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Institute of Science and Technology
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Technical Drawing

Practical Work / 2nd Year Bachelor / Civil and Hydraulic Engineering

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Chapter II:
Elements of Descriptive Geometry

Fundamental Concepts of Descriptive Geometry

Use of Descriptive Geometry

Descriptive geometry is essentially a graphical science. It is used to represent three-dimensional solids in space using two-dimensional figures.

- In industry, to manufacture a part, its shapes are first represented using projections, and if necessary, a perspective view accompanies the projections to facilitate the reading of the drawing.
- The representation of solids is based on **the orthogonal projection** method used in **descriptive geometry**. Before applying this method, one must first understand **how to represent a point on the two projection planes in a layout, as well as how to represent lines, their intersections, planes, and the intersections of these planes.**

Orthogonal Projection

An **orthogonal projection** of a point M into a plane P is defined as the point of intersection of the line passing through M that is perpendicular to the plane P. The line Mm is perpendicular to the plane P and is called the **projection line** of point M.

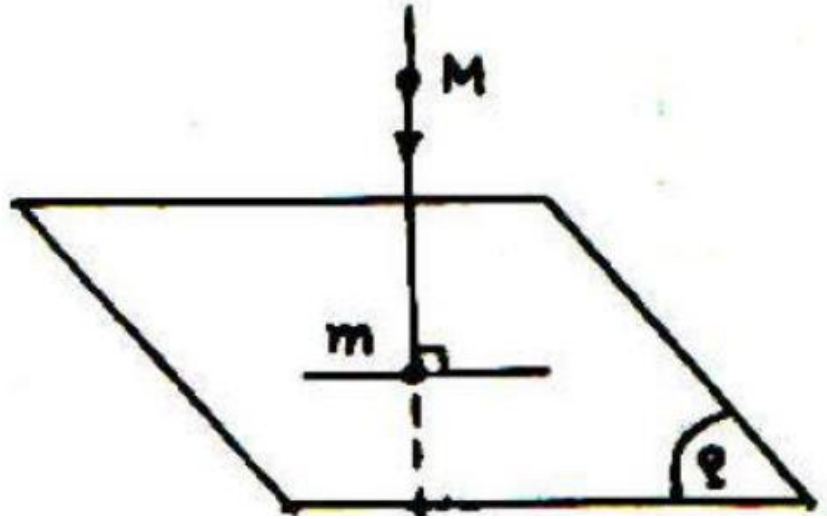


Fig.1. Orthogonal Projection of Point M

Double Orthogonal Projection

To represent three-dimensional (3D) objects in two dimensions (2D), we begin by defining two perpendicular projection planes in space: the first plane H is called the **horizontal plane**, and the second plane F is called the **frontal plane**. These two planes intersect along a line xy, called the **ground line**. These planes divide space into four **dihedral angles**, numbered as shown below:

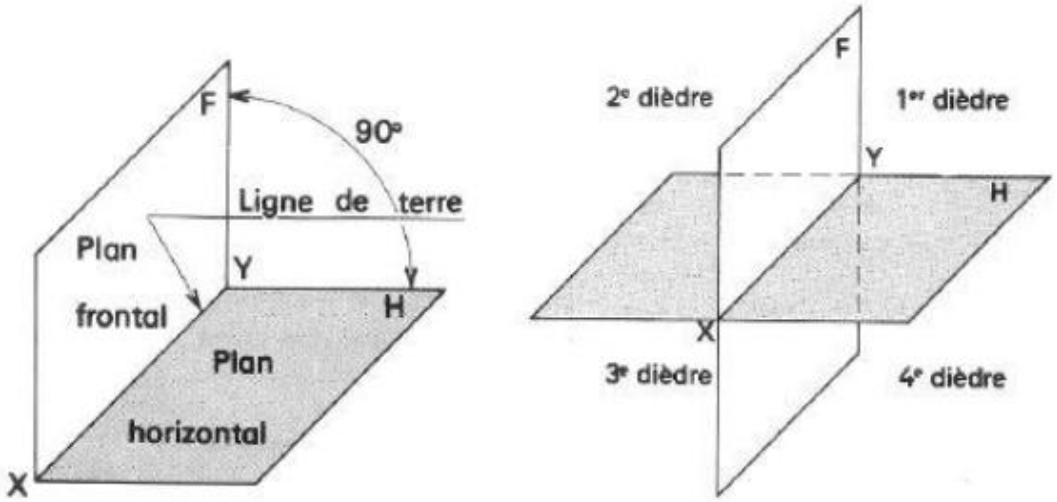


Fig2. Horizontal and Frontal Projection Planes

Projection of Spatial Elements

1) The point

Let there be a point A in space. This point A is projected **horizontally** into the plane H as a and **frontally** into the plane F as a′. The point a is called the **horizontal projection** of point A, while the orthogonal projection a′ is called the **frontal projection** of point A.

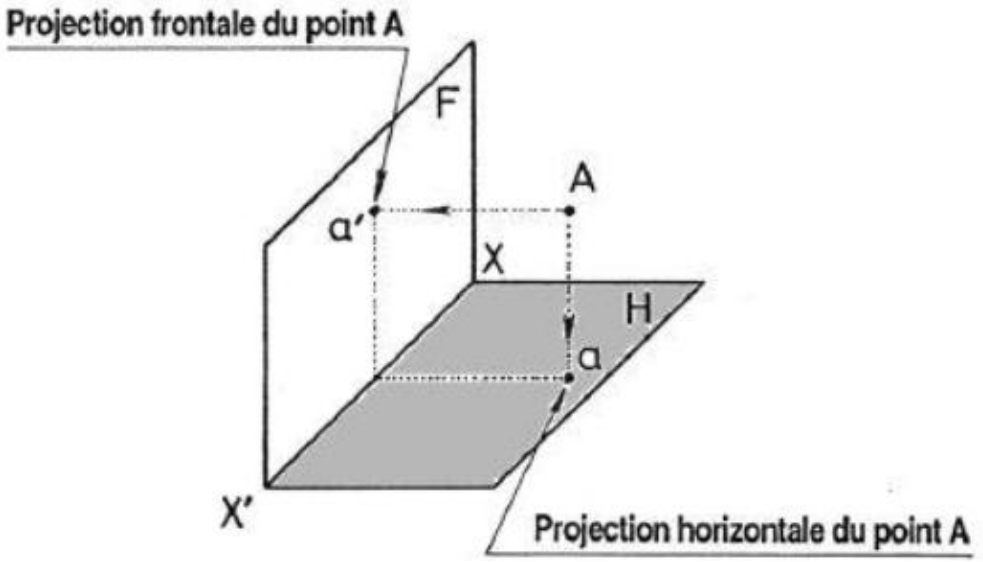


Fig3. Orthogonal Projection of a Point (A)

To obtain a **layout** of point A, the horizontal plane H is rotated around the **ground line** XX′ so that it is folded into the frontal plane F. As a result, the horizontal and frontal projections are placed on the same plane, thereby creating a **layout** of the three-dimensional object to be represented.

The line aa′ is called the **reference line**.
The distance Aa is called the **height** of point A.
The distance Aa′ is called the **depth** of point A.

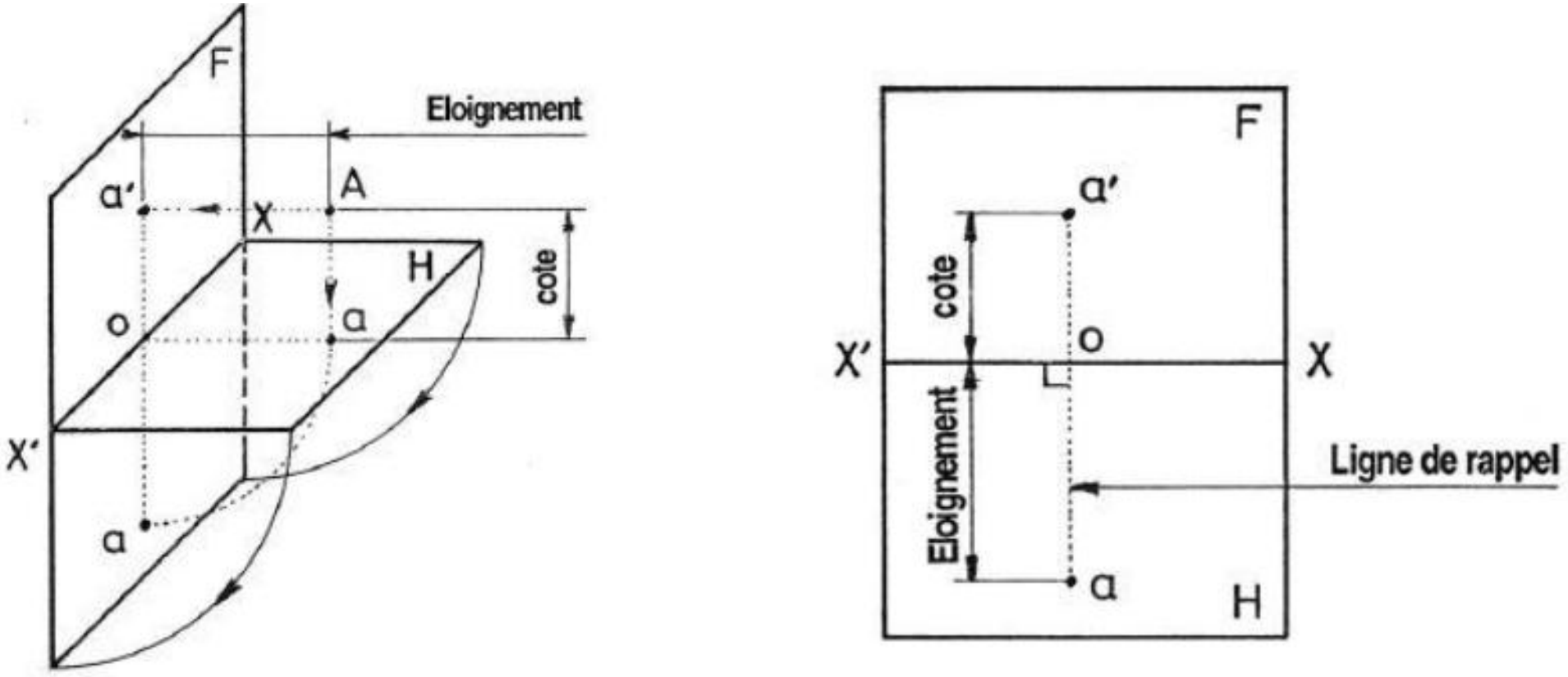


Fig 4. Layout of Point (A)

