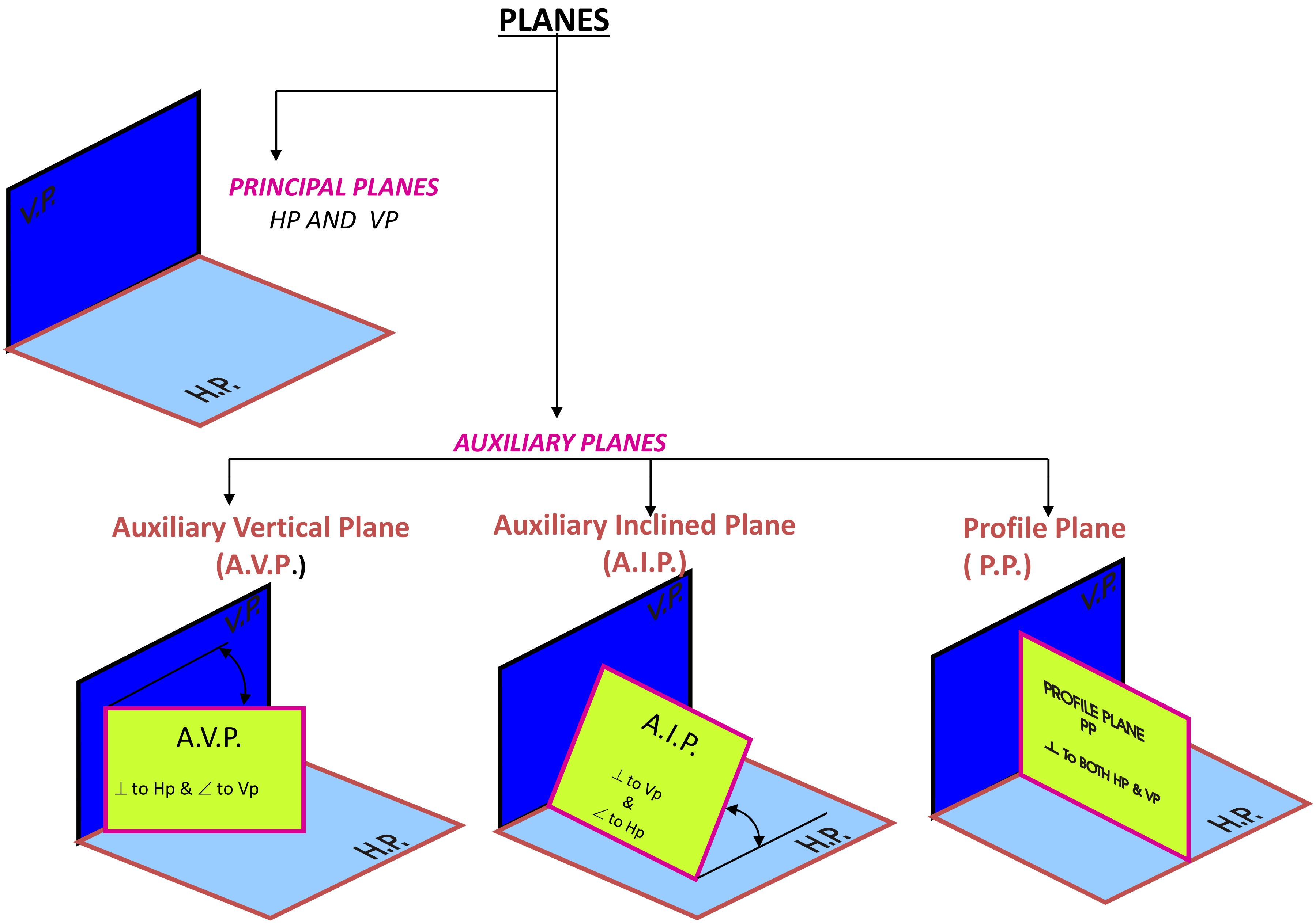
- Object to be Projected
- Observer's Eye (Station Point)
- The Plane of Projection
- Rays/ Lines of Sight/ Projectors

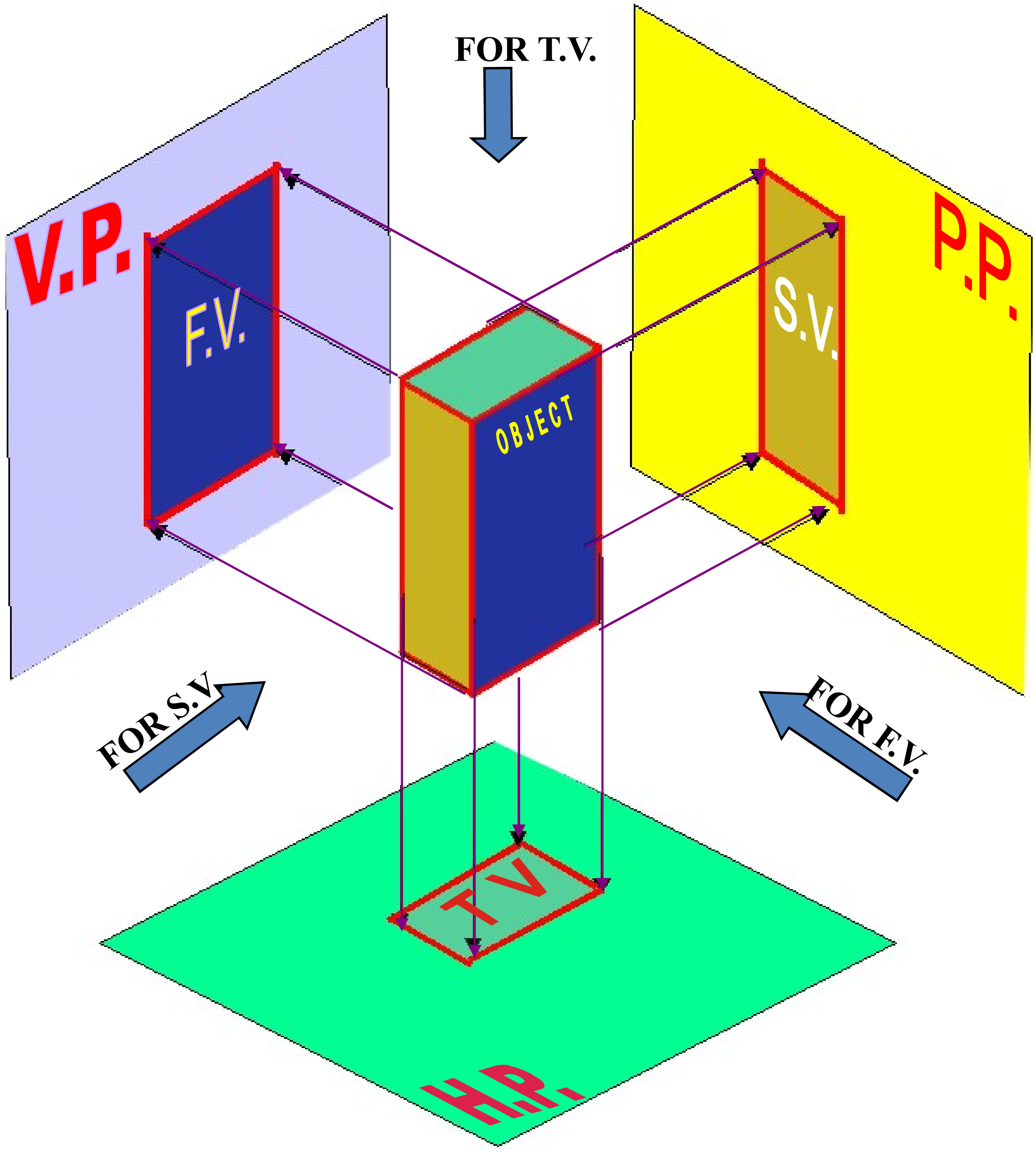


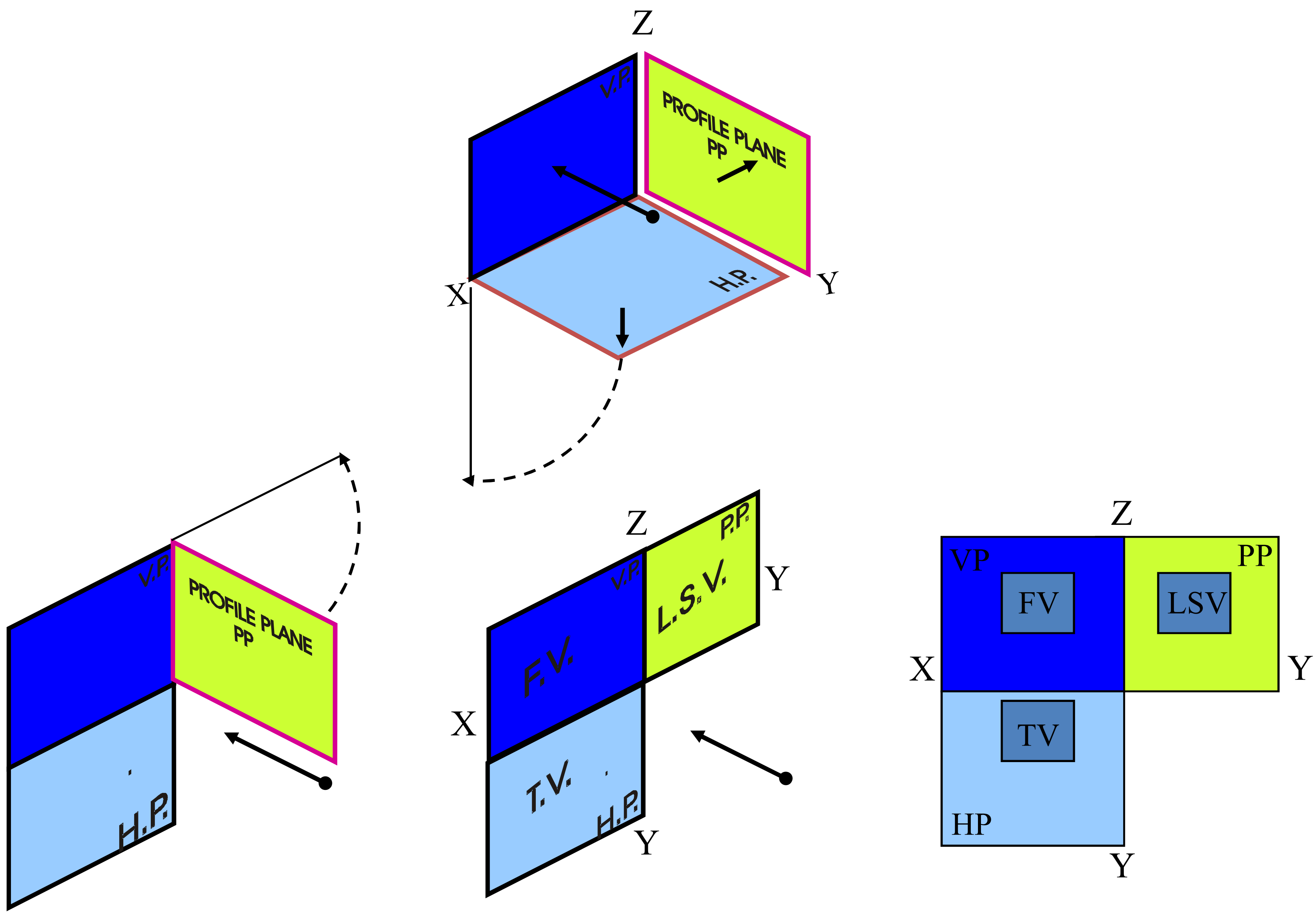
SYSTEMS OF PROJECTION



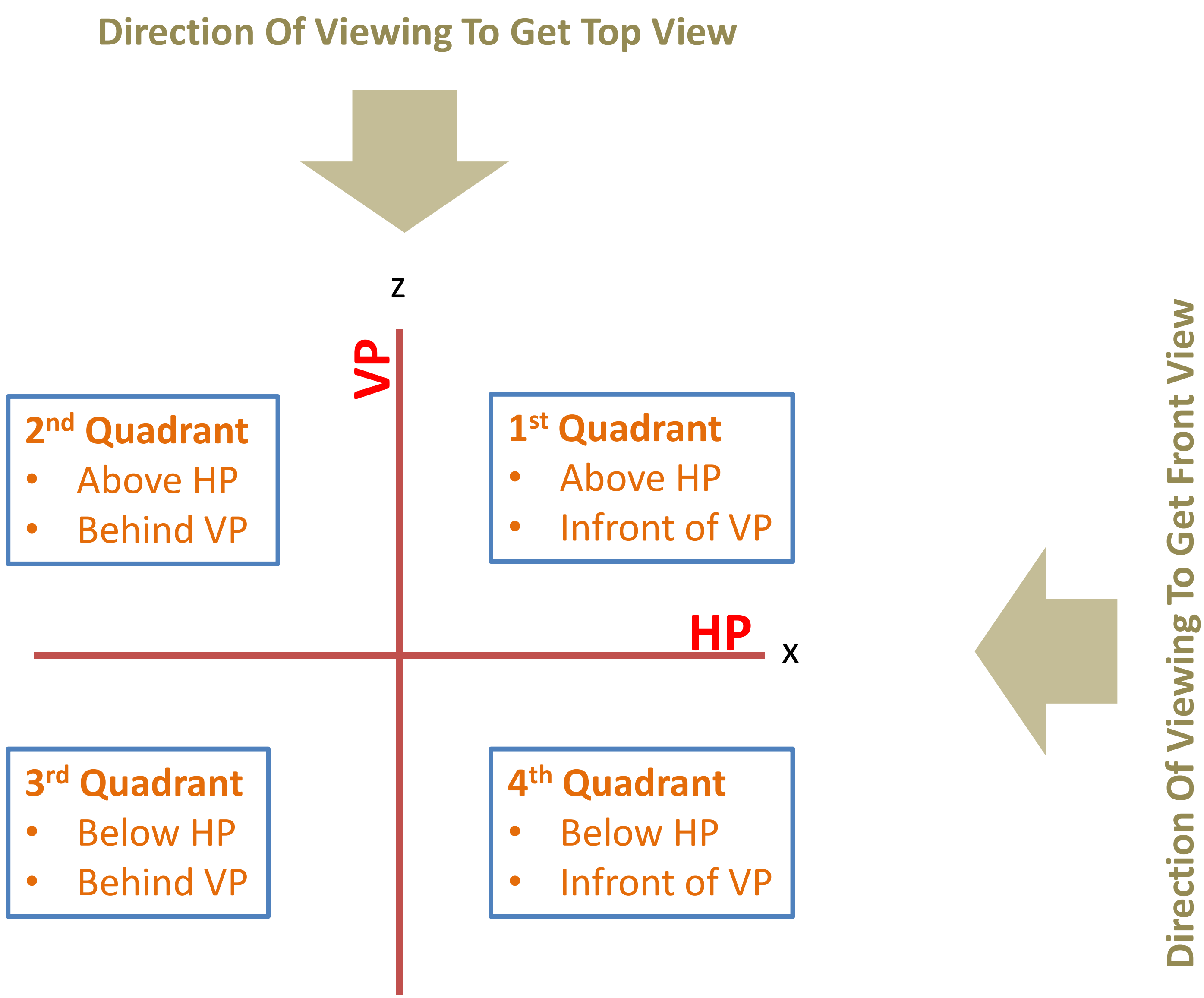
ORTHOGRAPHIC (MULTI VIEW)PROJECTION

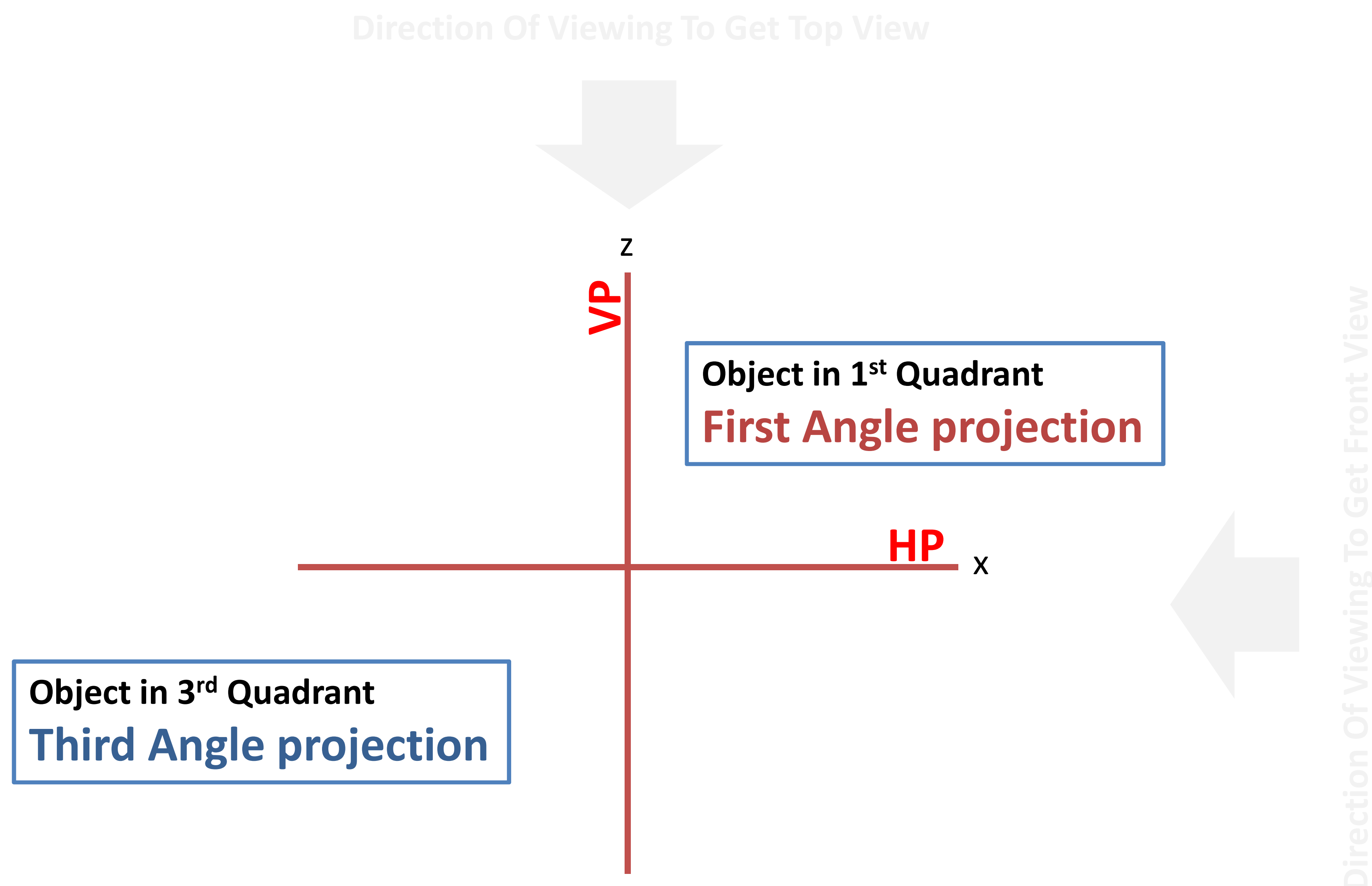

PLANES
PRINCIPAL PLANES
HP AND VP
V.P.
H.P.
AUXILIARY PLANES
Auxiliary Vertical Plane
(A.V.P.)
Auxiliary Inclined Plane
(A.I.P.)
Profile Plane
(P.P.)
V.P.
A.V.P.
⊥ to Hp & ∠ to Vp
H.P.
V.P.
A.I.P.
⊥ to Vp
&
∠ to Hp
H.P.
V.P.
PROFILE PLANE
PP
⊥ To BOTH HP & VP
H.P.