2) The line

In space, a line is defined by two aligned points.
To obtain the orthogonal projection of a line in the layout, it is sufficient to know its two points through their horizontal and frontal projections. Thus, a line is defined by its **horizontal projection** and **frontal projection**.

Let A and B be two distinct points in space. Only one line passes through these two points.

Let a and b be the horizontal projections of points A and B, and a′ and b′ their frontal projections.

Only one line passes through a and b: this is the **horizontal projection** of line AB. Similarly, only one line passes through a′ and b′: this is the **frontal projection** of line AB.

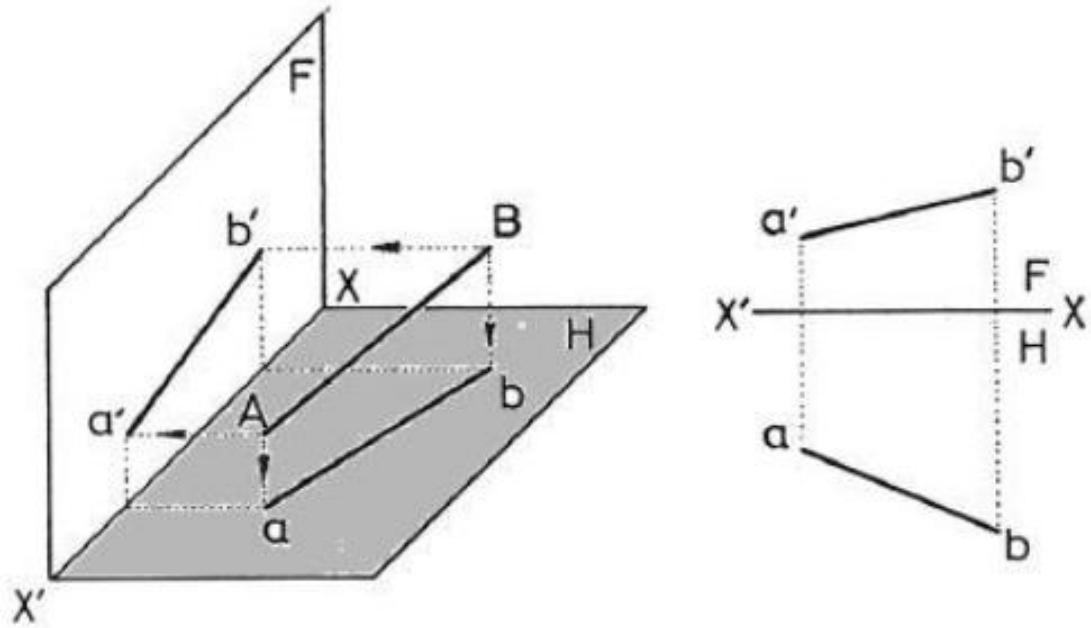


Fig 5. Orthogonal Projection of a Line

Remarkable Lines

A. Vertical Line

A vertical line is perpendicular to the horizontal plane and parallel to the frontal plane.

- A vertical line is shown in **true length (TL)** on the frontal plane F.
- Its frontal projection is perpendicular to the ground line xx′.
- Its horizontal projection is a point.
- All points on a vertical line have the same **depth**.

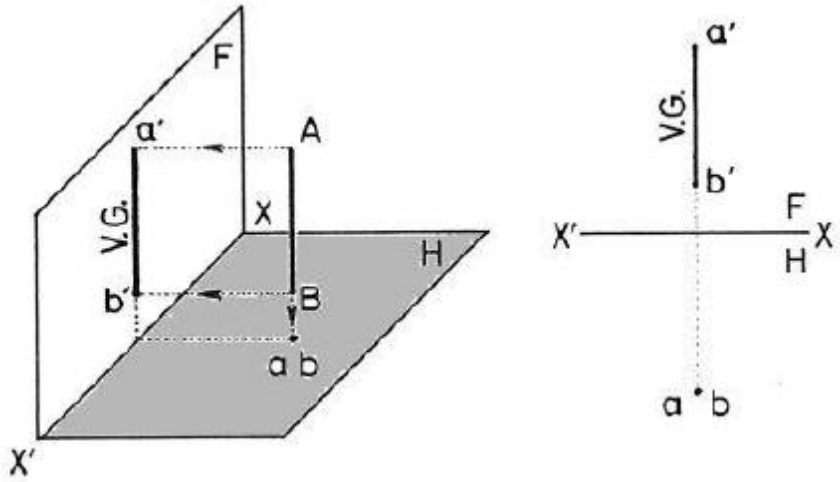


Fig 6. Vertical Line

B. Debout Line

- A debout line is perpendicular to the frontal projection plane and parallel to the horizontal plane.
- An end line is shown in **true length (TL)** on the horizontal plane H.
- Its frontal projection is a point.
- All points on an end line have the same **height**.

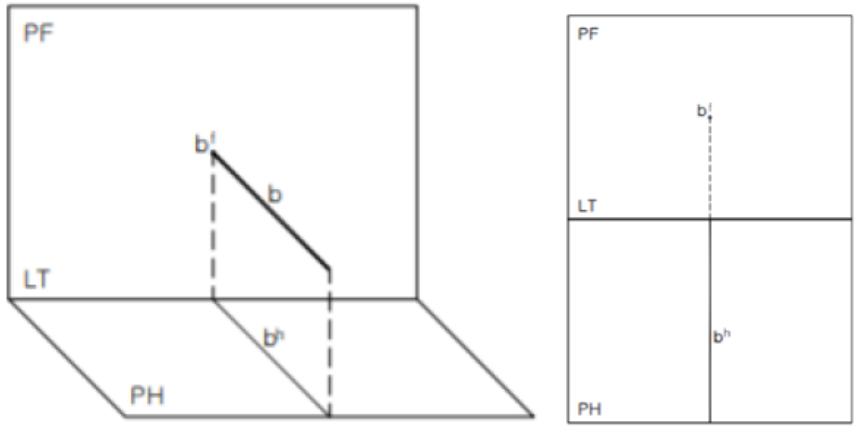


Fig 7. Debout Line

C. Horizontal Line

A horizontal line is parallel to the horizontal projection plane, and the angle it forms with the frontal plane can be any.

- A horizontal line is shown in **true length (TL)** on the horizontal plane H.
- Its frontal projection (a′b′) is parallel to the ground line xx′.
- All points on a horizontal line have the same **height**.

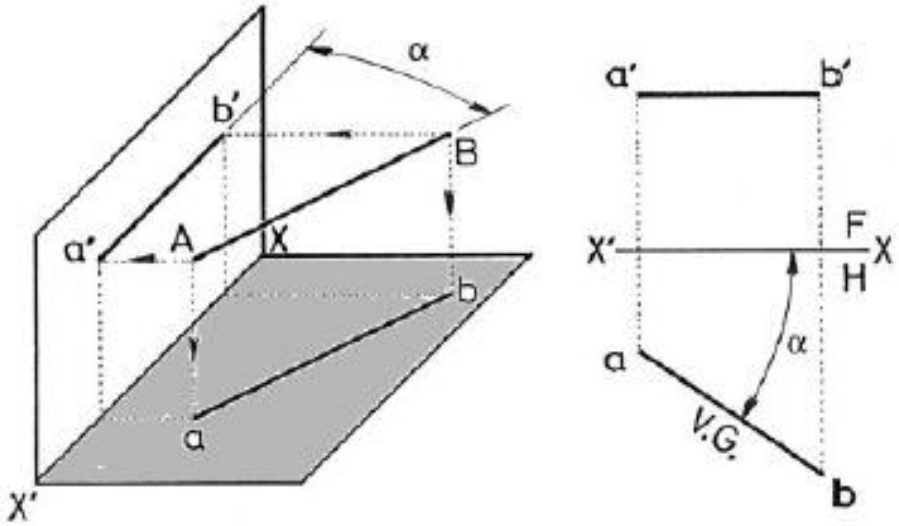


Fig 8. Horizontal Line

D. Frontal Line

A frontal line is parallel to the frontal projection plane, and the angle it forms with the horizontal plane can be any.

- A frontal line is shown in **true length (TL)** on the frontal plane F.
- Its horizontal projection (ab) is parallel to the ground line xx′.
- All points on a frontal line have the same **depth**.

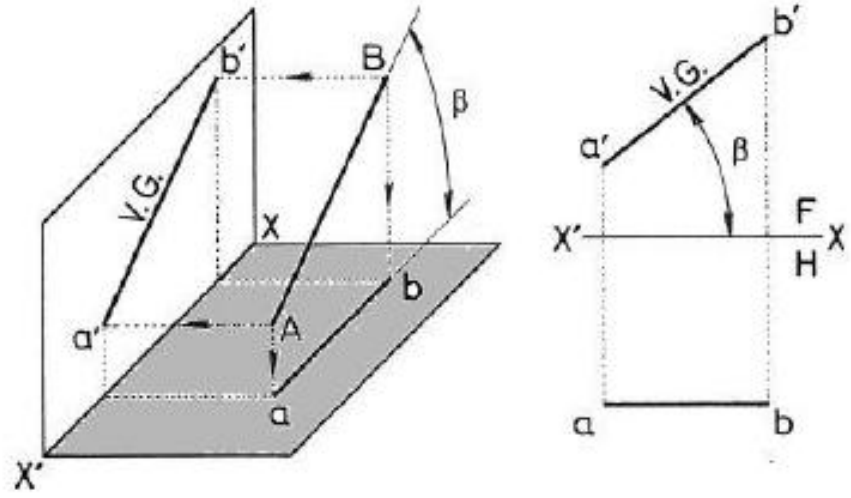


Fig 9. Frontal Line

E. Horizonto-Frontal Line

A horizonto-frontal line is parallel to both the horizontal and frontal projection planes. Consequently, it is parallel to the ground line xx′.

- A horizonto-frontal line is shown in **true length (TL)** on both planes H and F.
- Its horizontal projection (ab) and frontal projection (a′b′) are parallel to the ground line xx′.
- All points on such a line have the same **height** and **depth**.

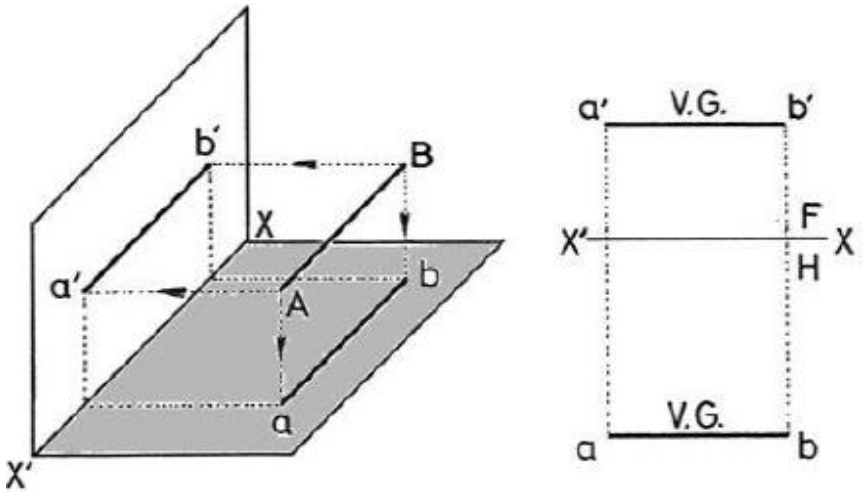


Fig 10. Horizonto-Frontal Line

F. Profile Line

A profile line is any line belonging to a plane perpendicular to the ground line xx′, and therefore to both projection planes H and F.

- A profile line is **not shown in true length (TL)** on either plane H or F.
- A profile line is fully defined only if the projections (ab and a′b′) of two of its points A and B are known.

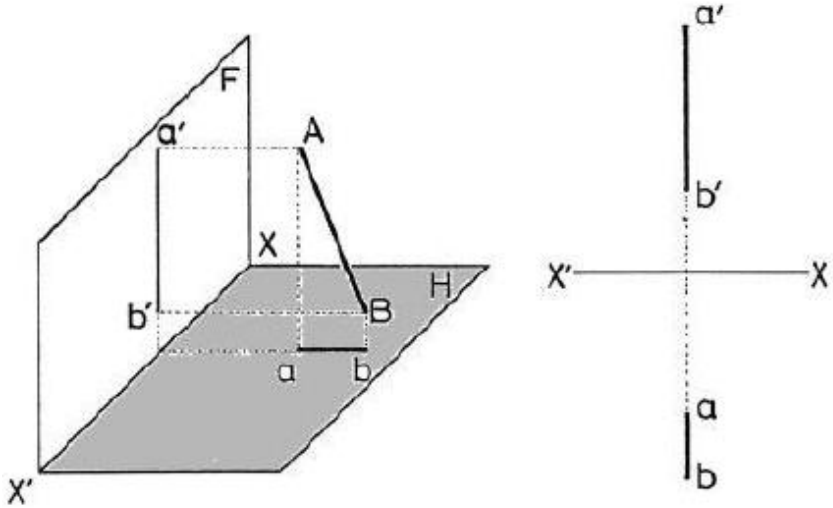


Fig 11. Profile Line

Notable Positions of Two Lines

A) Parallel Lines

Two lines in the same plane are parallel if they have no points in common.

If two lines are parallel in space, their horizontal projections are parallel, as are their frontal projections.

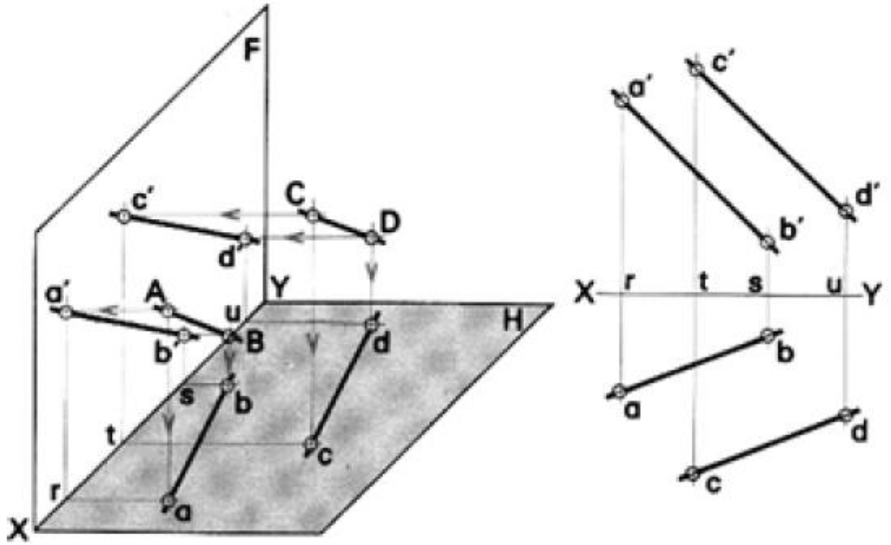


Fig 12. Parallel Lines

B) Intersecting Lines

Two lines are intersecting when they have a common point.

Let two lines AB and DC in space share a common point M.

This point belongs to both lines and therefore to their projections.

The intersection point of their horizontal projections (m) and the intersection point of their frontal projections (m′) necessarily lie on the same **reference line**.

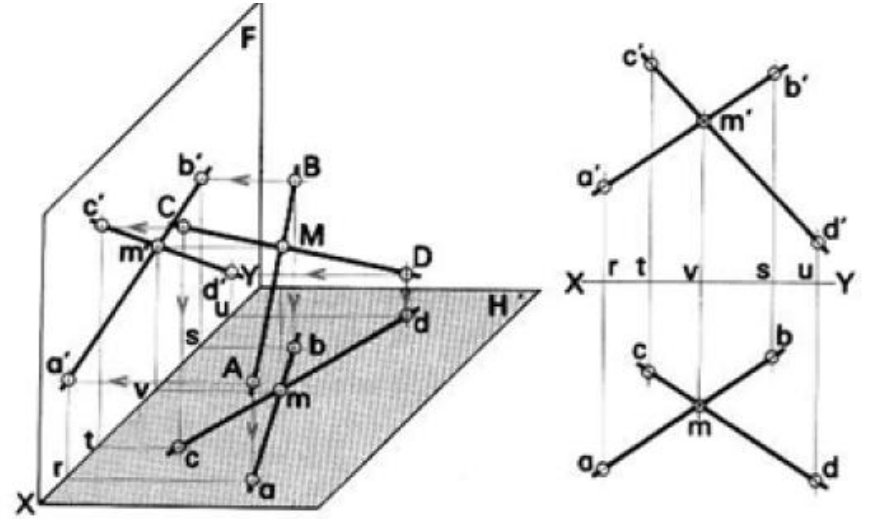


Fig 13. Intersecting Lines

3) The Plane

A plane is defined by:

- Three non-collinear points.
- A single point and a distinct line.
- Two lines intersecting at a point.
- Two parallel lines.
- In descriptive geometry, a plane is most often characterized by **two intersecting lines**, particularly through its **traces**.