FOR T.V.
V.P.
F.V.
OBJECT
S.V.
P.P.
FOR S.V
FOR F.V.
TV
H.P.

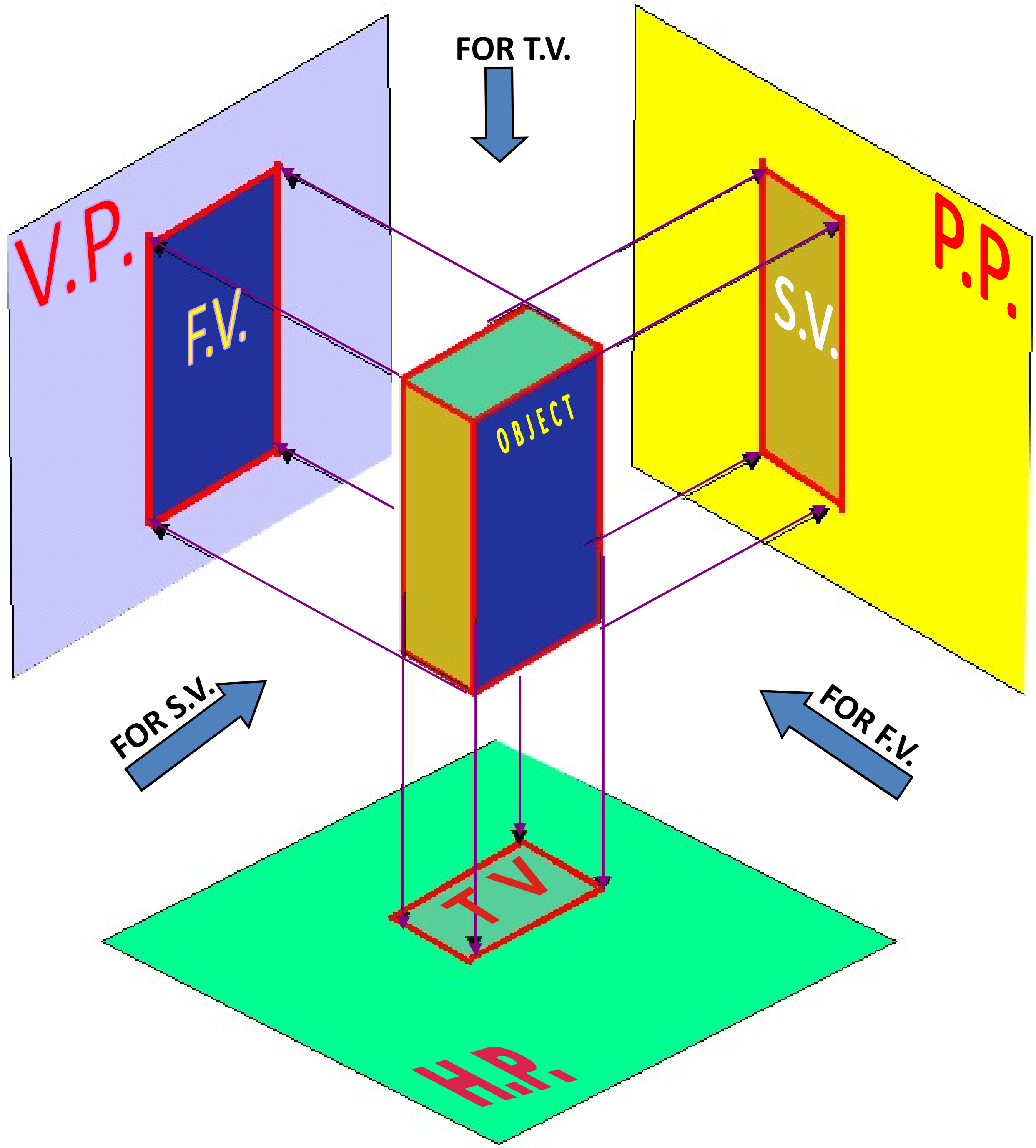


Z
V.P.
PROFILE PLANE
PP
X
H.P.
Y
V.P.
PROFILE PLANE
PP
H.P.
Z
P.P.
V.P.
L.S.V.
Y
F.V.
X
T.V.
H.P.
Y
Z
VP
FV
PP
LSV
X
Y
TV
HP
Y

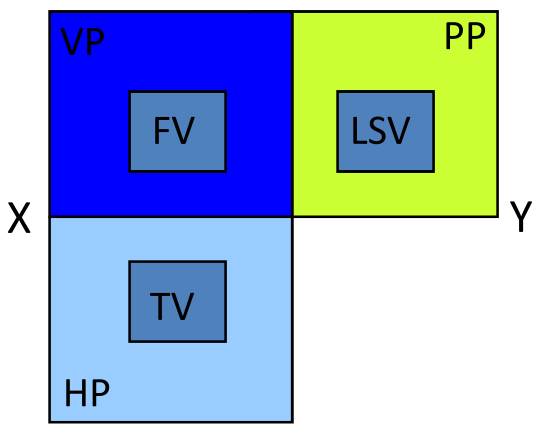

Direction Of Viewing To Get Top View
Z
VP
2nd Quadrant
Above HP
Behind VP
1st Quadrant
Above HP
Infront of VP
HP
X
3rd Quadrant
Below HP
Behind VP
4th Quadrant
Below HP
Infront of VP
Direction Of Viewing To Get Front View


Direction Of Viewing To Get Top View
Z
VP
Object in 1st Quadrant
First Angle projection
HP
X
Direction Of Viewing To Get Front View
Object in 3rd Quadrant
Third Angle projection

FIRST ANGLE PROJECTION

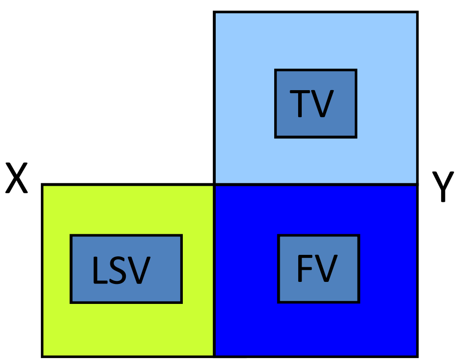


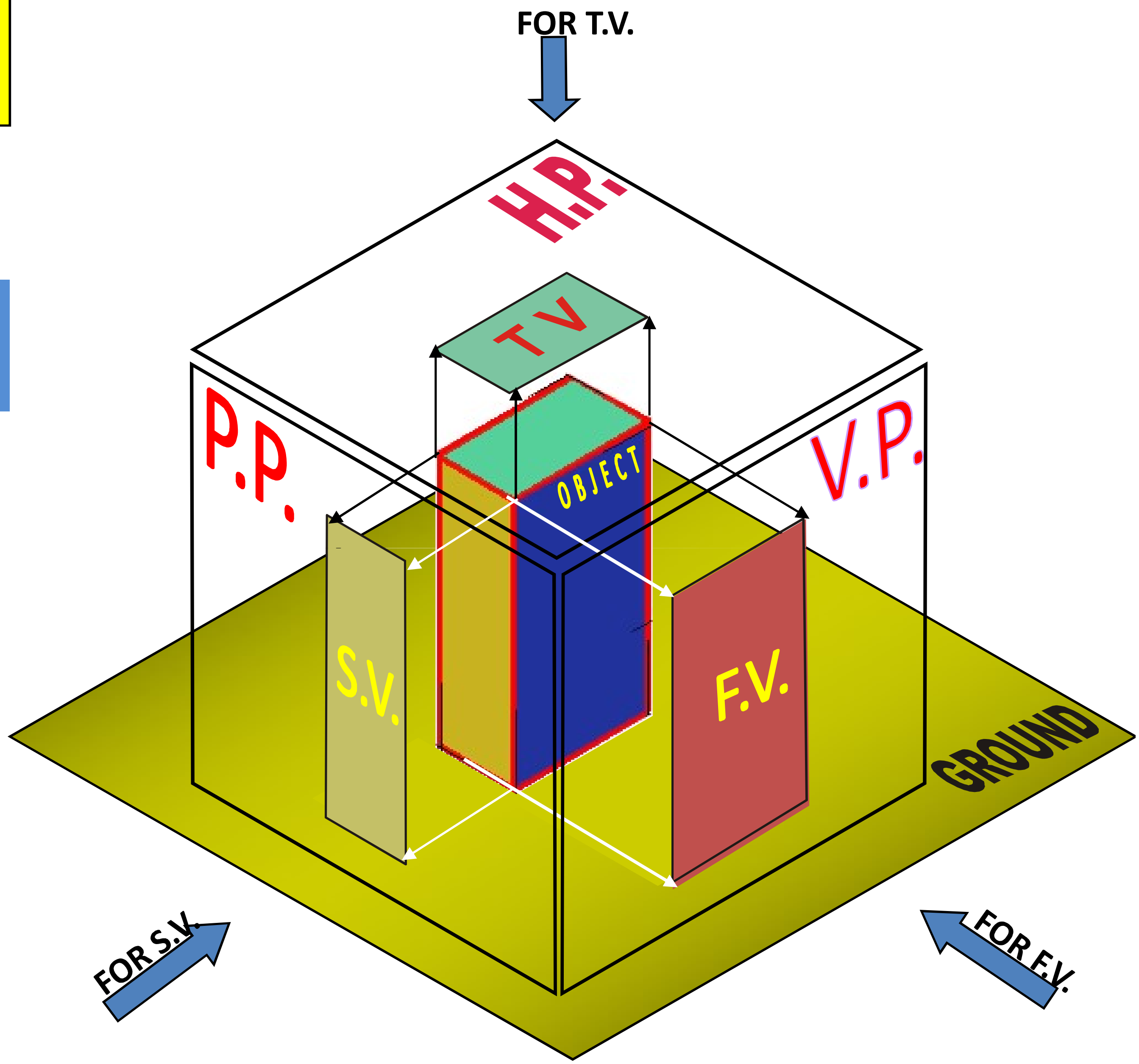
OBJECT IS INBETWEEN OBSERVER & PLANE.

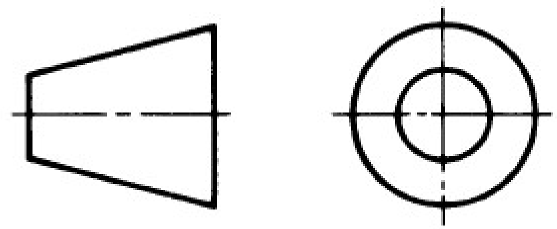
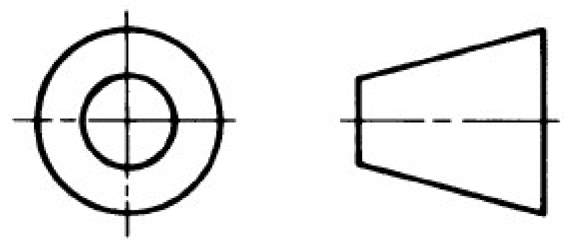


THIRD ANGLE PROJECTION

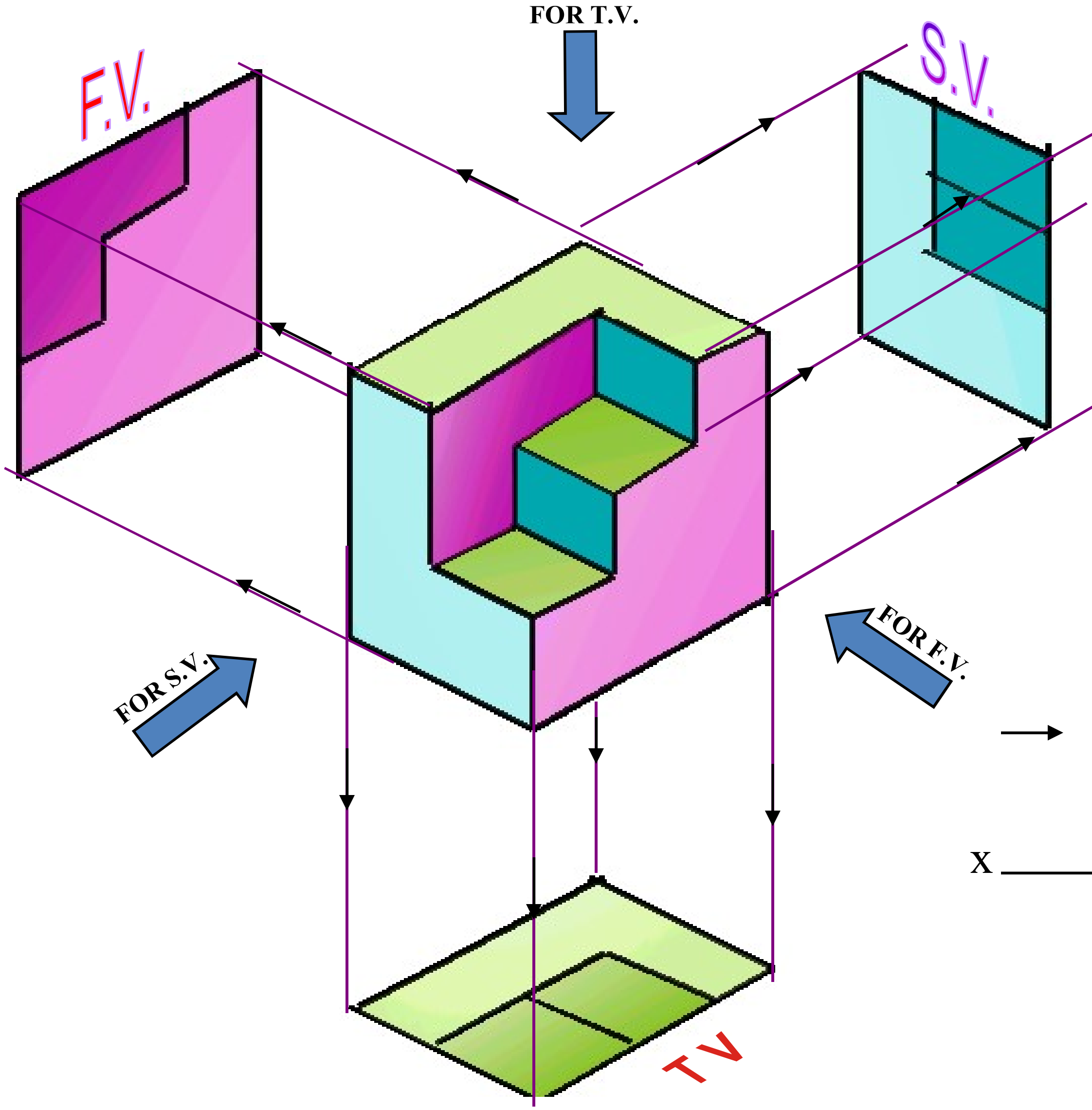
PLANES BEING TRANSPERENT
AND INBETWEEN
OBSERVER & OBJECT.

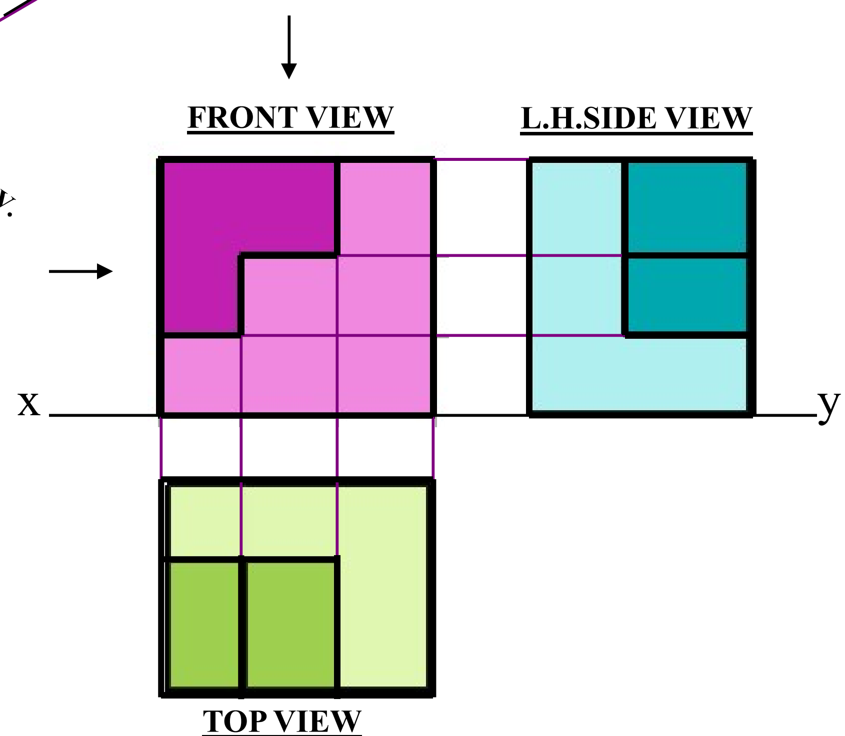




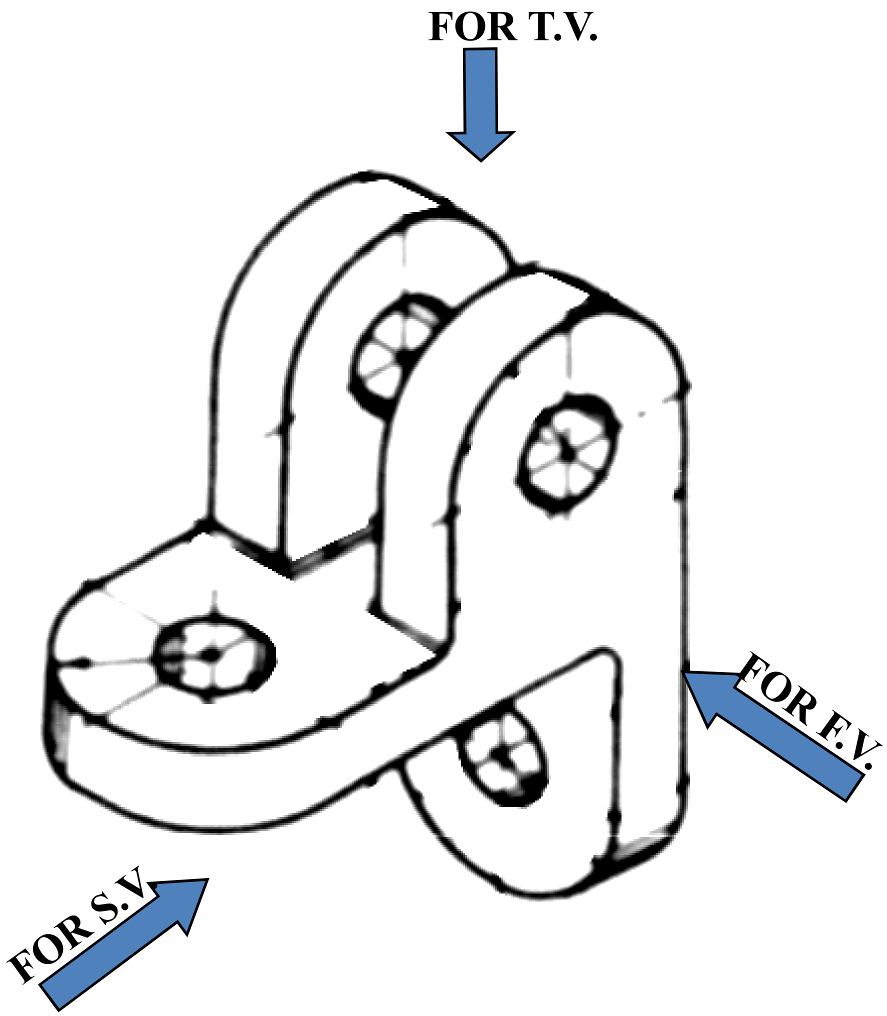
Projection	Symbol
First angle	
Third angle	