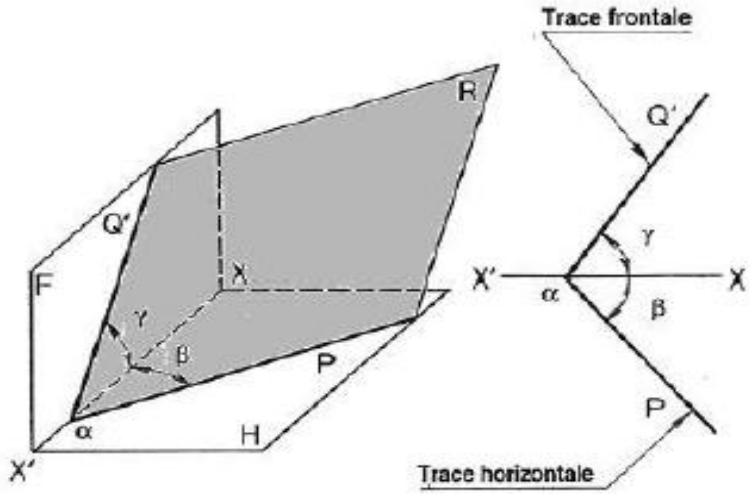


Fig 14. Traces of a Plane

Traces of a Plane

The traces of a plane are the lines along which it intersects the projection planes H and F.

- Pα and αQ are respectively called the **horizontal trace** and **frontal trace** of plane R.
- The two traces Pα and αQ intersect on the ground line xx′ at a point α.

Notable Positions of a Plane

A. Vertical Plane

A vertical plane is perpendicular to the horizontal projection plane H; the angle β it forms with the frontal plane F can be any.
The frontal trace αQ′ of a vertical plane is perpendicular to the ground line XY, and all points belonging to this plane are projected horizontally into its horizontal trace. For example, the horizontal projection a of a point A on plane R lies on the horizontal trace αP.

B. Debout Plane

A Debout plane is perpendicular to the frontal projection plane F; the angle δ it forms with the horizontal plane H can be any.
The horizontal trace αP of a debout plane R is perpendicular to the ground line XY, and all points belonging to this plane are projected frontally into its frontal trace. For example, the frontal projection a′ of a point A on plane R lies on the frontal trace αQ′.

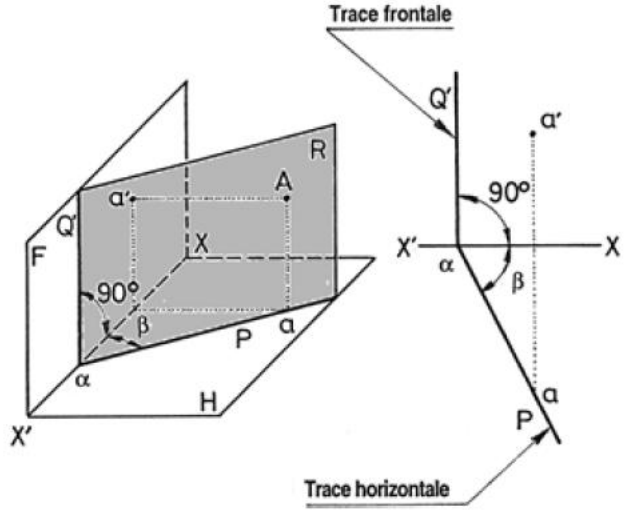


Fig 15. Vertical Plane

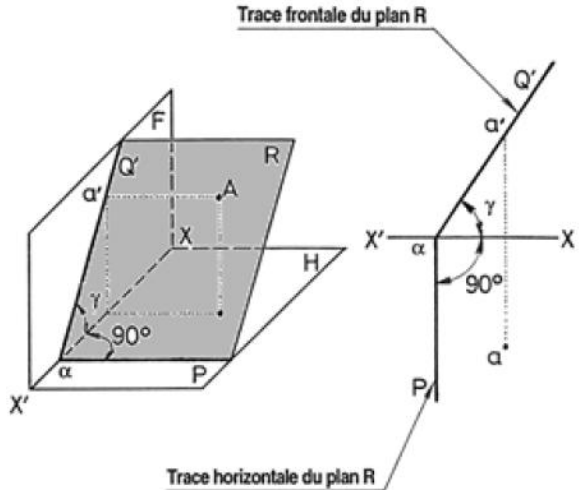


Fig 16. Debout Plane

C. Horizontal Plane

A horizontal plane is parallel to the horizontal plane H; consequently, it is perpendicular to the frontal plane F.

•Every point on a horizontal plane is projected frontally into the **frontal trace** of this plane. It has no horizontal trace, and its frontal trace is parallel to the ground line xx′. For example, the frontal projection (a′) of a point A on plane R lies on the frontal trace (Q′). Any plane figure contained within a horizontal plane is projected in **true length (TL)** on the horizontal plane H.

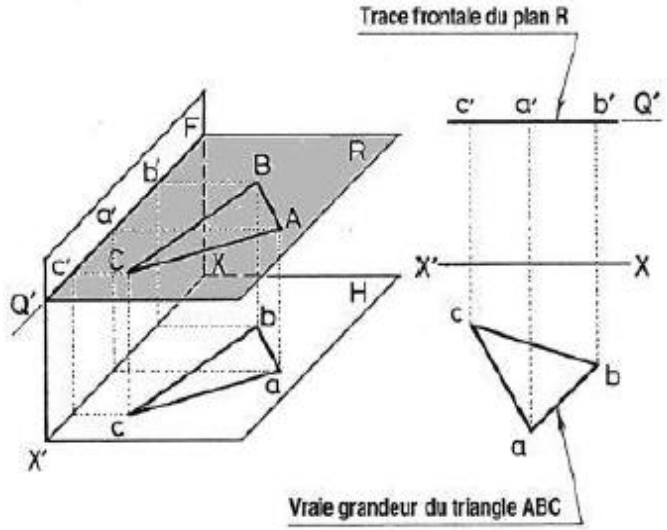


Fig17. Horizontal Plane

D. Frontal Plane

A frontal plane is parallel to the frontal plane F; consequently, it is perpendicular to the horizontal plane H.

•Every point on a frontal plane is projected horizontally into the **horizontal trace** of this plane. It has no frontal trace, and its horizontal trace is parallel to the ground line xx′. For example, the horizontal projection (a) of a point A on plane R lies on the horizontal trace (P). Any plane figure contained within a frontal plane is projected in **true length (TL)** on the frontal plane F.

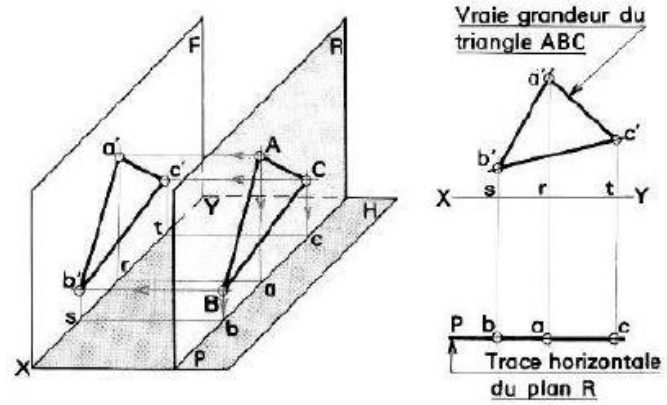


Fig 18. Frontal Plane

Views and Orthogonal Projections of an Object

1. Object

In industry, a precise and clear description of an object's shapes and dimensions is necessary for its manufacture.

Orthogonal projection is a descriptive geometry technique used to represent a part through multiple views.

2. Principle of Orthogonal Projection

Orthogonal projection involves projecting a geometric model of a part onto a plane perpendicular to the direction of observation. There are six main directions of observation:

A: Front view

B: Rear view

C: Right-side view

D: Left-side view

E: Top view

F: Bottom view

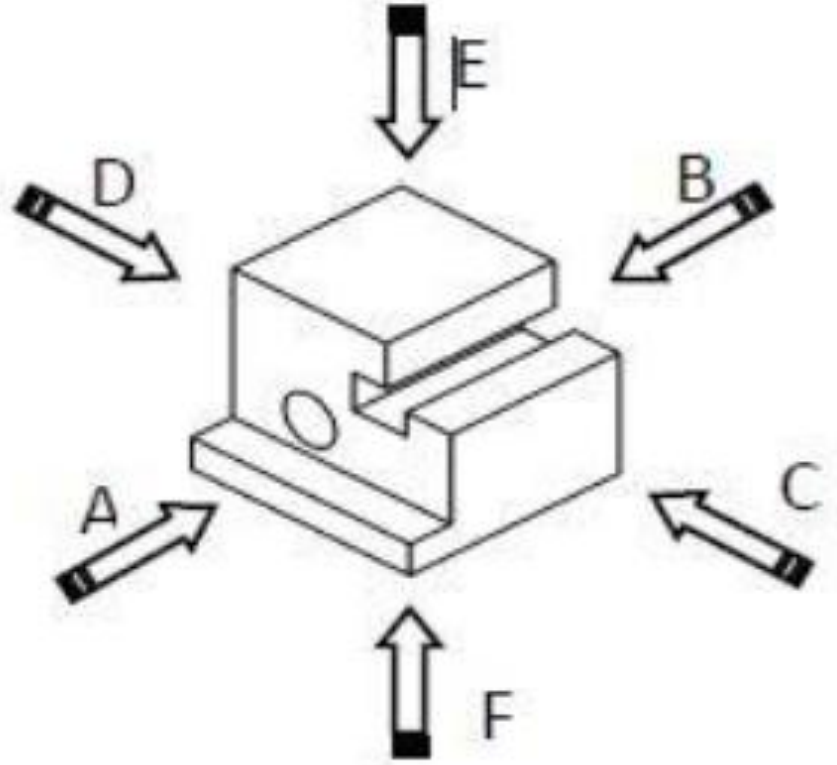


Fig 19. Different Views of a 3D Part

The observer positions themselves perpendicular to one of the faces of the object to be defined.

The observed face is then projected and drawn on a projection plane parallel to that face and located behind the object. The resulting flat drawing is an **orthogonal projection** of the object.

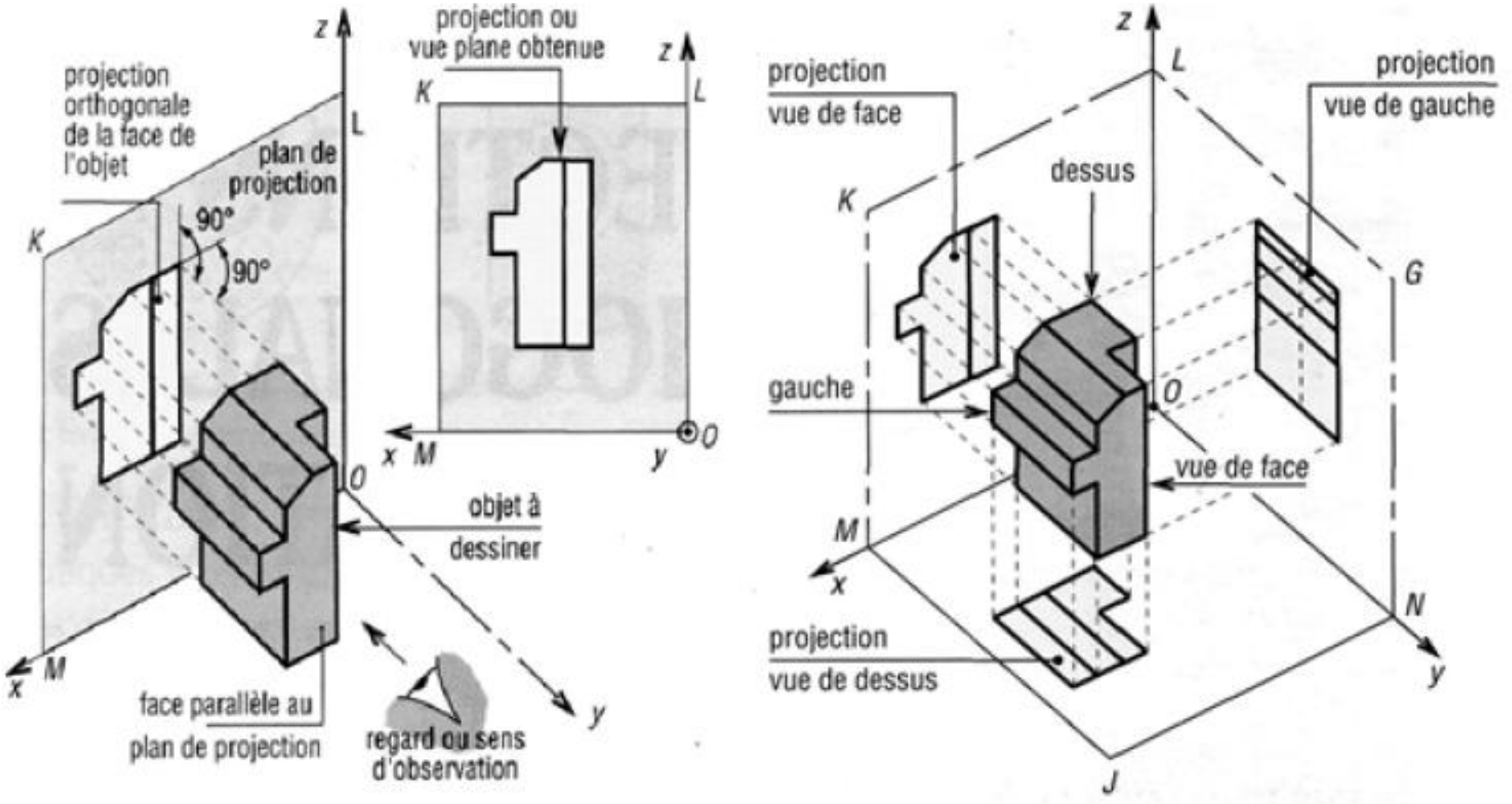


Fig 20. Principle of Orthogonal Projection

3. Orthogonal Projection System

In this representation system, the observer positions themselves perpendicular to one of the object's faces, called the **front view**. From this main view, it is possible to define five other orthogonal views or projections (analogous to the six faces of a die or cube).

- The obtained projections are called the **right**, **left**, **top**, **bottom**, and **rear views**.
- The planar representation of a part involves placing its geometric model inside a cube and projecting it orthogonally onto all six faces of the cube.

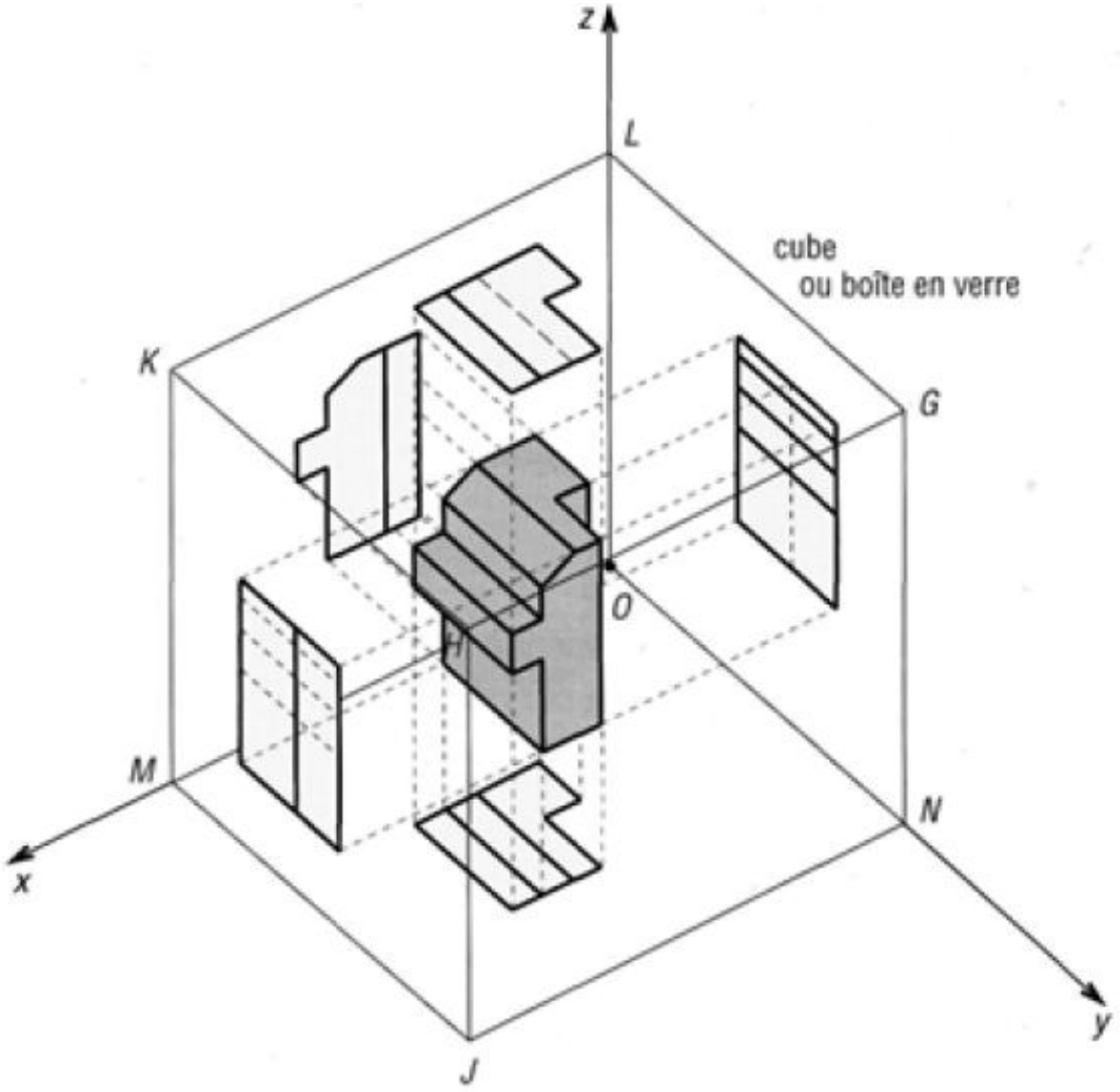


Fig 21. Orthogonal Projections on the Six Projection Planes

After projecting the solid into the six faces of the cube, the cube is then **unfolded**, as illustrated in the diagram below.