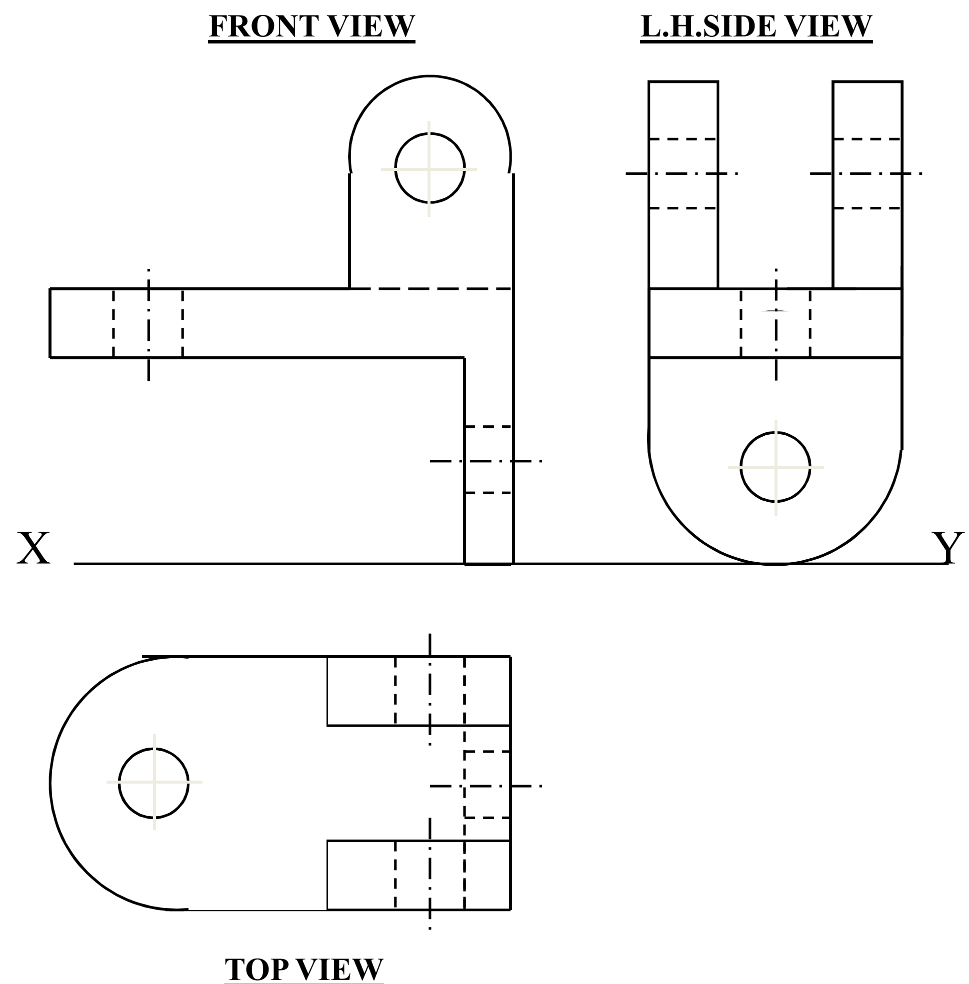
ORTHOGRAPHIC (FIRST ANGLE) PROJECTIONS





ORTHOGRAPHIC (FIRST ANGLE) PROJECTIONS

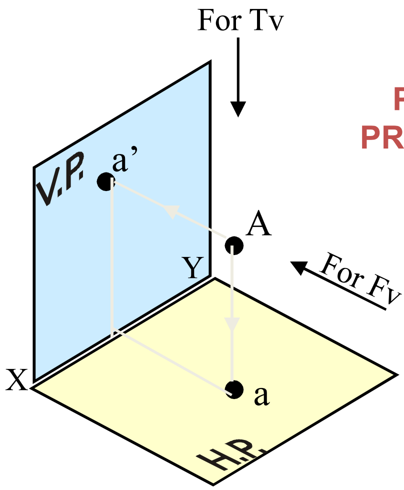




PROJECTION OF POINTS

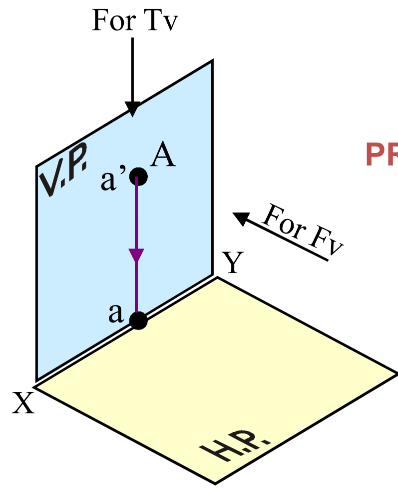
PROJECTIONS OF A POINT IN FIRST QUADRANT.

POINT A ABOVE HP & INFRONT OF VP



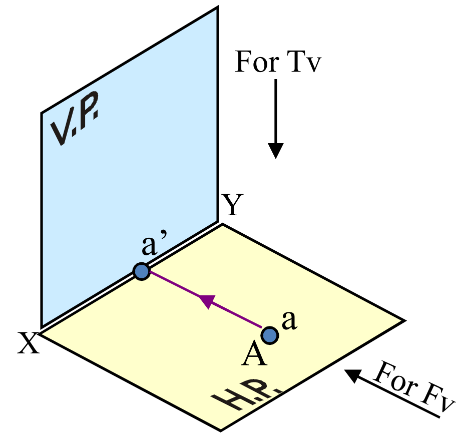
PICTORIAL PRESENTATION

POINT A ABOVE HP & IN VP



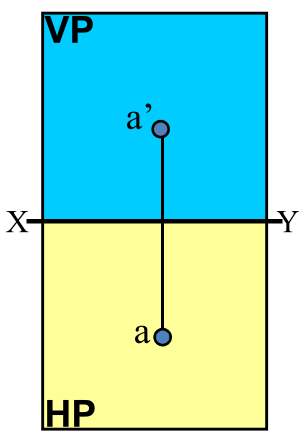
PICTORIAL PRESENTATION

POINT A IN HP & INFRONT OF VP

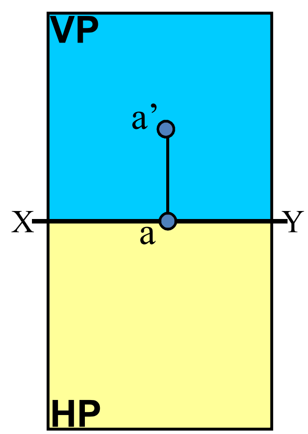


ORTHOGRAPHIC PRESENTATIONS OF ALL ABOVE CASES.

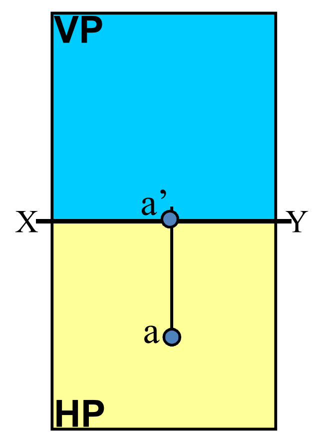
Fv above xy, Tv below xy.



Fv above xy, Tv on xy.



Fv on xy, Tv below xy.

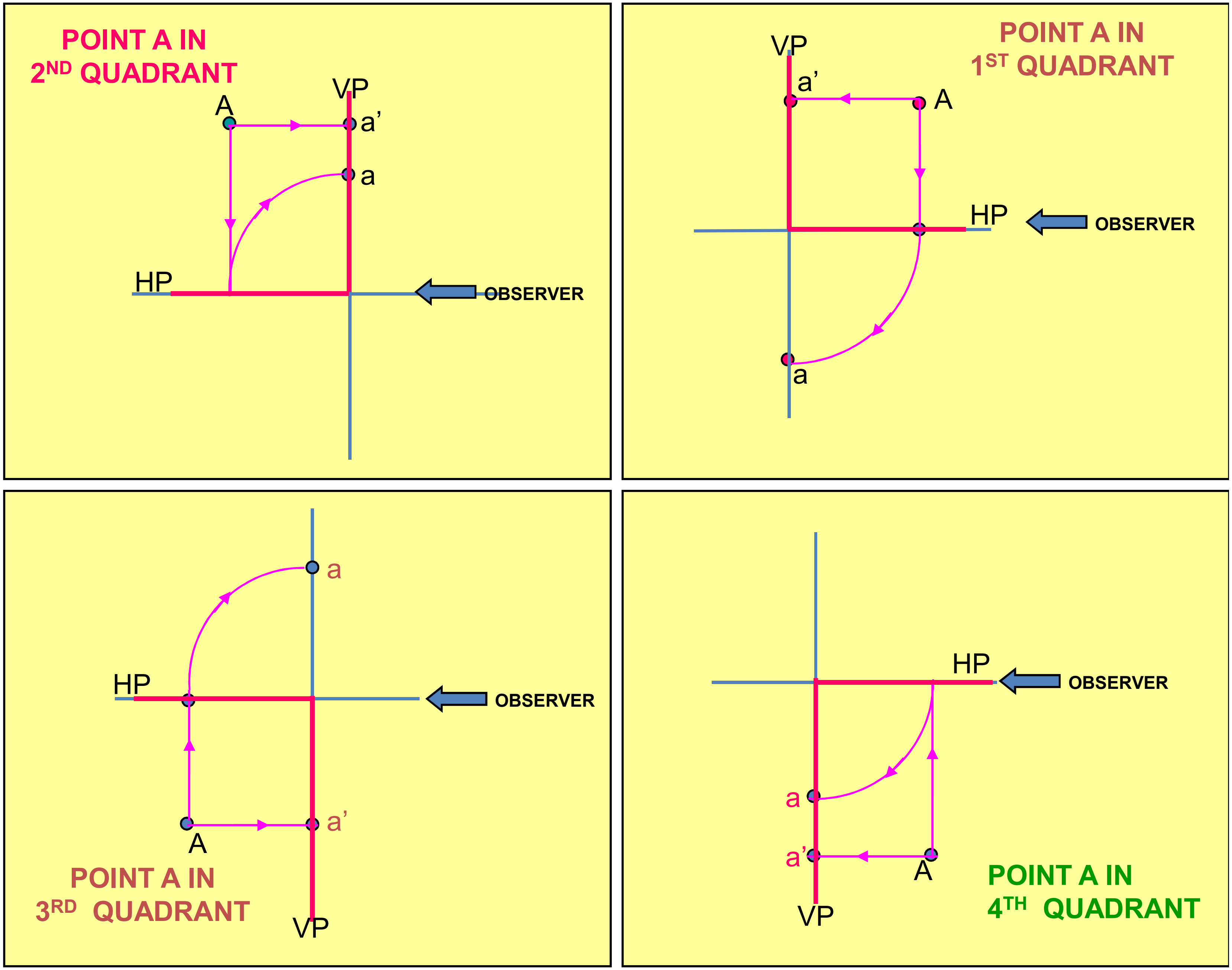


PLEASE NOTE:
This is not an orthographic view. Just a representation of the method of projection as viewed from the left side.

Point A is Placed In different quadrants and it's FV & TV are brought in same plane.

FV is visible as it is a view on VP. But as TV is a view on HP, it is rotated downward 90^0, In clockwise direction.

The In front part of HP comes below xy line and the part behind VP comes above.



PROJECTIONS OF STRAIGHT LINES

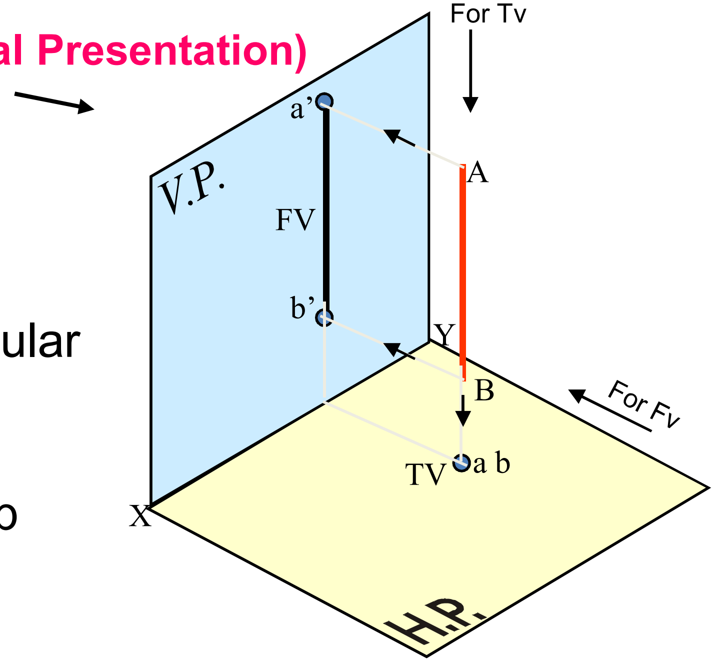
SIMPLE CASES OF THE LINE

1. A VERTICAL LINE (LINE PERPENDICULAR TO HP & // TO VP)
2. LINE PARALLEL TO BOTH HP & VP.
3. LINE INCLINED TO HP & PARALLEL TO VP.
4. LINE INCLINED TO VP & PARALLEL TO HP.
5. LINE INCLINED TO BOTH HP & VP.

1.

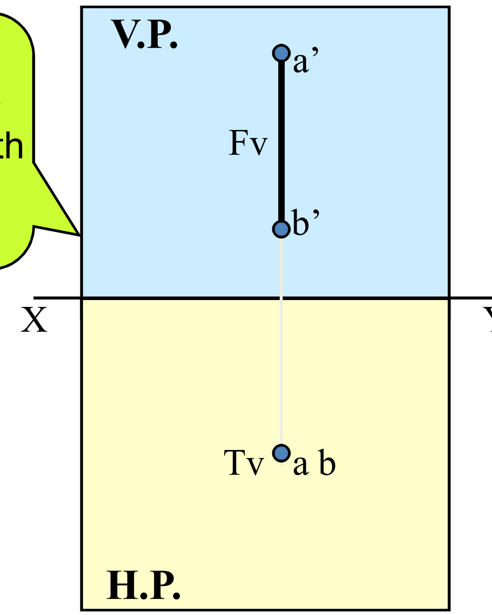
A Line
perpendicular
to Hp
&
// to Vp

(Pictorial Presentation)



Note:
Fv is a vertical line
Showing True Length
&
Tv is a point.

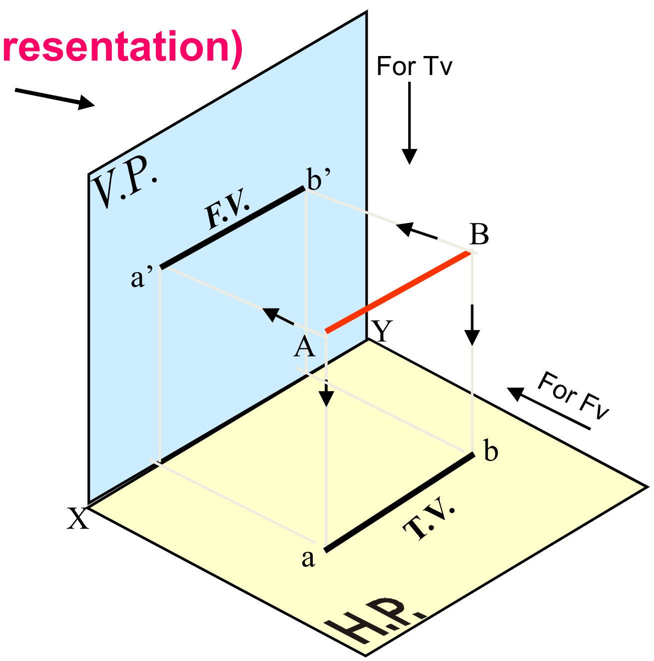
Orthographic Pattern



2.

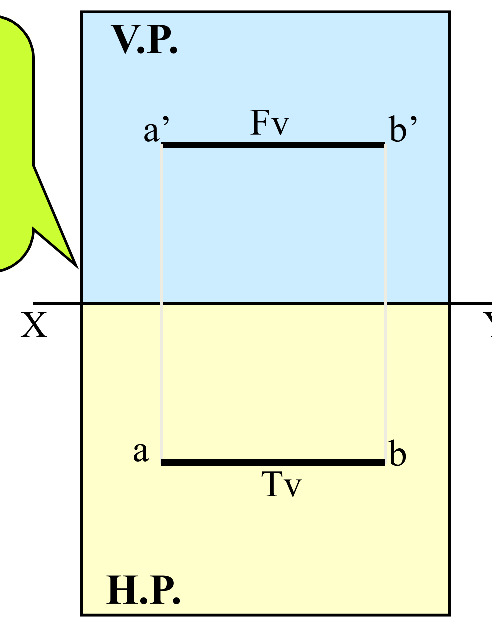
A Line
// to Hp
&
// to Vp

(Pictorial Presentation)



Note:
Fv & Tv both are
// to xy
&
both show T. L.

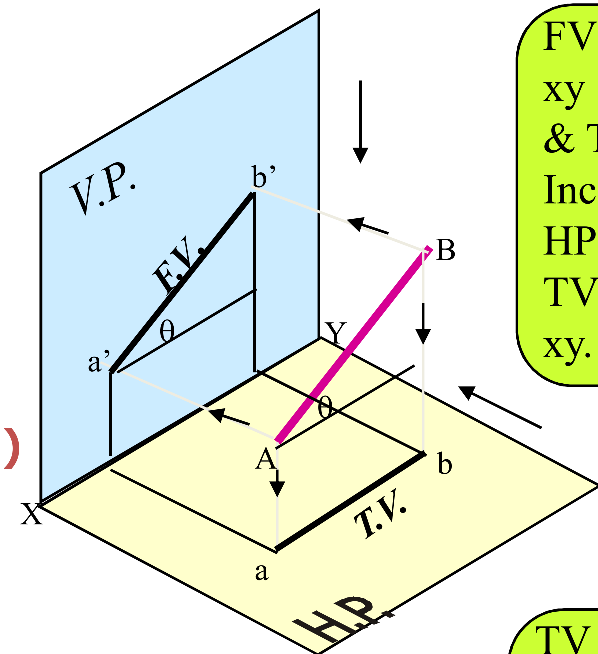
Orthographic Pattern



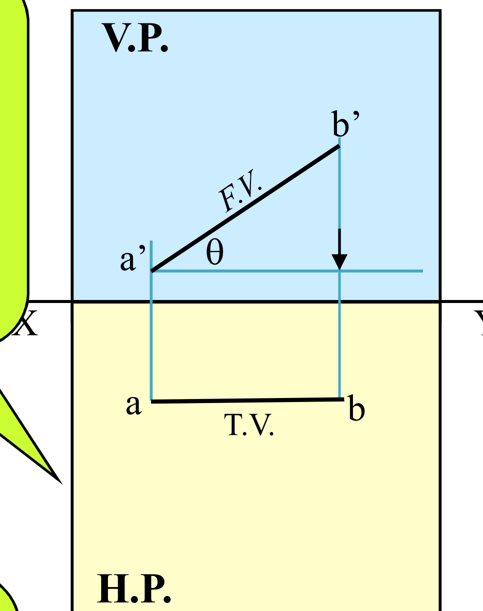
3.

A Line inclined to Hp
and
parallel to Vp

(Pictorial presentation)



FV inclined to xy showing TL & True Inclination with HP (θ).
TV parallel to xy.

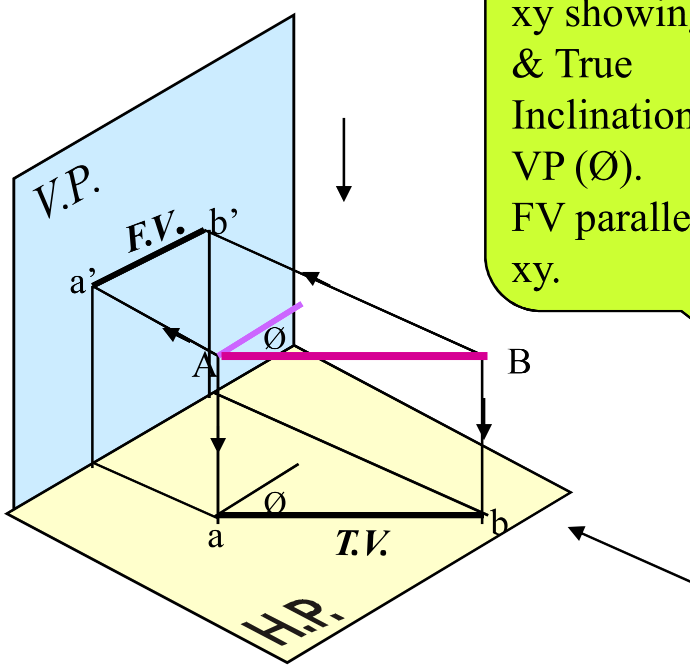


Orthographic Projections

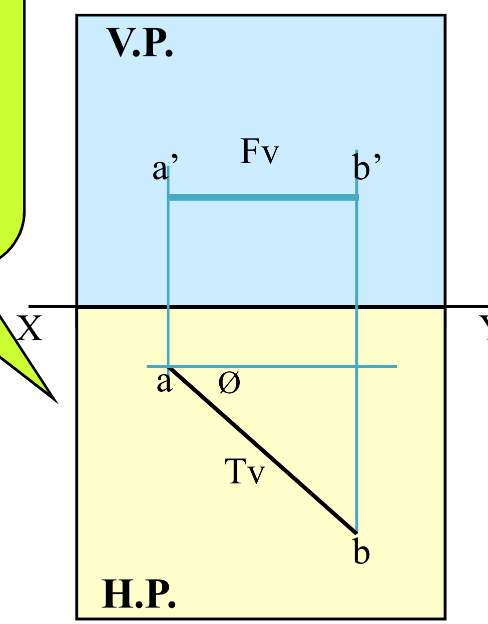
4.

A Line inclined to Vp
and
parallel to Hp

(Pictorial presentation)

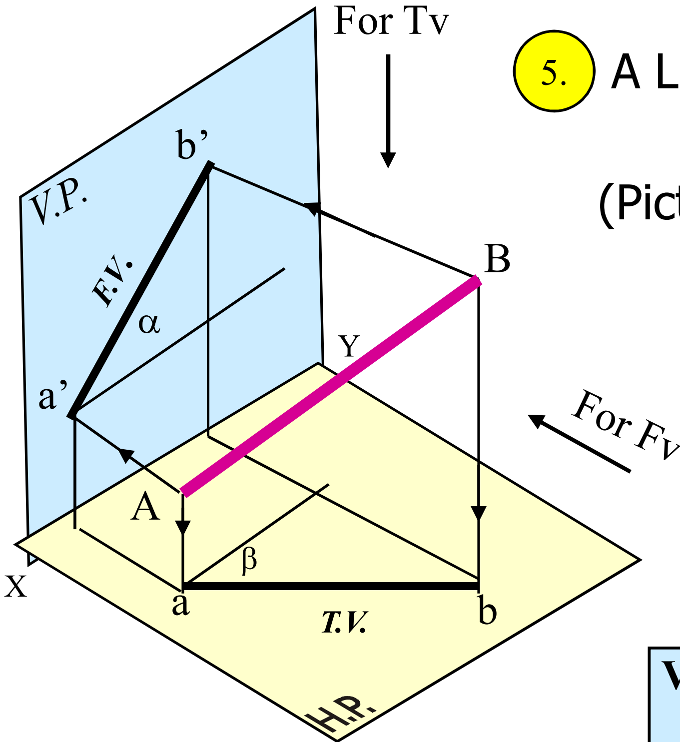


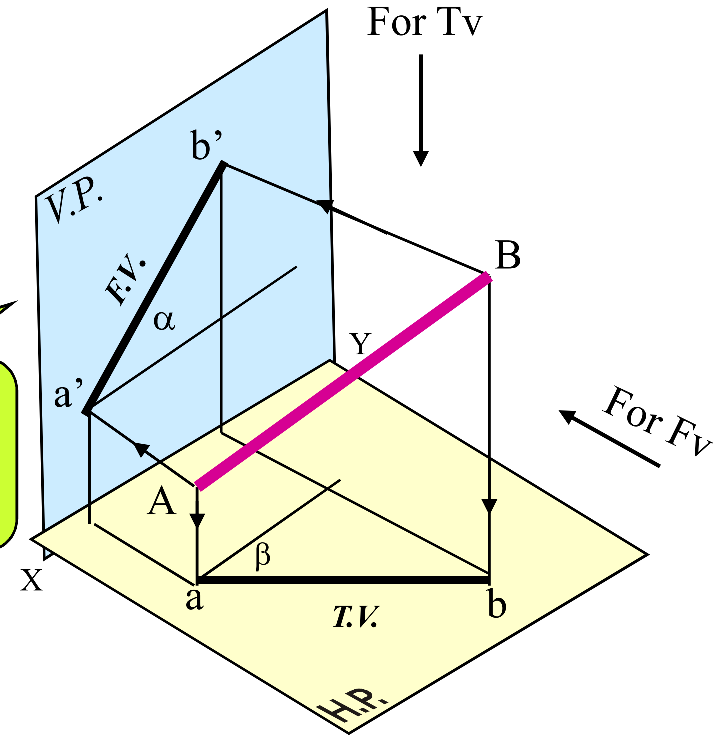
TV inclined to xy showing TL & True Inclination with VP (Ø).
FV parallel to xy.



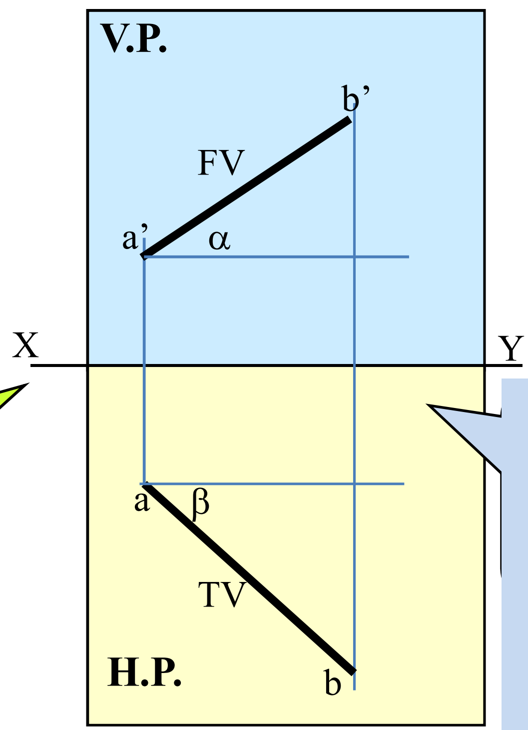
5. A Line inclined to both HP AND VP

(Pictorial presentation)





On removal of object i.e. Line AB
FV as an image on VP.
TV as an image on HP,

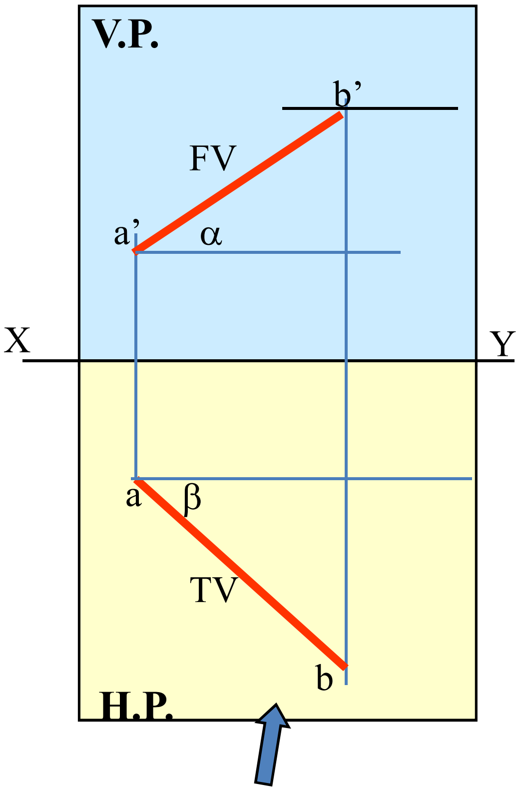


Orthographic Projections
FV is seen on VP
To see TV, HP is rotated 90^0 downwards,
Hence it comes below xy.

Note These Facts:-

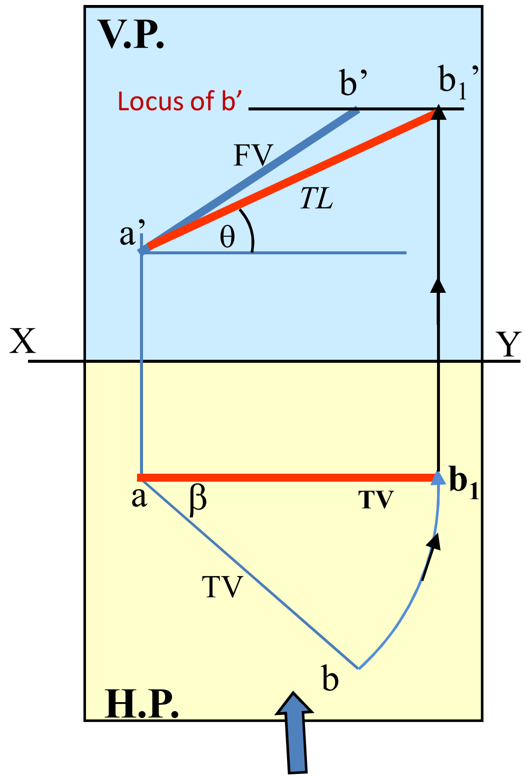
Both FV & TV are inclined to xy.
(No view is parallel to xy)
Both FV & TV are reduced lengths.
(No view shows True Length)
Both FV & TV inclined at greater angles.
(No view shows True Inclination)

Orthographic Projections
FV & TV of Line AB
are shown below,
with their apparent Inclinations
α & β



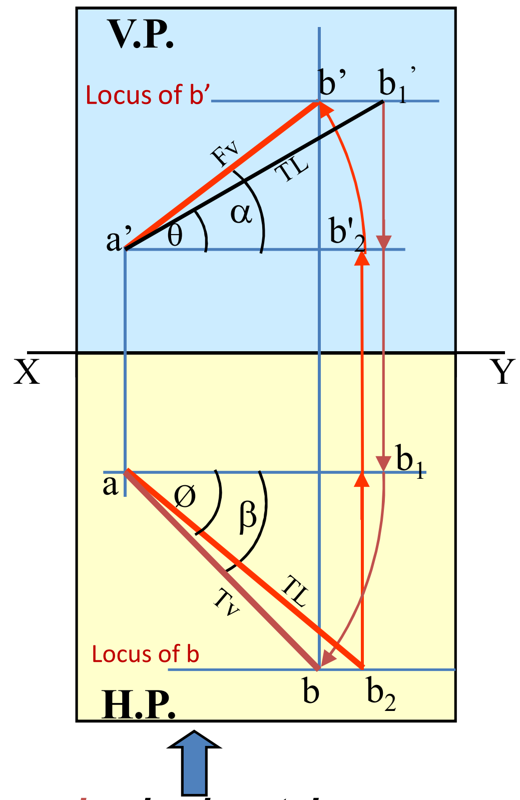
Here TV (ab) is not // to XY line
Hence it's corresponding FV
a' b' is not showing
True Length &
True Inclination with HP

Note the procedure
When FV & TV known,
How to find True Length.
(Views are rotated to determine
True Length & it's inclinations
with HP & VP).



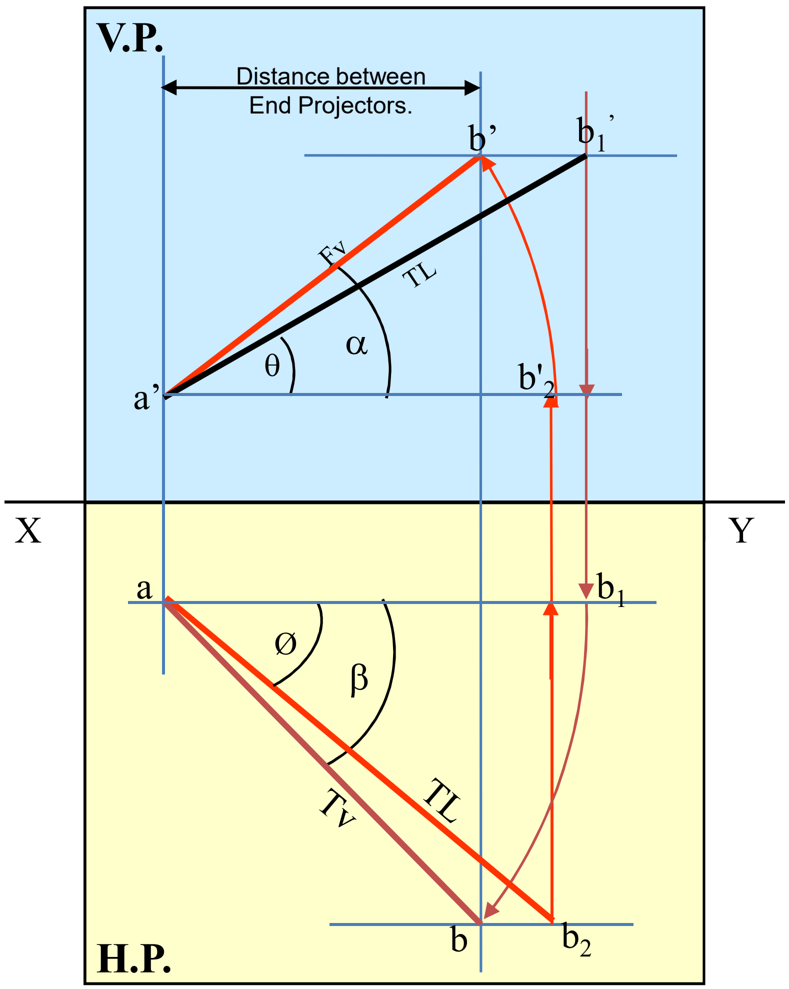
In this sketch, TV is rotated
and made // to XY line.
Hence it's corresponding
FV (a' b_1') is showing
True Length &
True Inclination with HP.

Note the procedure
When TL is known, How to locate FV & TV.
TL & True Inclination and their horizontal
components are drawn. Loci drawn. Then
horizontal components are rotated to the loci
to determine FV & TV)



Here ab_1 , horizontal component
of TL a'b' $_1$ gives length of TV.
Hence it is rotated
to get point b at the locus of b. ab will
be TV. Similarly a'b' also is obtained
which is FV.

The most important diagram showing graphical relations among all important parameters of this topic.
Study and memorize



1) True Length (TL) – a' b_1' & a b_2
2) Angle of TL with HP - θ
3) Angle of TL with VP – Ø
4) Angle of FV with xy – α
5) Angle of TV with xy – β
6) LTV (length of TV, a-b) = Component **(a-b_1)**
7) LFV (length of FV, a'-b') = Component **(a'-b'$_2$)**
8) Position of A- **Distances of a & a' from xy**
9) Position of B- **Distances of b & b' from xy**
10) Distance between End Projectors

Important TEN parameters to be remembered with Notations used here onward

NOTE this

θ & α Construct with ***a'***

Ø & β Construct with ***a***

b' & b_1' on same locus.

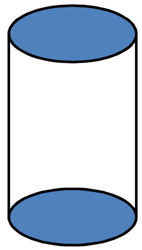
b & b_1 on same locus.

Also Remember

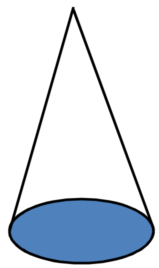
True Length is never rotated. It's horizontal component is drawn & it is further rotated to locate view.