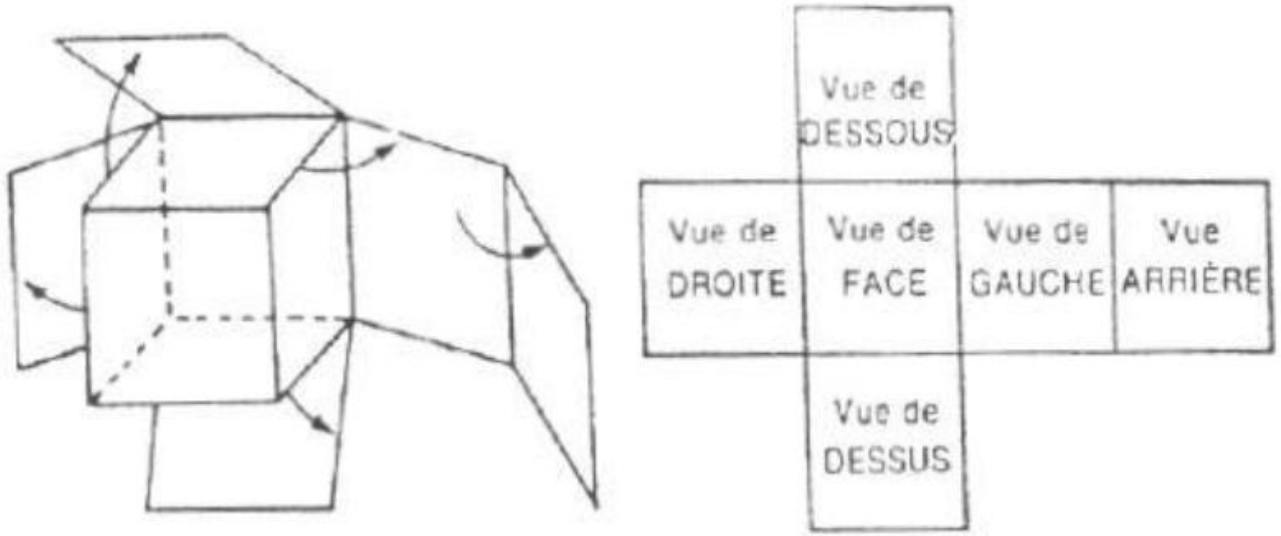


Fig 22. Arrangement of Views

Folding involves creating the drawing in a **single plane**.

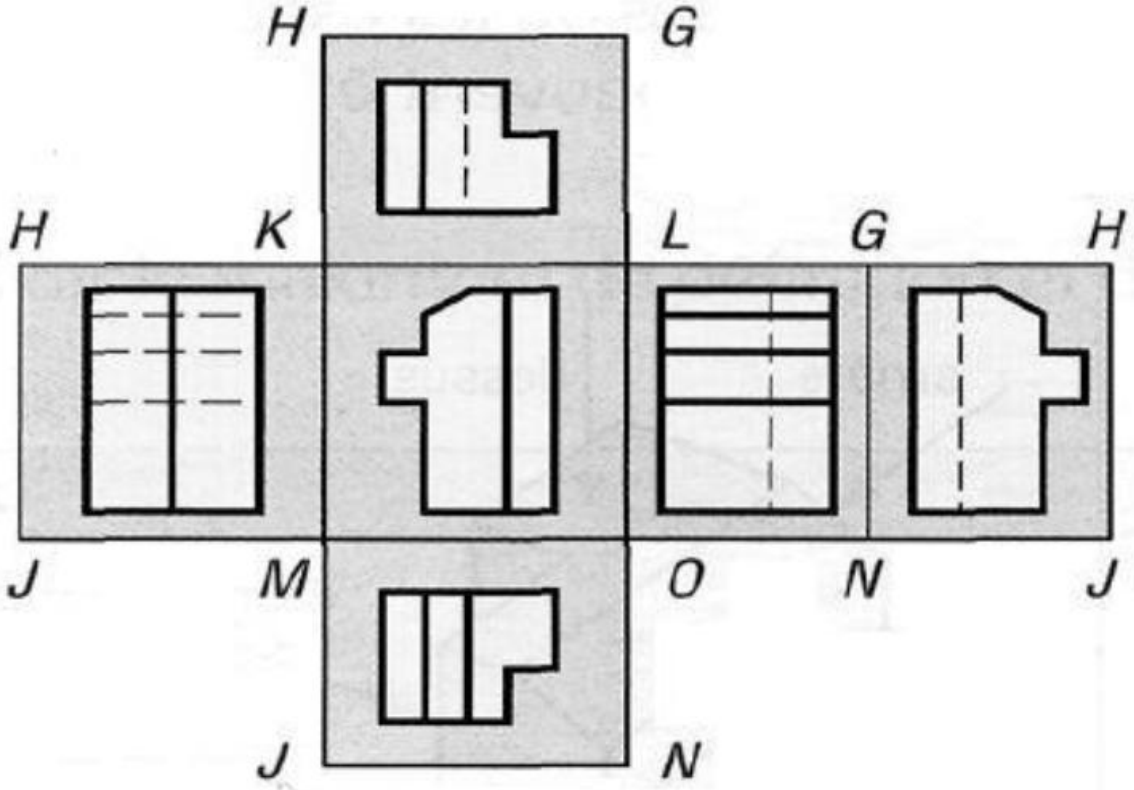


Fig 23. Folded Reference Cube

Six views are obtained: **front view, top view, bottom view, left view, right view, and rear view**.

•**Note:**

•The **right view** is drawn on the left, the **left view** is placed on the right; the **top view** is placed below, and the **bottom view** is placed above. The **front view** is chosen arbitrarily (often corresponding to an important face).

•**Important:**

•In technical drawing, views are arranged relative to a **central view**, which can be any face of the part as defined by the drafter—this is the **front view**.

•The front view is chosen to best represent the part, showing the **maximum details**, shapes, and contours.

•Preference is given to views with the **fewest hidden edges or broken lines**. Unnecessary views are omitted. The **rear view** is rarely needed.

•Among the six possible views, only those necessary to describe the shape of the object are represented. **Three views** are usually sufficient to describe a part, while some simple objects require only **one or two views**.

4. Rules (Standardization)

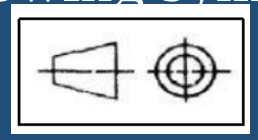
- The **visible parts** of the object (edges, surfaces) are drawn with **thick continuous lines**.
- The **hidden parts** (edges, surfaces, internal features, etc.) are drawn with **short dashed lines**.
- In case of overlap or superposition, the **priority order** for the final drawing of lines is:
  - **Continuous line** or thick line;
  - **Dashed line** or short interrupted line;
  - **Chain line** or thin mixed line (axes, centerlines, etc.).
- **Example:** If a thick continuous line overlaps a short dashed line, the **thick line** takes precedence in the final drawing.

5. Types of Projection

•The **ISO international standard** adopts the principle of orthogonal projections and the resulting arrangement of views. The corresponding standardized symbol should be included on every drawing using this principle.

•European Projection

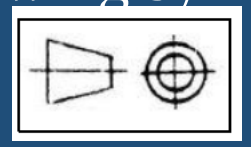
The European method, or **first-angle projection**, is designated by the letter **E** and has the following symbol:



In this projection, the object is positioned **between the observer and the projection plane**. For example, in the front view, the observer is placed in front of the object and projects it onto the plane behind. The name of the view is thus determined by the **observer's position**.

•American Projection

The American method, or **third-angle projection**, is designated by the letter **A** and has the following symbol:



In this case, the **projection plane is located between the observer and the object**. In other words, the observer and the projection plane are on the same side relative to the object. Here, the name of the view is determined by the **position of the projection plane**.

6. Correspondence of Views

•From known views, it is possible to deduce any other view using the **view correspondence projection**.

•Views constructed from mutually perpendicular projection planes have the property, after unfolding and development, of being **in correspondence** or **aligned** with one another.

•The dimensions of the object or its features are preserved from one view to another without variation and can be determined using the same **vertical, horizontal, or other reference lines**.