Views are always rotated, made horizontal & further extended to locate TL, θ & Ø

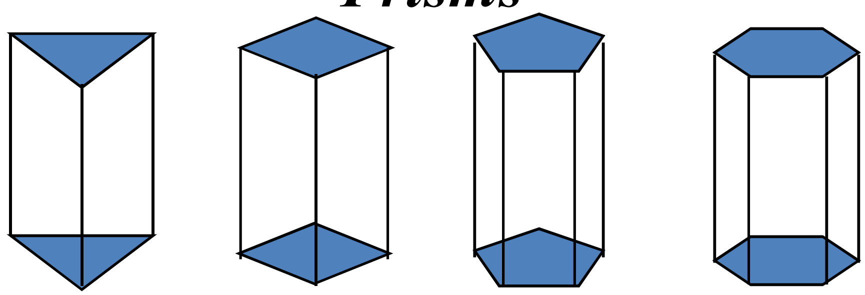
Cylinder



Cone

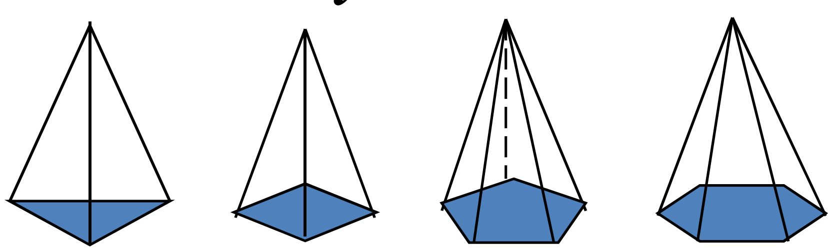


Prisms

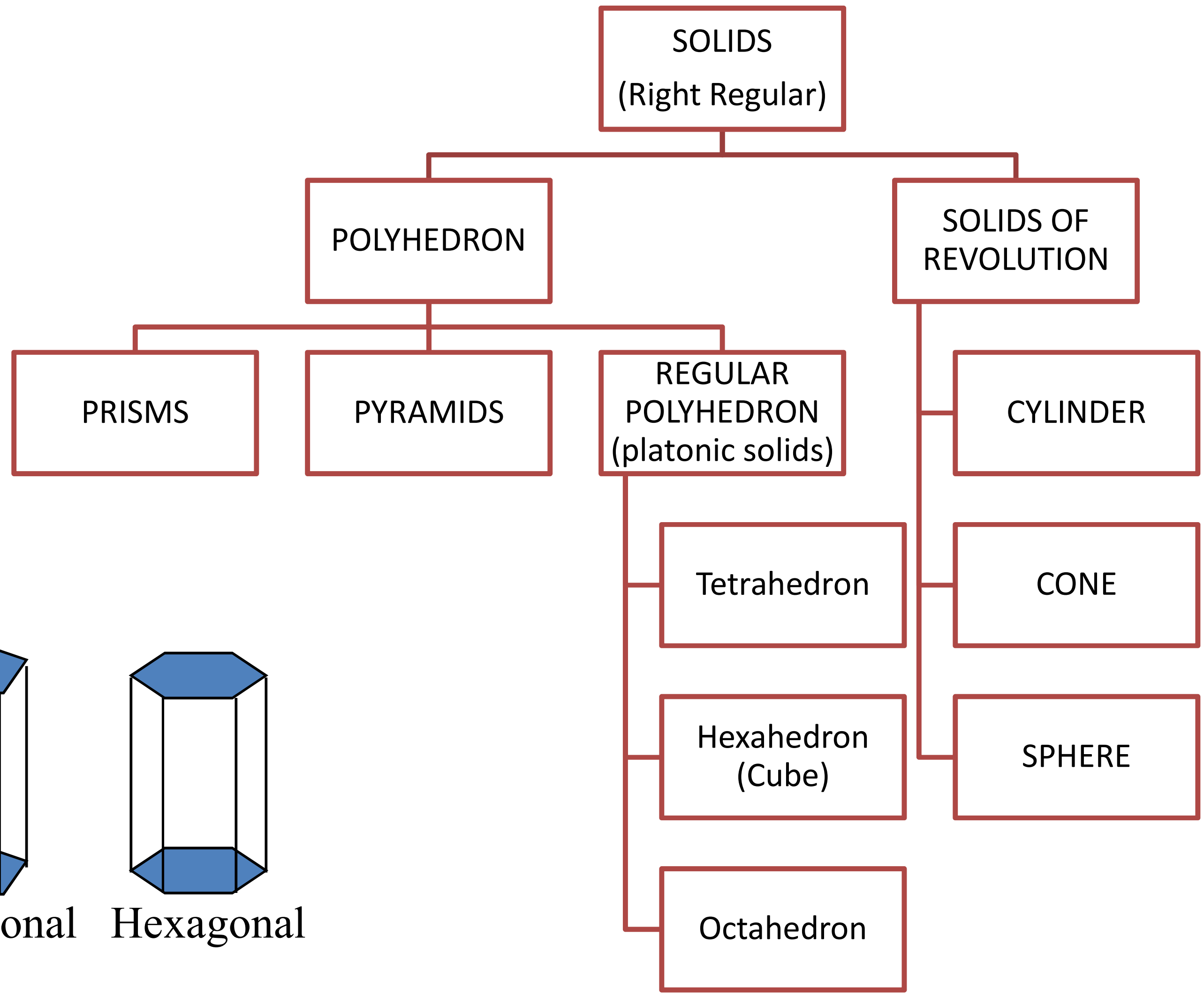


Triangular Square Pentagonal Hexagonal

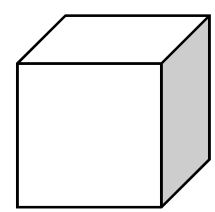
Pyramids



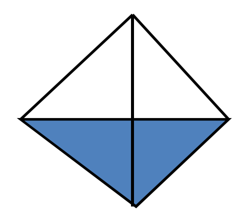
Triangular Square Pentagonal Hexagonal



Hexahedron (Cube)

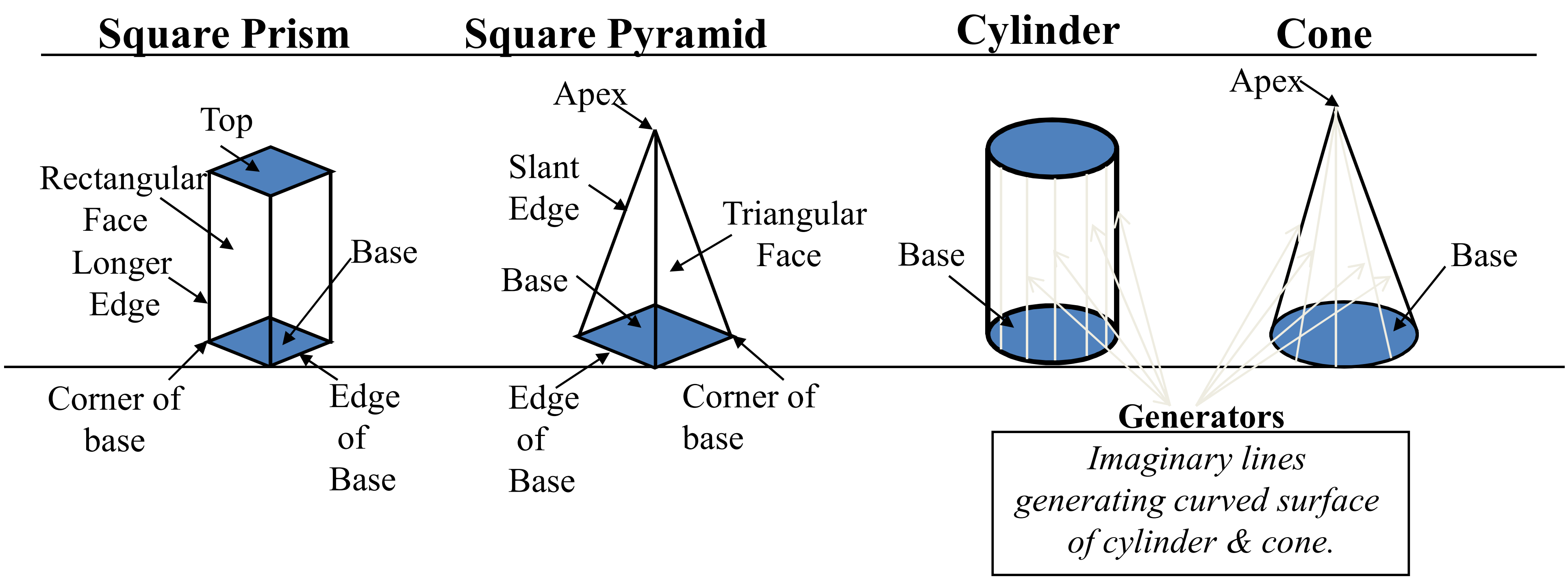


Tetrahedron



SOLIDS

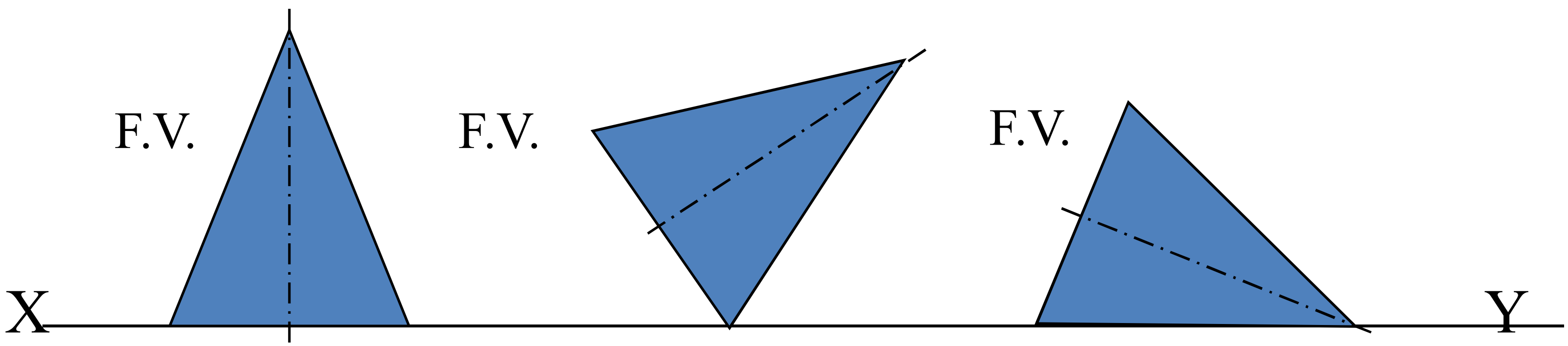
Dimensional parameters of different solids.



STANDING ON H.P
On it's base.
(Axis perpendicular to Hp
And // to Vp.)

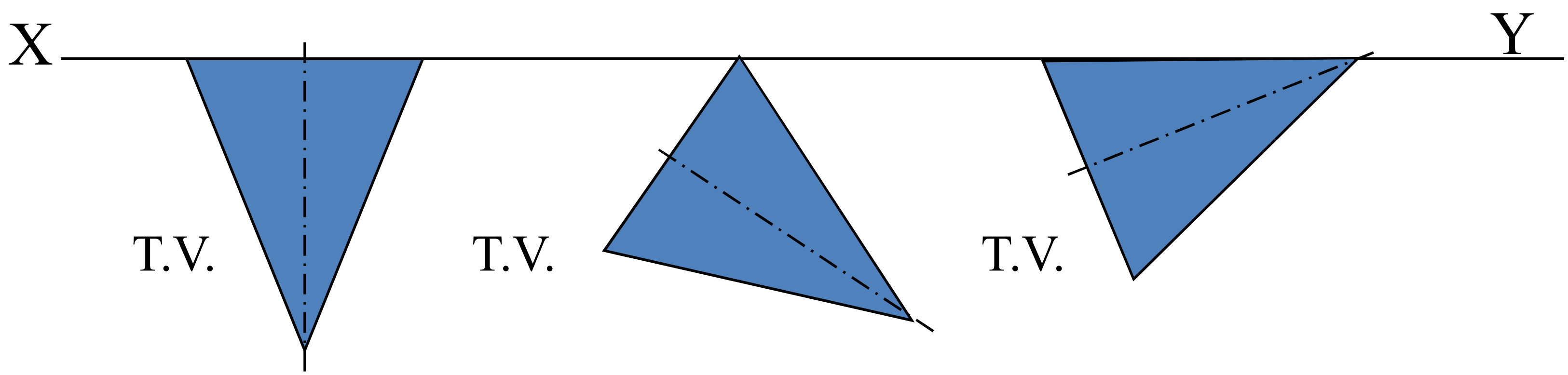
RESTING ON H.P
On one point of base circle.
(Axis inclined to Hp
And // to Vp)

LYING ON H.P
On one generator.
(Axis inclined to Hp
And // to Vp)



While observing FV, x-y line represents Horizontal Plane. (Hp)

While observing Tv, x-y line represents Vertical Plane. (Vp)



STANDING ON V.P
On it's base.
Axis perpendicular to Vp
And // to Hp

RESTING ON V.P
On one point of base circle.
Axis inclined to Vp
And // to Hp

LYING ON V.P
On one generator.
Axis inclined to Vp
And // to Hp

STEPS TO SOLVE PROBLEMS IN SOLIDS

Step 1: Simple Position (Axis $\perp^r$ to one reference plane)**;** Draw FV & TV of that solid in standing position:
(If it is resting on HP, assume it standing on HP)
(If it is resting on VP, assume it standing on VP)

Characteristic View:
IF STANDING ON HP- IT'S TV WILL BE *TRUE SHAPE OF IT'S BASE/TOP.*
IF STANDING ON VP- IT'S FV WILL BE *TRUE SHAPE OF IT'S BASE/TOP.*

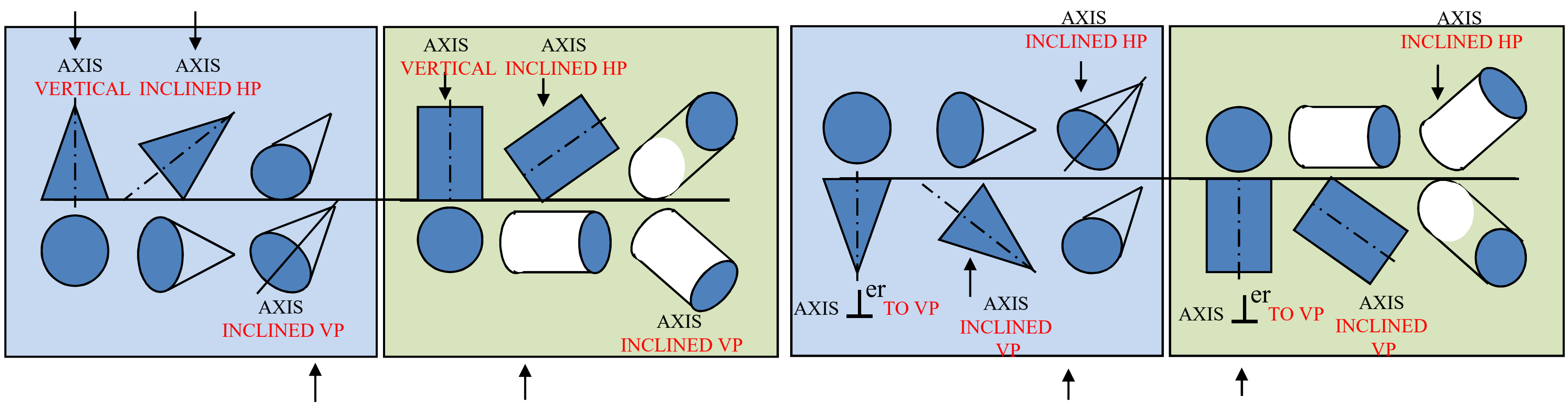
The other view:
Outline of it's other view will be a RECTANGLE, if solid is ***cylinder or one of the prisms.***
Outline of it's other view will be a TRIANGLE, if solid is ***cone or one of the pyramids.***

Step 2: Second position (Axis $//^l$ to one reference plane and inclined to the other); considering solid's inclination with the reference plane on which it was standing initially, draw its new FV & TV.

Step 3: Third Position (Axis inclined to two planes); considering remaining inclination, draw it's final FV & TV.

GENERAL PATTERN (THREE STEPS) OF SOLUTION:

SOLID CONE **SOLID CYLINDER** **SOLID CONE** **SOLID CYLINDER**



Three steps
If solid is inclined to Hp

Three steps
If solid is inclined to Vp

A square pyramid, 40 mm base sides and axis 60 mm long, has a triangular face on the ground and TV of the axis makes an angle of 45^0 with the VP. Draw its projections. Take apex nearer to VP

NOTE:

Another way to express the same question;

A square pyramid, 40 mm base sides and axis 60 mm long, has a triangular face on the ground and the vertical plane containing the axis makes an angle of 45^0 with the VP. Draw its projections. Take apex nearer to VP

(The vertical plane containing the axis makes an angle of 45^0 with the VP) = (TV of the axis makes an angle of 45^0 with the VP)

SOLUTION STEPS :

1. **Simple Position (Axis $\perp^r$ to reference plane):** Here, axis $\perp^r$ to HP. [*since, solid on ground*]. It's TV will show True Shape of base i.e., square [*characteristic view*]. Draw the characteristic view (square of 40mm sides) in EDGE POSITION [*one base edge $\perp^r$ to x-y line*] & project FV taking 60 mm axis. Name all the points as shown in the illustration.
2. **Second position (Axis $//^l$ to one reference plane and inclined to the other):** Draw FV in lying position (Δ^r face on ground). i.e., redraw the FV with face o'c'd' on x-y. Project it's TV. Make visible lines dark and hidden dashed, as per the procedure. Name all the points.
3. **Third Position (Axis inclined to two planes):** redraw the TV inclined to x-y. Here apparent inclination of axis is given. So redraw the TV at 45^0 so that the TV of the axis is making 45^0. (If true inclination was given, apparent inclination was to be found out using line rotation method). Project its FV. Name all the points.
4. **Mark the dimensions.**

NOTE:

Characteristic view in **Edge Position** when resting on edge or lateral face, in **Corner Position** when resting on corner or lateral edge.

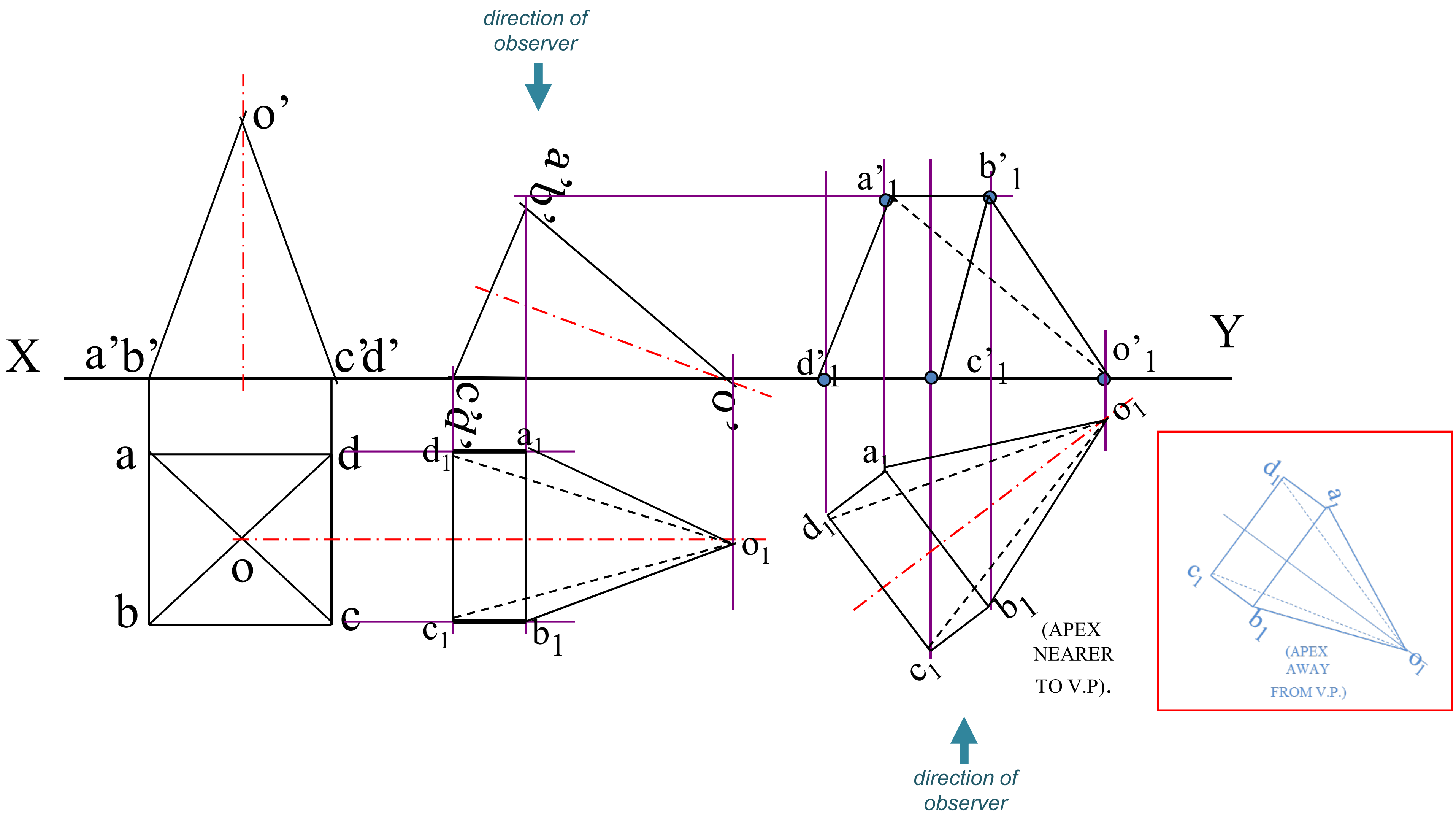
Visible & Invisible edges:

1. Draw proper outline of new view using Thick Continuous Lines (Outlines are always visible).
2. Decide *direction of observer*.
3. Select nearest point to observer and draw all lines starting from it as Thick Lines (Visible).
4. Select farthest point to observer and draw all lines (remaining) from it as Dashed Lines (Invisible).
5. A line crossing a visible line will always be invisible (or no two visible lines cross each other).

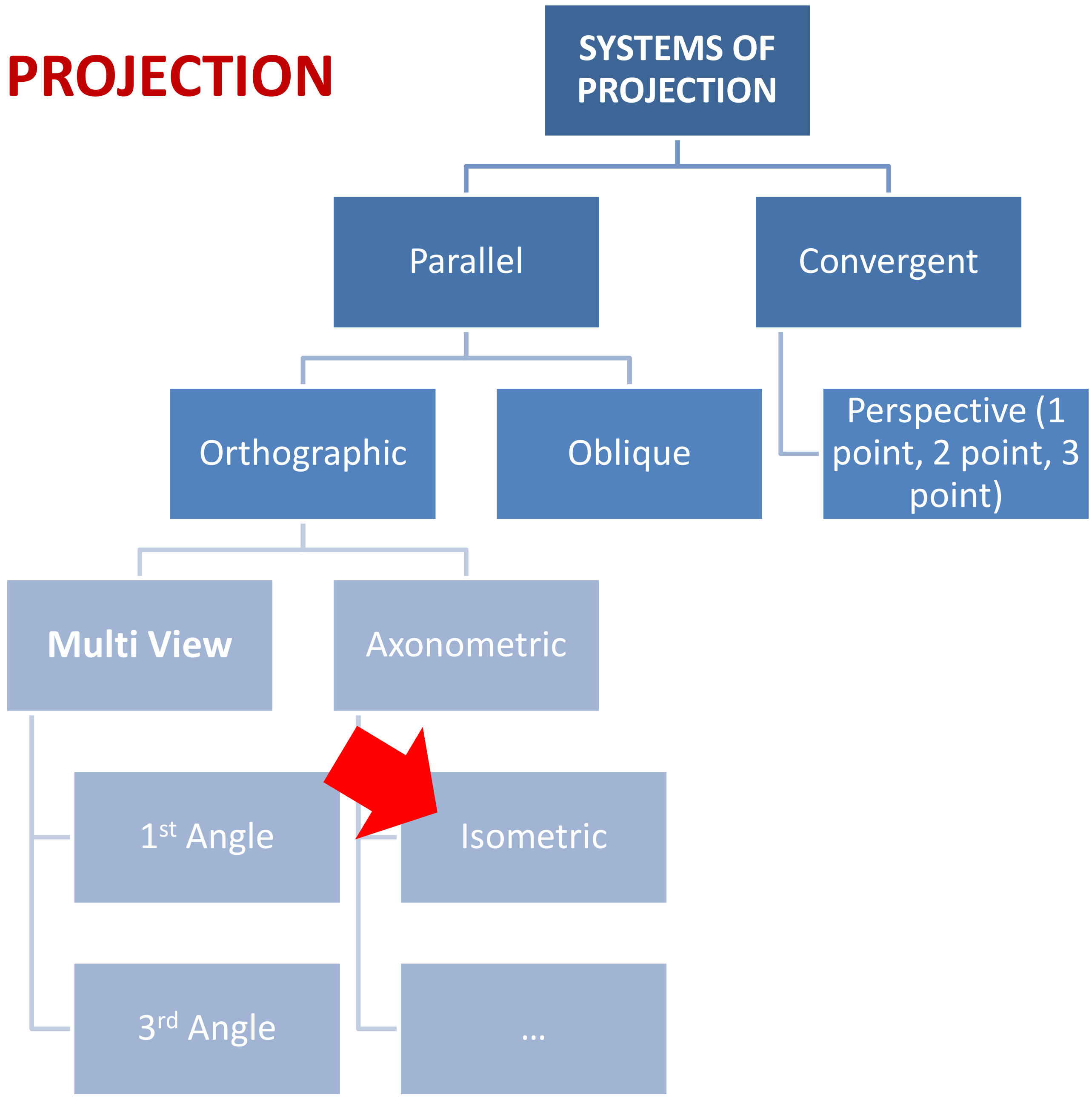
Simple Position (Axis ⊥r to reference plane)

Second Position (Axis //l to one reference plane and inclined to the other)

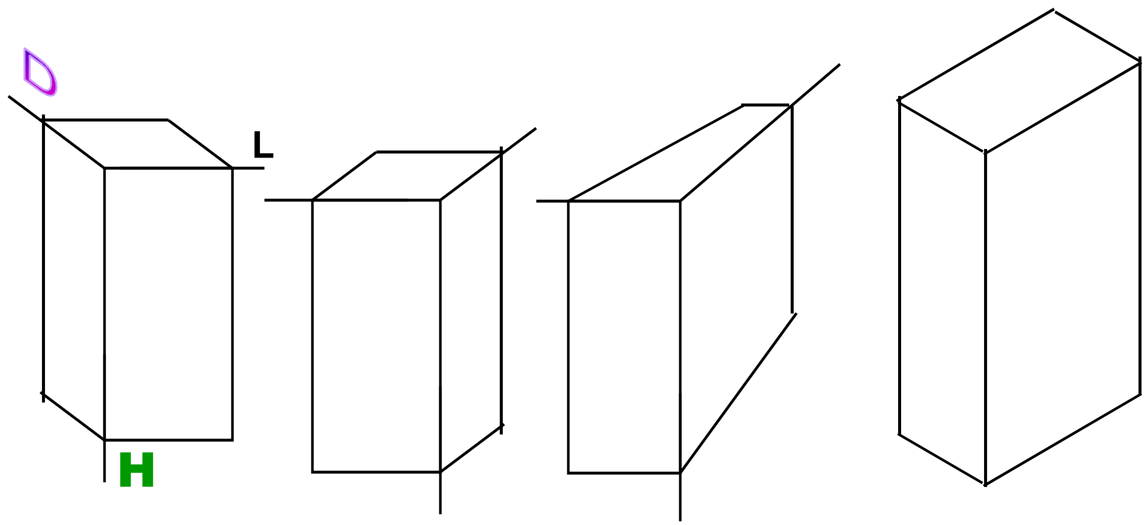
Third Position (Axis inclined to two planes)



SYSTEMS OF PROJECTION



3-DIMENSIONAL DRAWINGS, or PHOTOGRAPHIC or PICTORIAL DRAWINGS.

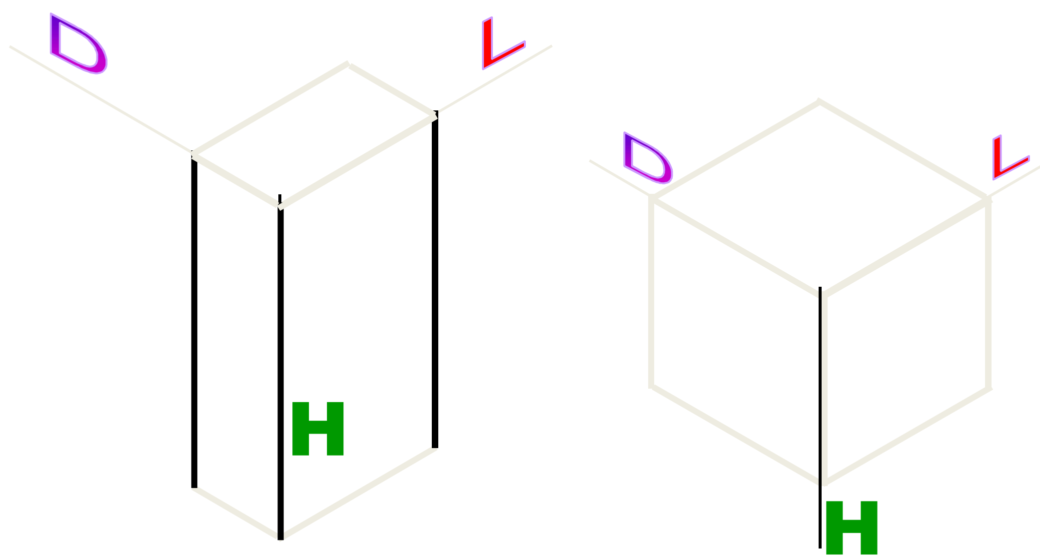


ISOMETRIC DRAWING

IT IS A TYPE OF PICTORIAL PROJECTION IN WHICH ALL THREE DIMENSIONS OF AN OBJECT ARE SHOWN IN ONE VIEW AND IF REQUIRED, THEIR ACTUAL SIZES CAN BE MEASURED DIRECTLY FROM IT.

IN THIS 3-D DRAWING OF AN OBJECT, ALL THREE DIMENSIONAL AXES ARE MENTAINED AT EQUAL INCLINATIONS WITH EACH OTHER.(120^0)

PURPOSE OF ISOMETRIC DRAWING IS TO UNDERSTAND OVERALL SHAPE, SIZE & APPEARANCE OF AN OBJECT PRIOR TO IT'S PRODUCTION.

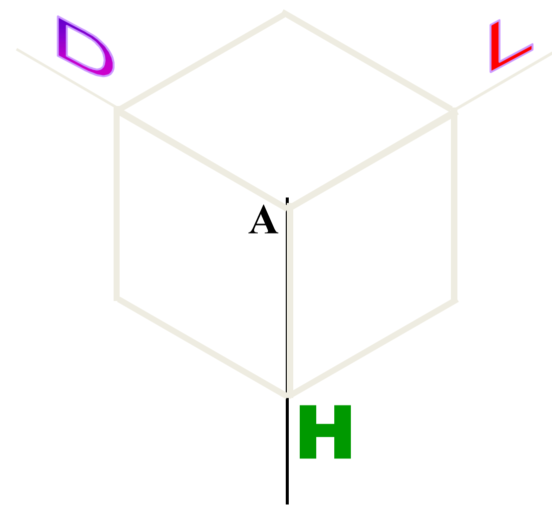


ISOMETRIC AXES, LINES AND PLANES:

The three lines AL, AD and AH, meeting at point A and making
120^0 angles with each other are termed *Isometric Axes.*

The lines parallel to these axes are called *Isometric Lines*.

The planes representing the faces of of the cube as well as
other planes parallel to these planes are called *Isometric Planes*.



ISOMETRIC SCALE:

When one holds the object in such a way that all three dimensions are visible then in the process all dimensions become proportionally inclined to observer's eye sight and hence appear apparent in lengths.

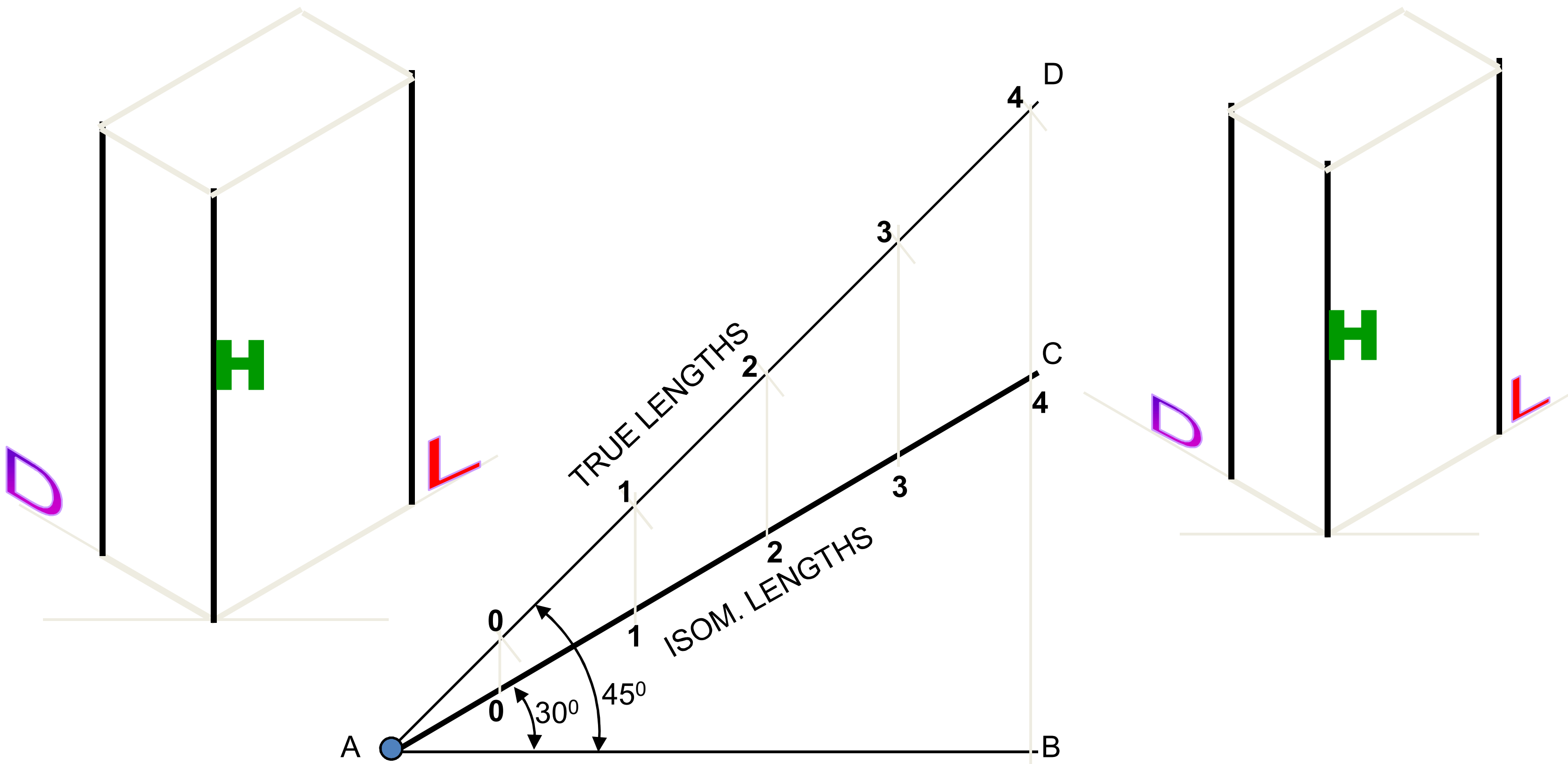
This reduction is 0.815 or 9 / 11 (approx.) It forms a reducing scale which Is used to draw isometric drawings and is called *Isometric scale.*

In practice, while drawing isometric projection, it is necessary to convert true lengths into isometric lengths for measuring and marking the sizes. This is conveniently done by constructing an isometric scale as described on next page.

TYPES OF ISOMETRIC DRAWINGS

ISOMETRIC VIEW
Drawn by using True scale
(True dimensions)

ISOMETRIC PROJECTION
Drawn by using Isometric scale
(Reduced dimensions)



Isometric scale [Line AC]
required for Isometric Projection

ISOMETRIC OF PLANE FIGURES

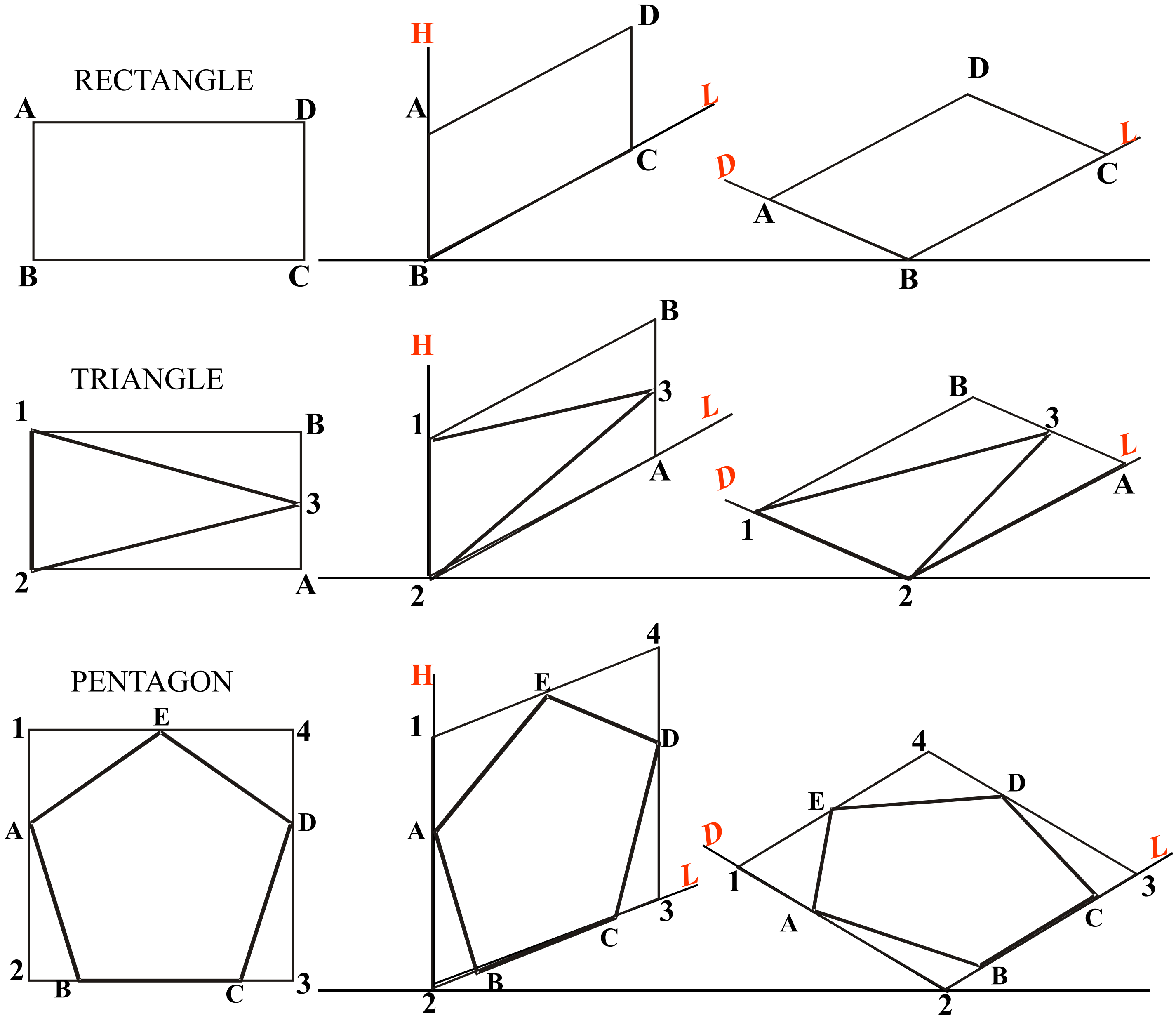
SHAPE | **Isometric view if the Shape is F.V. or T.V.**

AS THESE ALL ARE 2-D FIGURES WE REQUIRE ONLY TWO ISOMETRIC AXES.

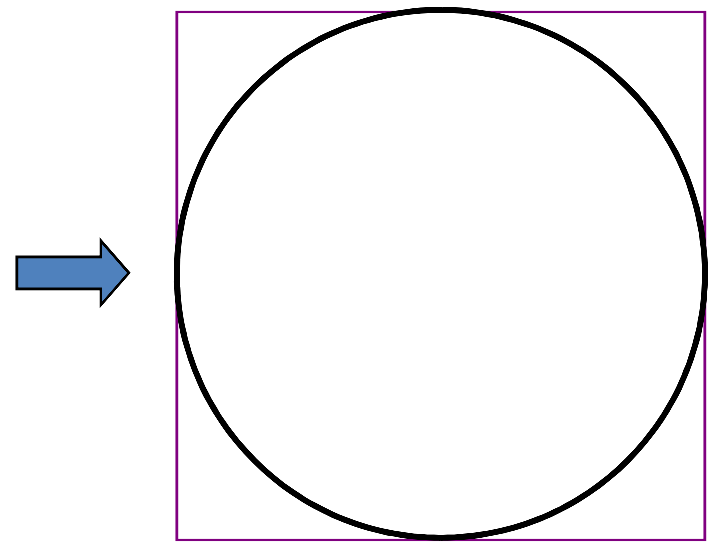
IF THE FIGURE IS FRONT VIEW, H & L AXES ARE REQUIRED.