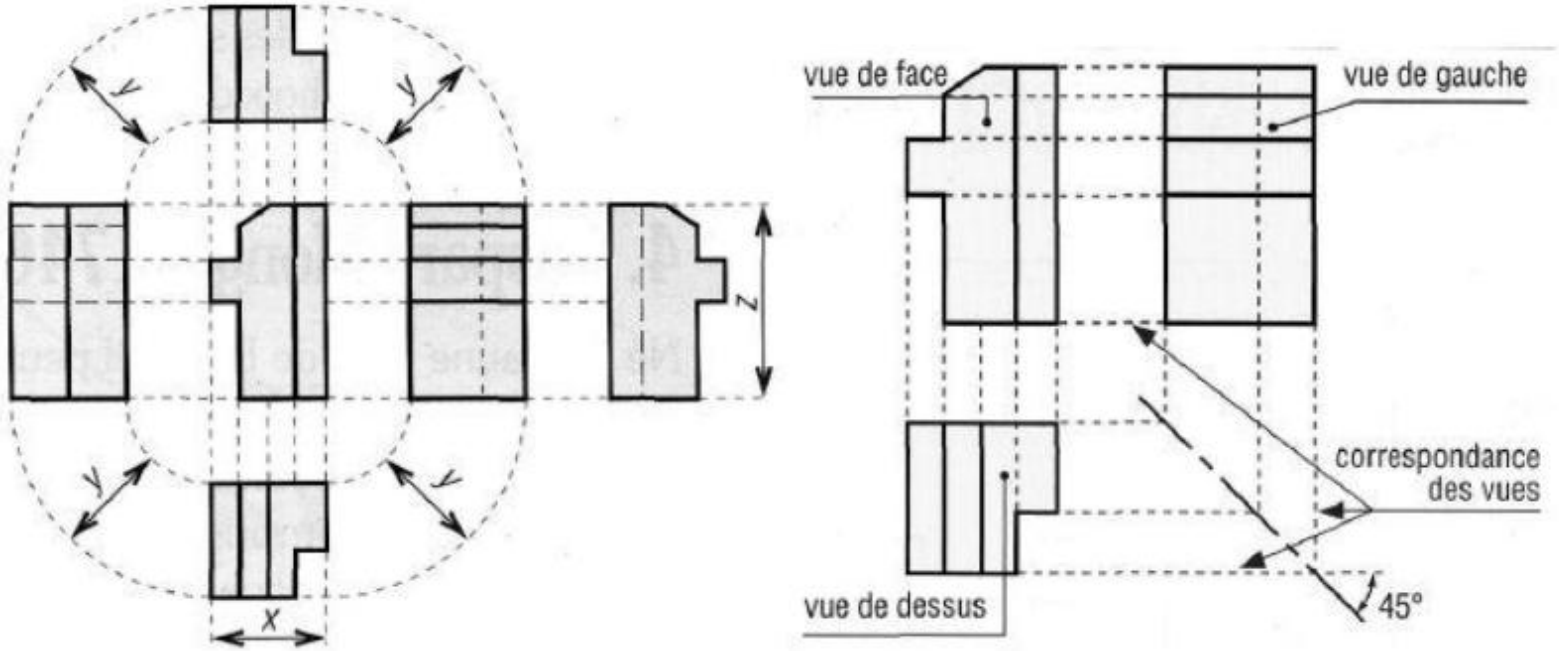


Fig 24. Correspondence of Views

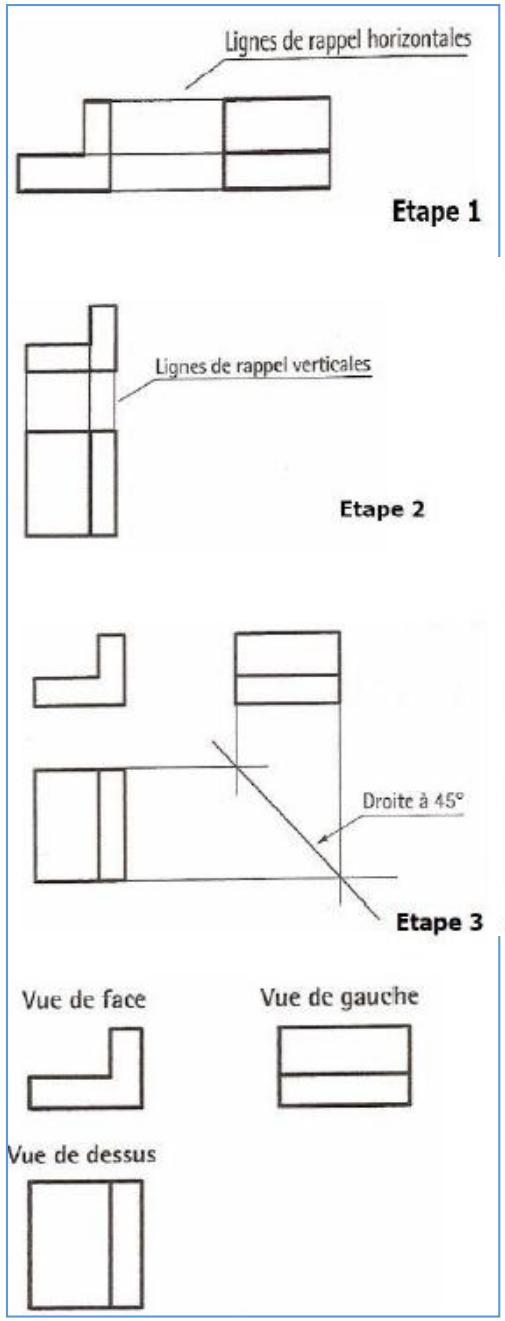
Procedure for Constructing an Additional View from Two Known Views

•Step 1:
Draw **thin horizontal reference lines** between the front view and the profile view (left or right).

•Step 2:
Draw **thin vertical reference lines** between the front view and the top (or bottom) view.

•Step 3:
Draw **thin reference lines** between the profile view (left or right) and the top (or bottom) view using a line inclined at **45°**.

•Step 4:
Once the view is completed, **erase all the reference lines** (vertical, horizontal, and inclined).



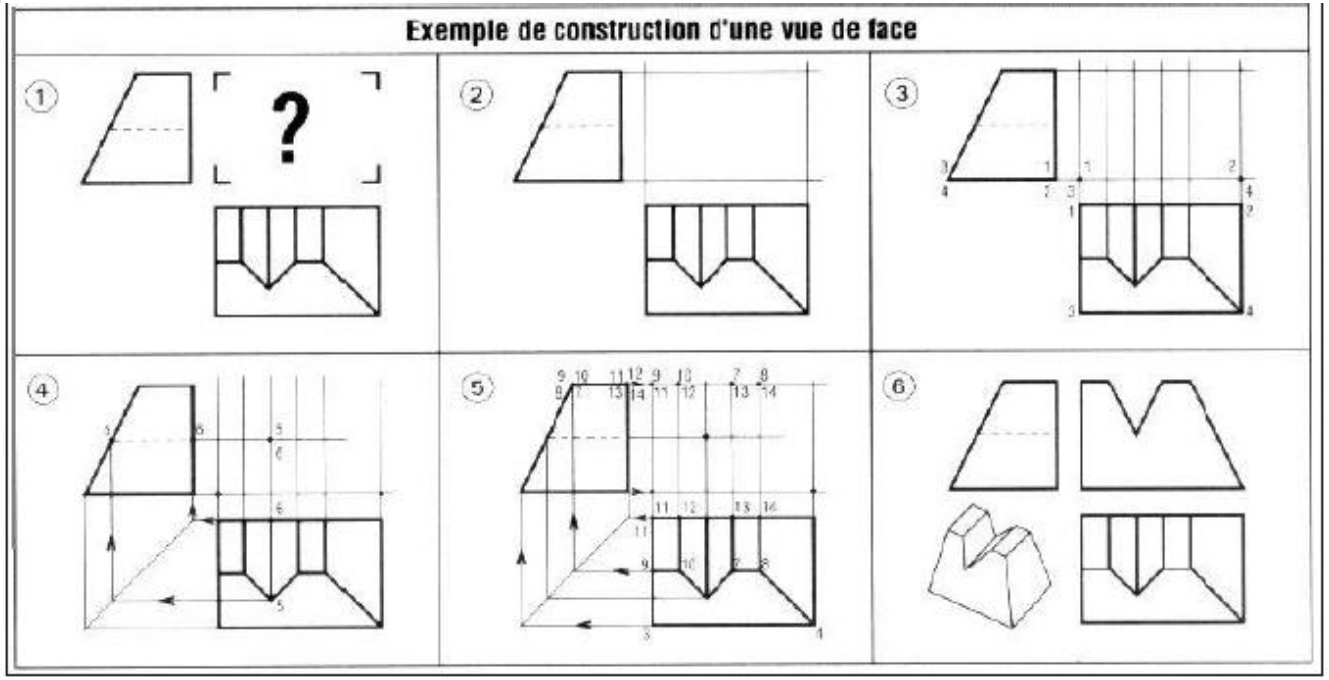


Fig 25. Example of Constructing a Front View

7. Selection of Views

•The drawing of an object intended for production should include **only the views necessary** for a clear and complete description of the object's shape. These views are called **necessary views**.

•For objects with **simple shapes**, **constant thickness**, or **specific symmetries** (e.g., rotational parts such as shafts, axles, fasteners), **one or two views** may be sufficient.