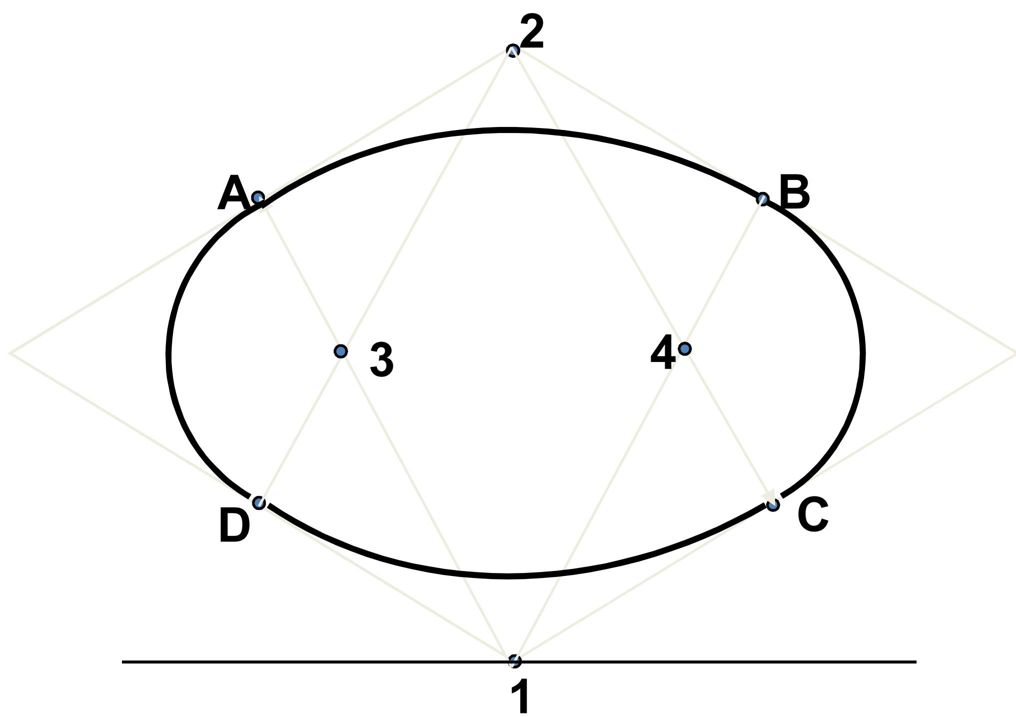
IF THE FIGURE IS TOP VIEW, D & L AXES ARE REQUIRED.

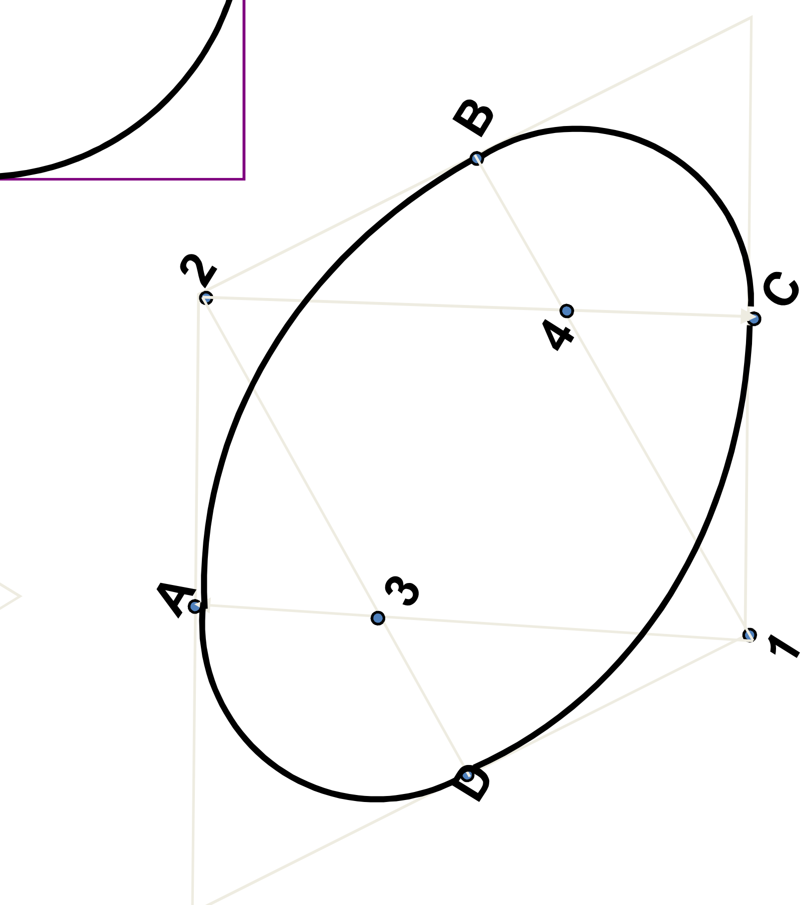
Shapes containing Inclined lines should be enclosed in a rectangle as shown. Then first draw isom. of that rectangle and then inscribe that shape as it is.



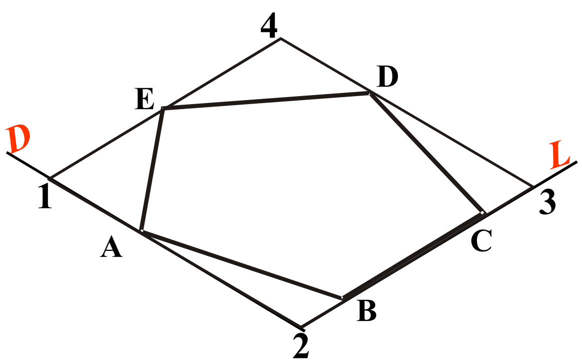
DRAW ISOMETRIC VIEW OF A CIRCLE IF IT IS A TV OR FV.



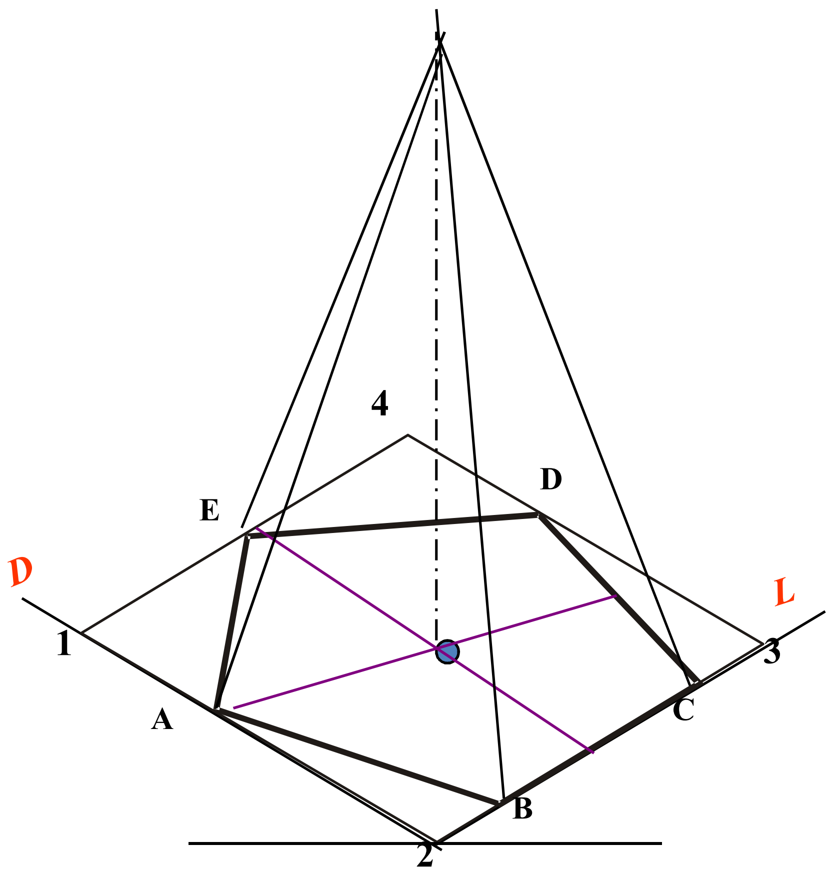


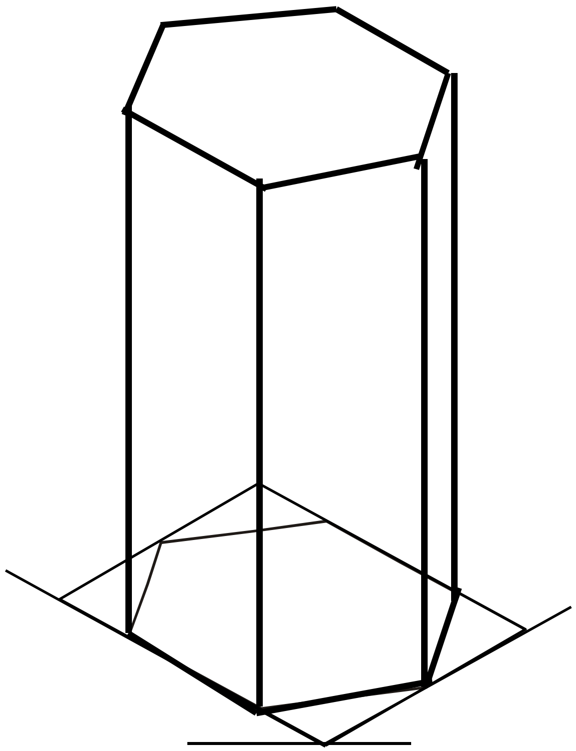


ISOMETRIC VIEW OF BASE OF
PENTAGONAL PYRAMID
STANDING ON H.P.



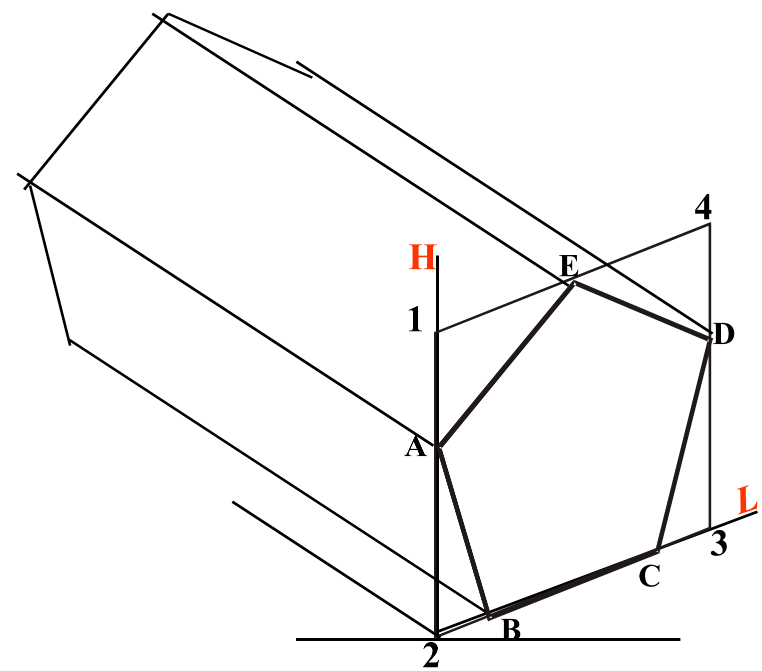
ISOMETRIC VIEW OF
PENTAGONAL PYRAMID
STANDING ON H.P.
(Height is added from center of pentagon)



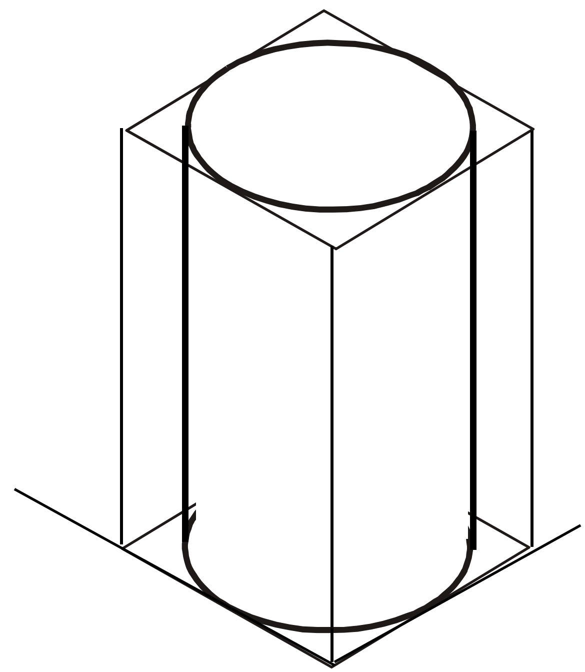


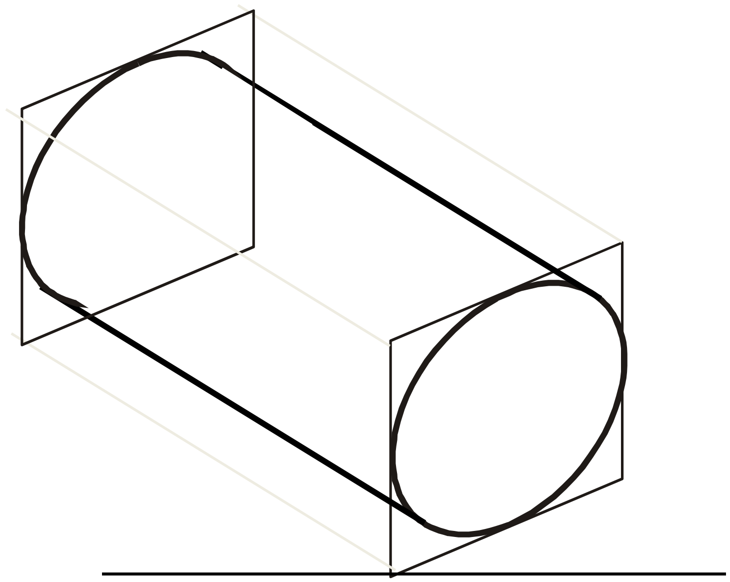
ISOMETRIC VIEW OF
HEXAGONAL PRISM
STANDING ON H.P.

ISOMETRIC VIEW OF
PENTAGONALL PRISM
LYING ON H.P.



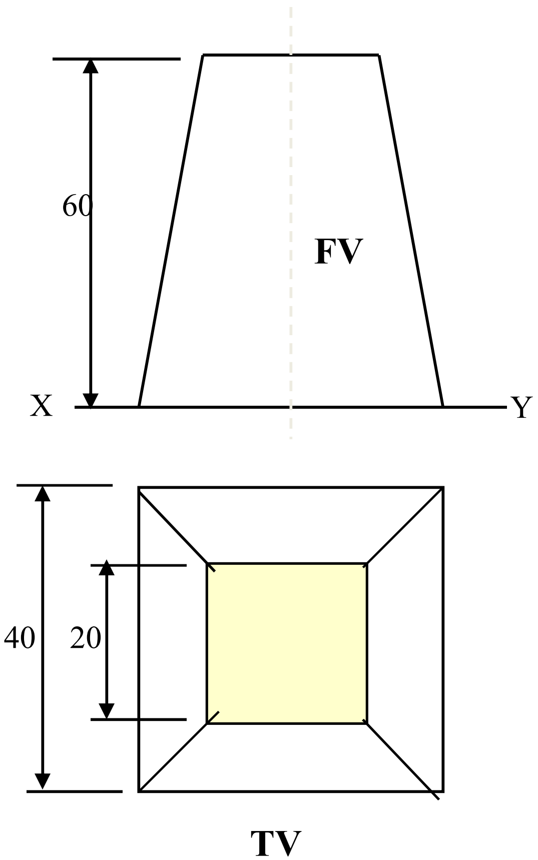
CYLINDER STANDING ON H.P.

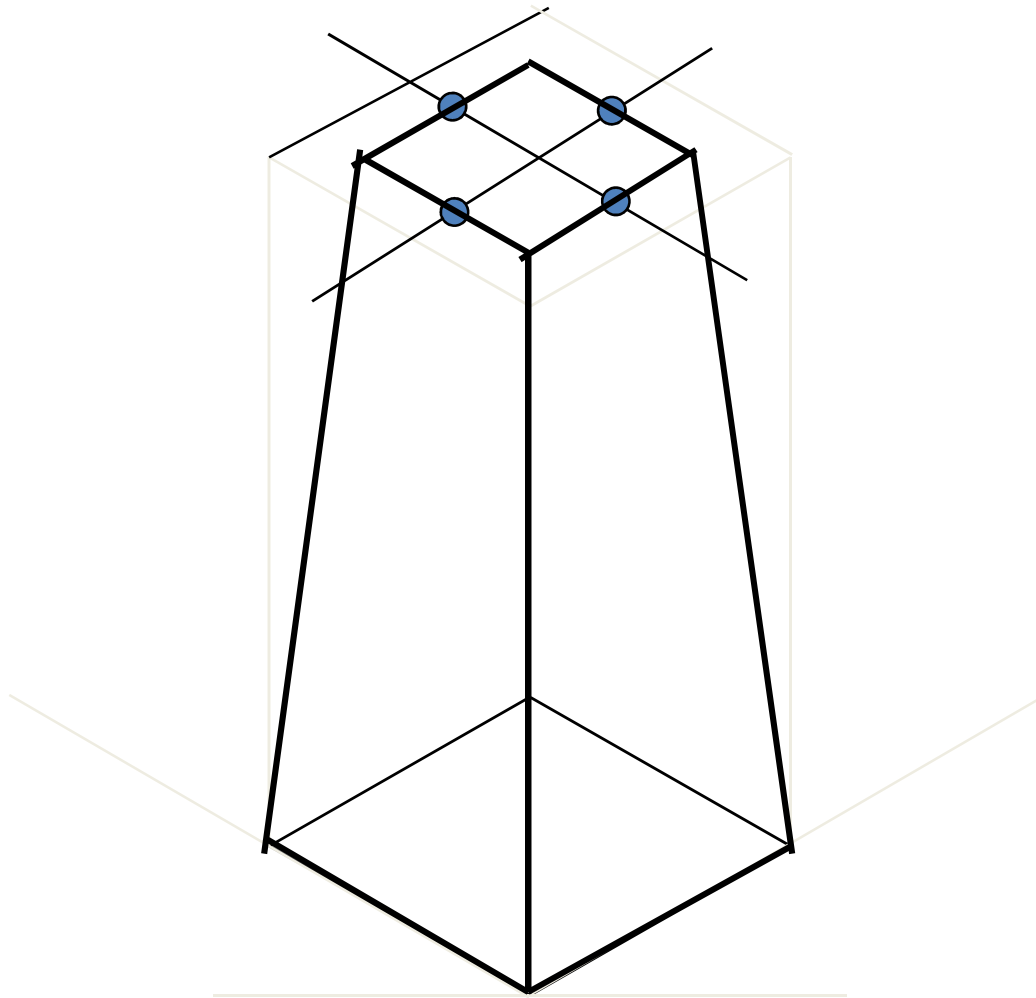




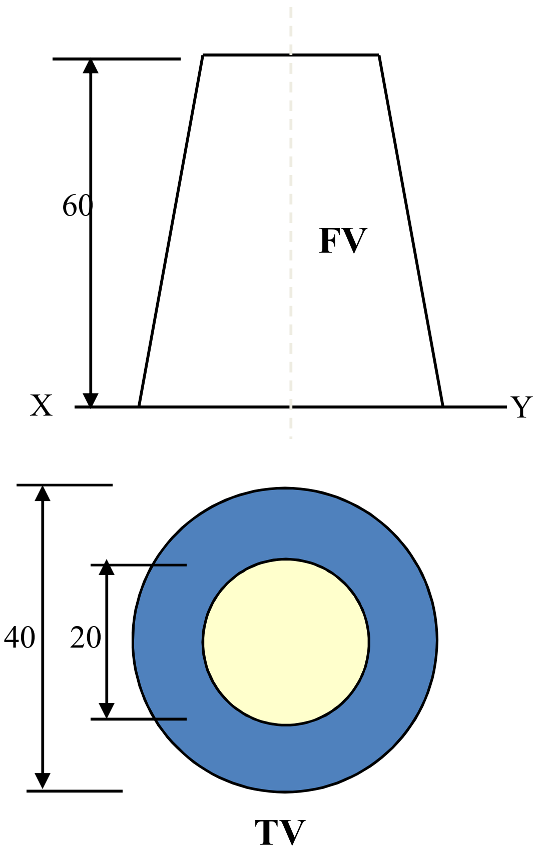
CYLINDER LYING ON H.P.

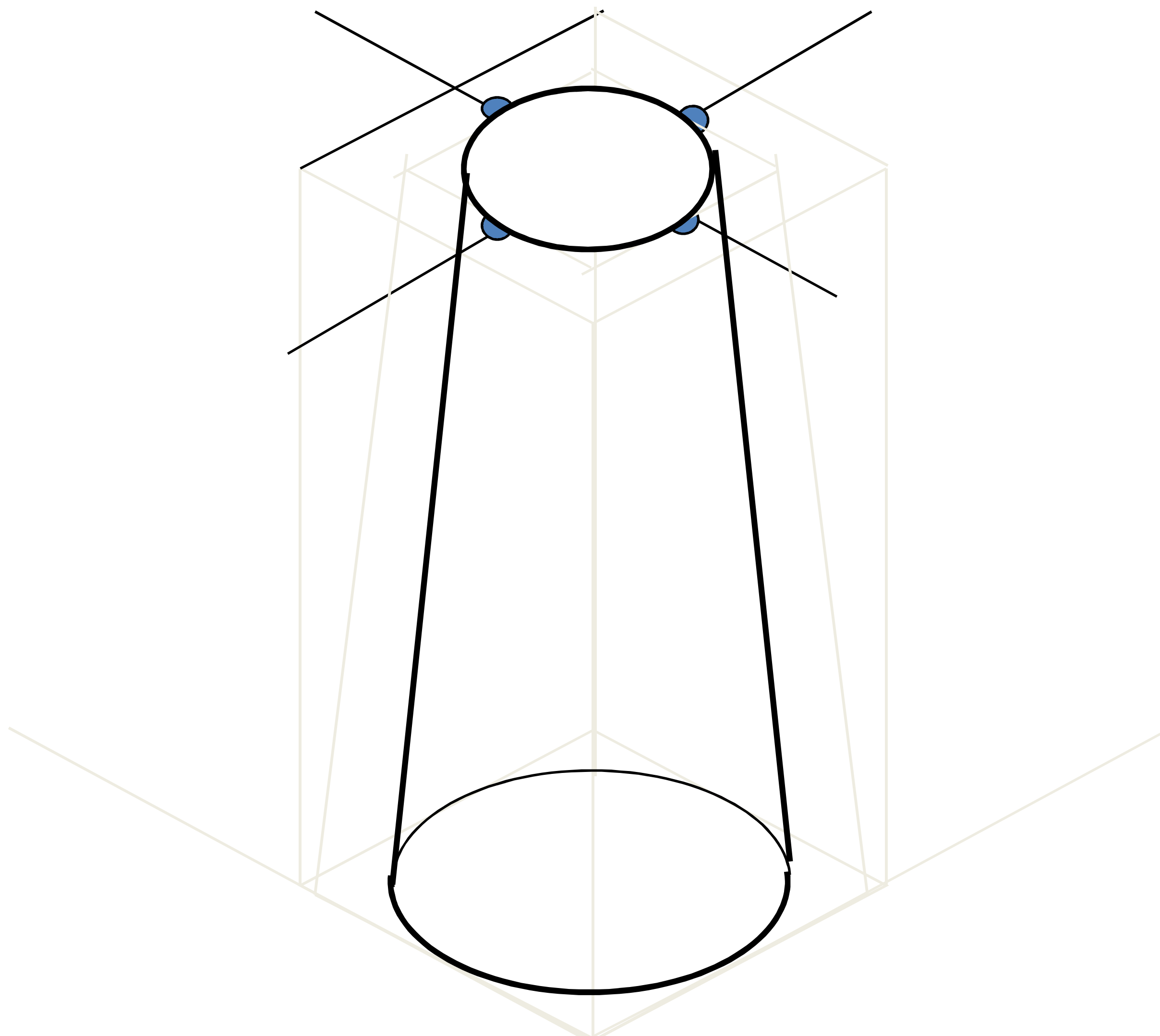
ISOMETRIC VIEW OF
A FRUSTOM OF SQUARE PYRAMID
STANDING ON H.P. ON IT'S LARGER BASE.



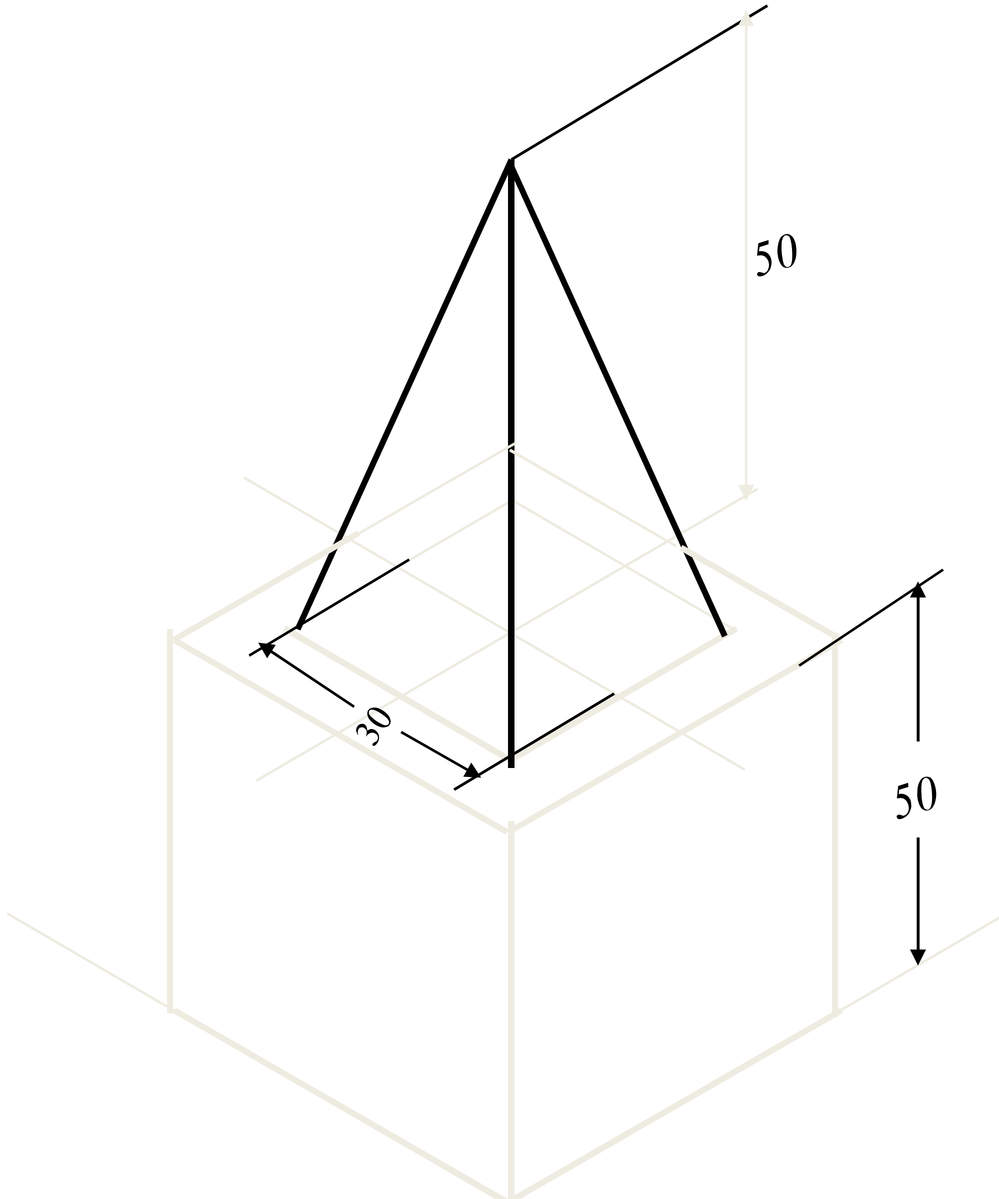


ISOMETRIC VIEW OF
A FRUSTOM OF CONE
STANDING ON H.P. ON IT'S LARGER BASE.

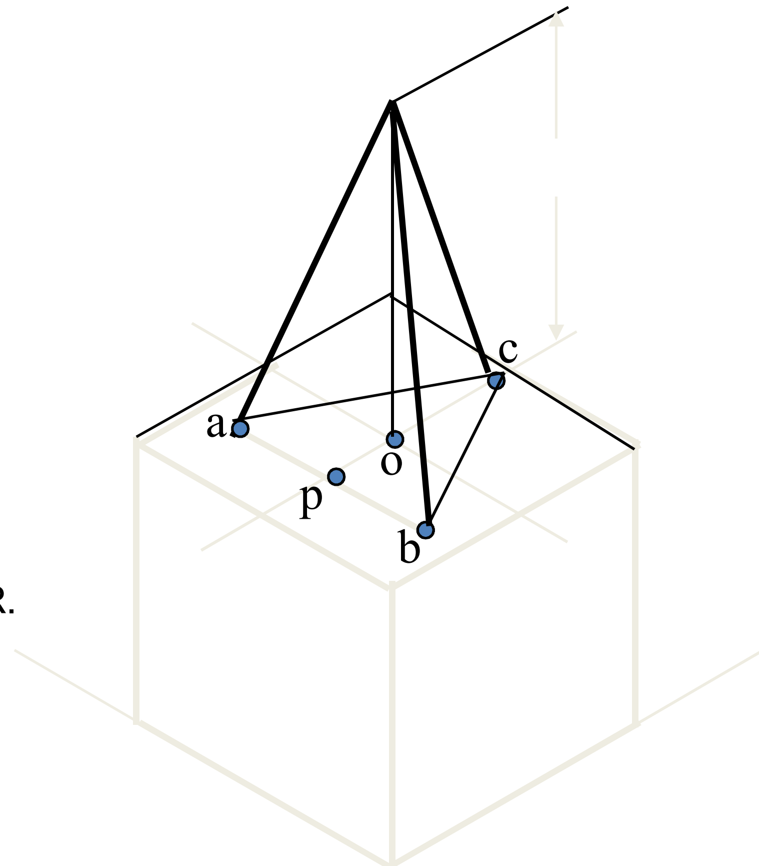


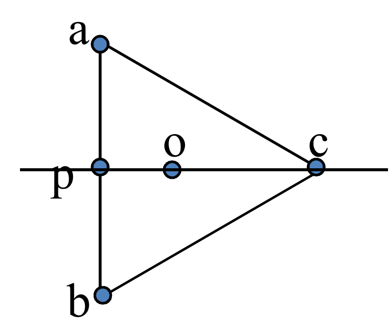


PROBLEM: A SQUARE PYRAMID OF 30 MM BASE SIDES AND 50 MM LONG AXIS, IS CENTRALLY PLACED ON THE TOP OF A CUBE OF 50 MM LONG EDGES.DRAW ISOMETRIC VIEW OF THE PAIR.



PROBLEM: A TRIANGULAR PYRAMID OF 30 MM BASE SIDES AND 50 MM LONG AXIS, IS CENTRALLY PLACED ON THE TOP OF A CUBE OF 50 MM LONG EDGES.
DRAW ISOMETRIC VIEW OF THE PAIR.





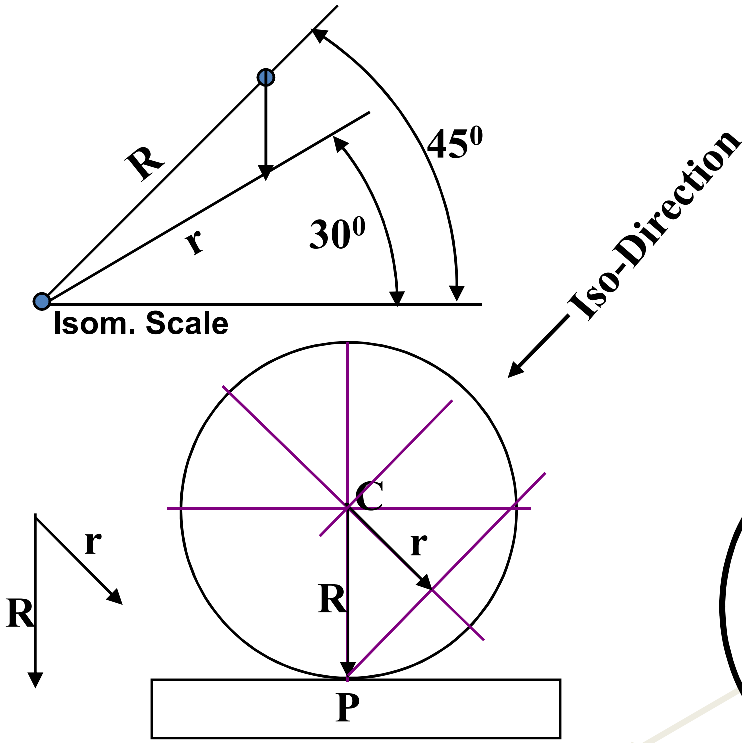
SOLUTION HINTS.

TO DRAW ISOMETRIC OF A CUBE IS SIMPLE. DRAW IT AS USUAL.

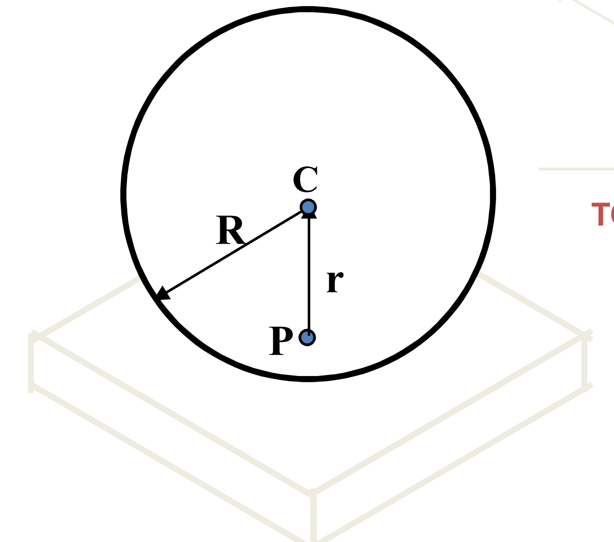
BUT FOR PYRAMID AS IT'S BASE IS AN EQUILATERAL TRIANGLE, IT CAN NOT BE DRAWN DIRECTLY.SUPPORT OF IT'S TV IS REQUIRED.

SO DRAW TRIANGLE AS A TV, SEPARATELY AND NAME VARIOUS POINTS AS SHOWN.
AFTER THIS PLACE IT ON THE TOP OF CUBE AS SHOWN.
THEN ADD HEIGHT FROM IT'S CENTER AND COMPLETE IT'S ISOMETRIC AS SHOWN.

ISOMETRIC PROJECTIONS OF SPHERE & HEMISPHERE

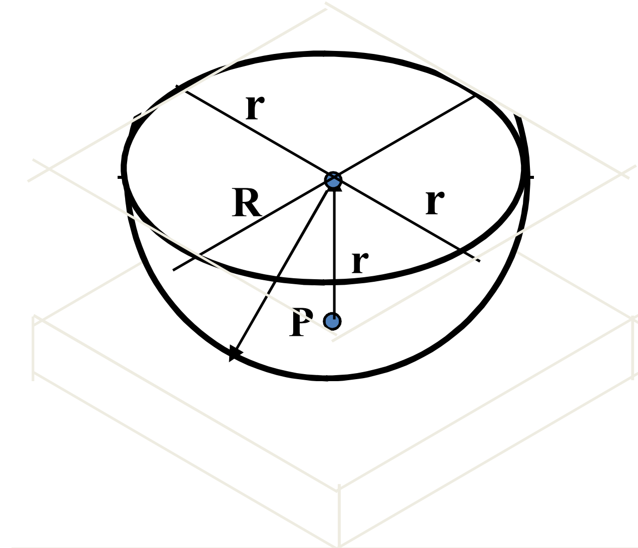


C = Center of Sphere.
P = Point of contact
R = True Radius of Sphere
r = Isometric Radius.



TO DRAW ISOMETRIC PROJECTION OF A SPHERE

1. FIRST DRAW ISOMETRIC OF SQUARE PLATE.
2. LOCATE IT'S CENTER. NAME IT P.
3. FROM PDRAW VERTICAL LINE UPWARD, LENGTH ' r mm' AND LOCATE CENTER OF SPHERE "C"
4. 'C' AS CENTER, WITH RADIUS 'R' DRAW CIRCLE.
   THIS IS ISOMETRIC PROJECTION OF A SPHERE.

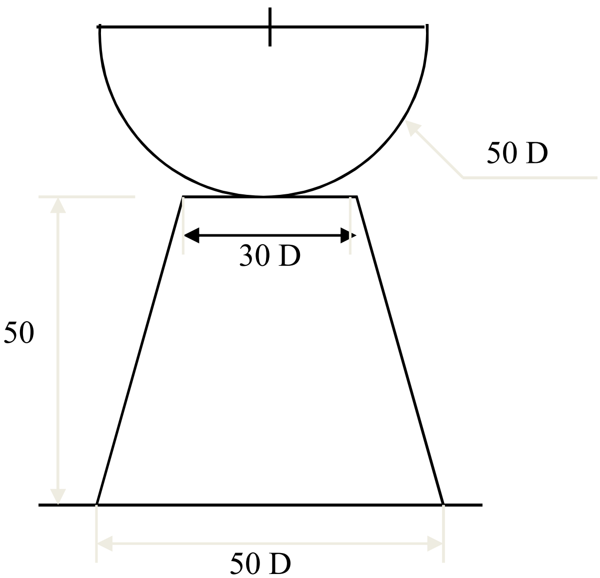


TO DRAW ISOMETRIC PROJECTION OF A HEMISPHERE

Adopt same procedure.
Draw lower semicircle only.
Then around 'C' construct Rhombus of Sides equal to Isometric Diameter.
For this use iso-scale.
Then construct ellipse in this Rhombus as usual
And Complete Isometric-Projection of Hemi-sphere.

PROBLEM:

A HEMI-SPHERE IS CENTRALLY PLACED
ON THE TOP OF A FRUSTOM OF CONE.
DRAW ISOMETRIC PROJECTIONS OF THE ASSEMBLY.



**FIRST CONSTRUCT ISOMETRIC SCALE.
USE THIS SCALE FOR ALL DIMENSIONS
IN THIS PROBLEM.**