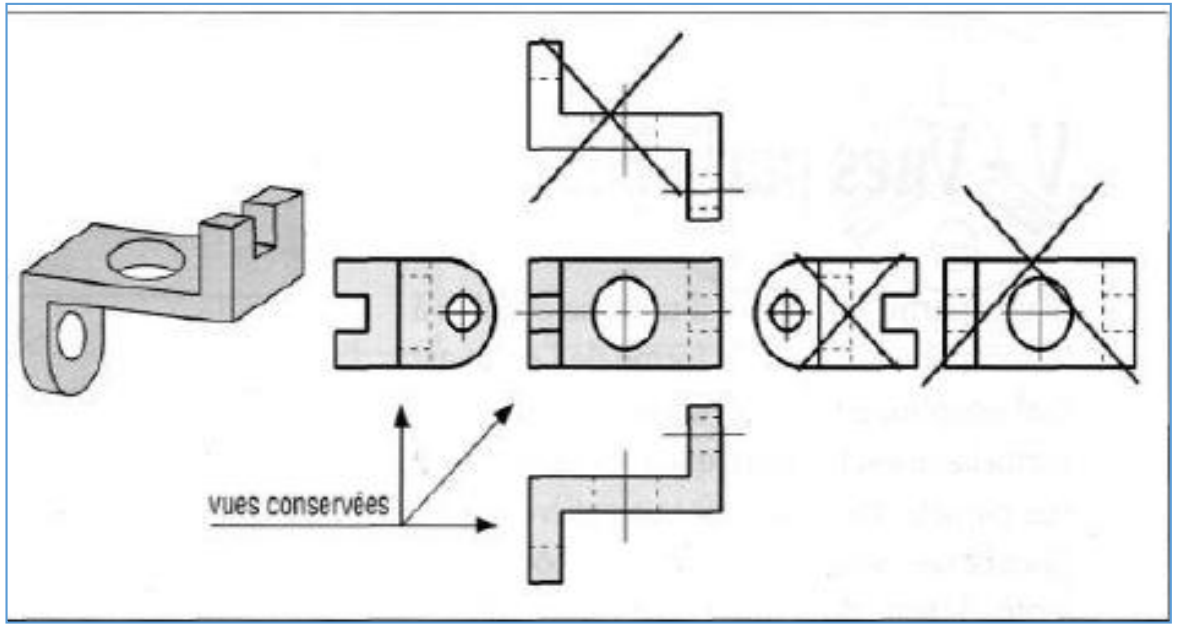


Fig 26. Example of Necessary Views

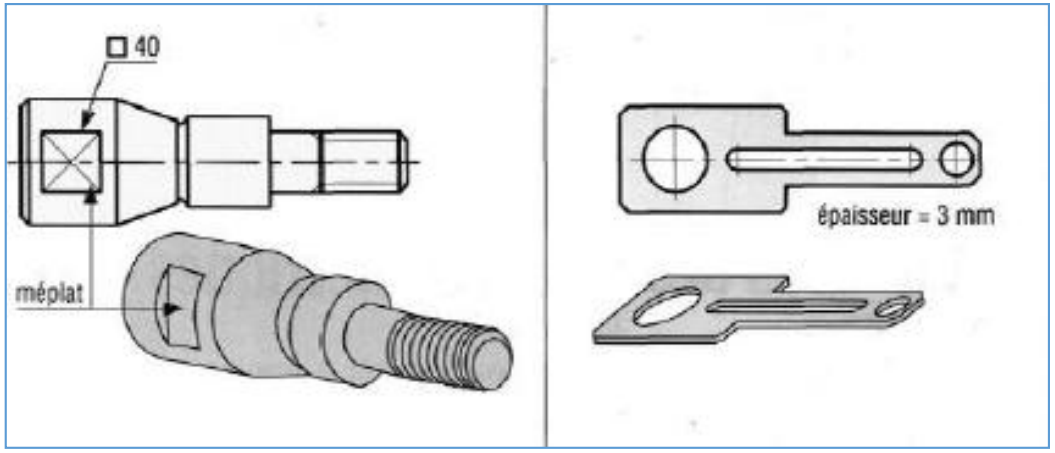


Fig 28. Example: One View Is Sufficient

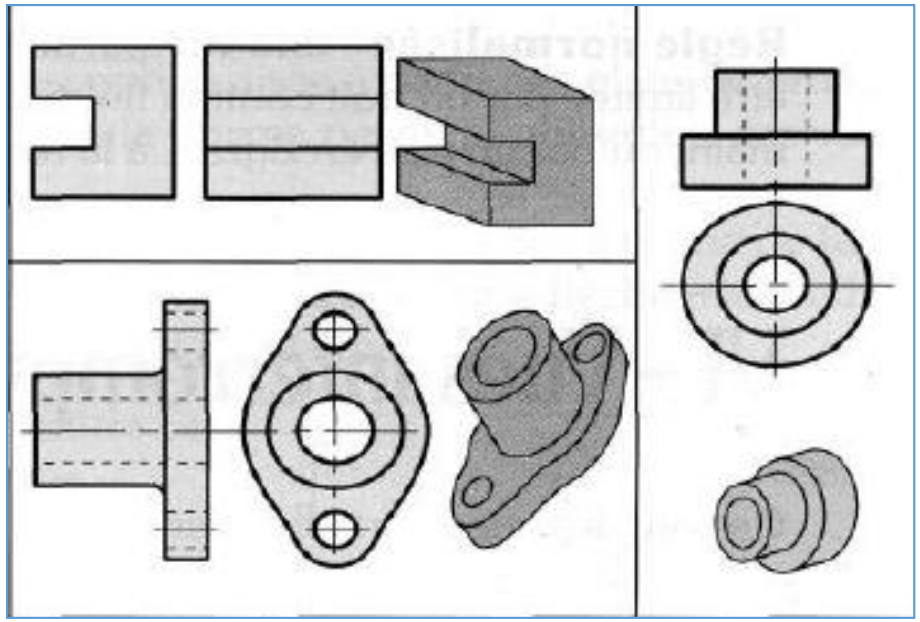


Fig 27. Example: Two Views Are Sufficient

Methods for Executing a Drawing

•**Before constructing the main views**, determine the three dimensions of the object: **width, height, and depth**. **Frame and title block:** Every drawing must be framed and properly identified.

•The different views of a drawing must be **centered on the sheet**, maintaining **regular spacing** between them.

•To achieve this, it is necessary to know: the **sheet format dimensions**, the **frame values**, the **title block dimensions**, and the **space requirements for the views at the chosen scale**. This ensures a **well-organized presentation** with evenly spaced views.

•Two intervals are calculated:

•**IH:** horizontal interval **IV:** vertical interval

•The formulas depend on the number of views to be drawn. For example, in the case of the **three views shown**:

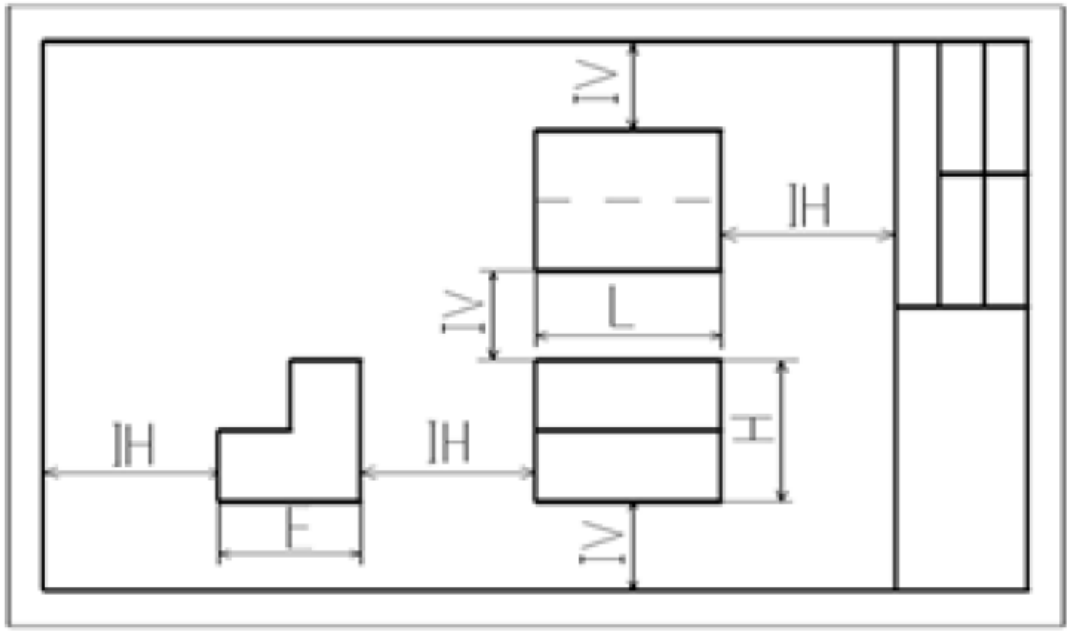


Fig 29. Drawing Layout Execution

$$IH = \frac{247-E-L}{3}$$

$$IV = \frac{190-H-E}{3}$$

Execution of Views

•1. Make the sketch (entire drawing) with thin lines:

a. Draw the **bounding rectangles**.

b. Draw each shape in all views simultaneously, starting with the view in which the shape is most clearly represented.

•2. Finalize the drawing with thick lines:

c. Always start with the **thin lines**: axes, dashed lines, then proceed to the **thick lines**.

d. Draw all **circles and rounded features** first.

e. Redraw all the **overall views**, sweeping the drawing **top to bottom** for horizontal lines and **left to right** for vertical lines.

f. Add **dimensions**.

g. Include **section indications and annotations**.

Conclusion

•Descriptive geometry is a fundamental branch of mathematics that allows the representation of three-dimensional objects on a two-dimensional plane. It provides the necessary tools to **graphically describe the shape, dimensions, and spatial relationships** of objects in a precise and rigorous manner.

•Technical drawing, based on the principles of descriptive geometry, is a means of **formalizing ideas and effectively communicating technical concepts**. It goes beyond a simple depiction of shapes, enabling the **conveyance of all geometric characteristics** of an object through **orthogonal projection views**.

•In conclusion, **descriptive geometry and technical drawing** remain complementary and essential disciplines for **formalizing, communicating, and designing three-dimensional objects**, whether in a manual or digital context.

Bibliography

1. Guide du dessinateur industriel, Chevalier, Hachette, édition 2004.
2. Le dessin technique 2ème partie, le dessin industriel, Felliachi d. et bensaada s, édition OPU Alger, 1995.
3. Premières notions de dessin technique, Andre Ricordeau, édition Andre Casteilla.
4. Aide mémoire de l'élève dessinateur et du dessinateur industriel, M. Norbert et R. Philippe, édition la capitelle, Année 1981.
5. Chevalier, Guide du dessinateur industriel, Hachette édition 2004.
6. Guide des sciences et technologie industrielle, J. L. Fanchon, édition Natan, 2001.