

## ORTHOGRAPHIC AUXILIARY VIEWS

### 6.1 Introduction

An auxiliary view is an orthographic view on a plane that is not one of the principal planes of projection. It is created from at least two principal views with the aim of showing the true shape and size of a feature. Conceptually, it is a normal view obtained by looking on a plane in a direction perpendicular to it. The direction of a plane is defined by an axis perpendicular to it. Though there is no limit to the number of auxiliary views that can be generated from principal views, practical considerations restrict views to preferred directions of inclined and oblique faces on objects. Consequently, a limited number of auxiliary views are normally needed in technical graphics. A primary auxiliary view is the first auxiliary view that is obtained from two principal views of an object. A secondary auxiliary view is generated from a primary auxiliary view and one principal view. Third, fourth, etc. auxiliary views may be drawn; however, most technical graphic problems can be solved with one or two auxiliary views. Successive auxiliary views are views obtained from one principal view and a primary auxiliary view or from two other auxiliary views. Usually, one auxiliary view can substitute for one of the standard or principal views and thus reduce the total number of views necessary for complete description of a component. Hidden lines appearing behind auxiliary views are usually not shown for clarity purposes.

### 6.2 Understanding Auxiliary Views

Auxiliary views are needed when a feature is foreshortened in one or more principal views. Features are foreshortened when they appear on inclined and or oblique faces. Foreshortened images are distorted, so there is always a necessity to clarify such images in technical graphics. Auxiliary view techniques allow us to look directly (perpendicularly) at a face on an object and hence see the features on it in true shape and size. Hence the techniques of generating auxiliary views help us correct the distortion of foreshortened images on principal views, though they are often tedious to create manually. However, auxiliary can be generated easily from CAD packages.

In creating auxiliary views, some concepts need to be properly understood. These include the true length (TL) line, edge view of a plane, inclined and oblique planes. A true length line is one whose true size is represented on a view. The edge view of a plane is a line. This is the view of a plane when the view direction is parallel to the plane. Inclined and oblique planes can be recognized by inspecting two adjacent principal views.

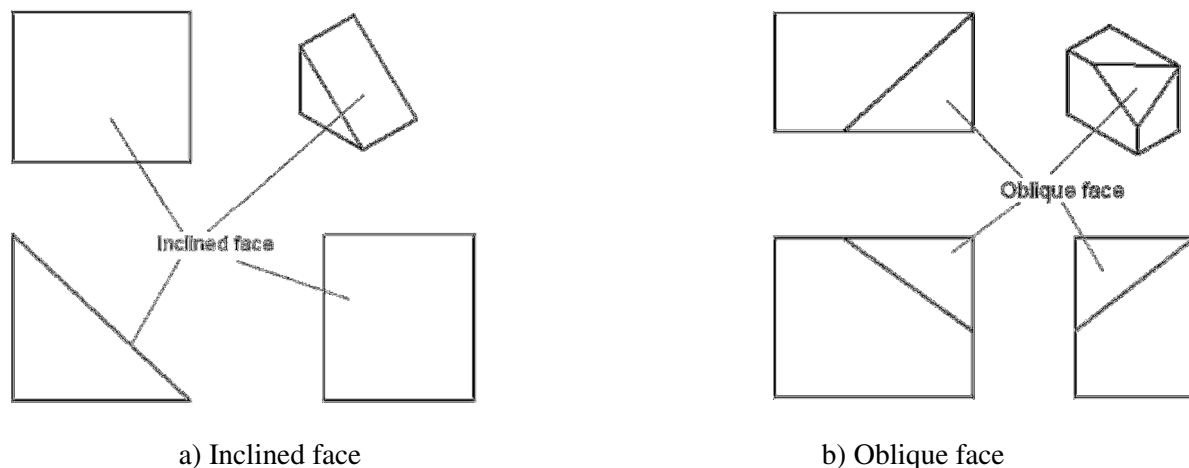


Fig. 6.1: Inclined and oblique faces

Fig. 6. 1a shows the case of an inclined face where the *edge view* of the face is shown in one principal (front) view. The face is shown foreshortened in the other two principal views. In Fig. 6.1a two adjacent views are sufficient to identify the face as inclined (front and right or front and top). In a problem with an inclined face, only a primary auxiliary view will be needed to create the true shape and size of a feature on it. Hence for Fig. 6.1a, one auxiliary is required to reveal the true shape of the inclined face. Fig. 6.1b shows the case of an oblique face where no *edge view*

of the face is shown in a principal view. That is, the face is shown foreshortened in the three principal views. In Fig. 6. 1b, a combination of the front and top views or the front and right views is enough to identify the face as oblique since the plane appears foreshortened in either pair. In this case, both primary and secondary auxiliary views would be needed to create the true shape and size of the feature on such a face.

In orthographic projection, standard drawing views are created on the standard projection planes of top (horizontal), front (frontal), side (profile). The frontal and profile planes are vertical, while the top is horizontal. The view direction for the frontal and profile planes is horizontal and the view direction for the horizontal plane is vertical. To see the true shape and size on an inclined or oblique face, an auxiliary view must be created. A view direction perpendicular to the edge view of a plane will always reveal the true shape and size of features on a plane. Hence, the auxiliary view that will reveal the true shape of a feature must be projected from a view that shows an inclined face or shows an oblique face as an edge or a line.

Features are foreshortened whenever they appear on an inclined or oblique face on an object. As the form of components gets more complicated, inclined and oblique faces may become part of the features. To create the necessary auxiliary view for the true shape and size of faces and features on them, first identify or create an edge view of the face; then project the face in a direction perpendicular to the edge view plane. Fig. 6.2a shows two adjacent views of a line with end points 1 and 2. Point 1 in the front view is indicated by F1 and H1 in the top view. In the front view, the line is horizontal and parallel to the fold line, a reference line between the two views. On the top (horizontal) view, the line is inclined and shows the true length of the line. Hence a view showing the true length of an inclined line is adjacent to a view that shows the inclined line parallel to a fold line. Fold lines are not always shown in standard orthographic view. They may be safely assumed to be midway in the gap between the adjacent views. Fig. 6.2b shows an oblique face with no TL line. To create a TL line, the line F2-F4 is drawn horizontal and projected to the top view as H2-H4. The line H2-H4 is a TL line. This line gives the required view direction for the edge view of the oblique face. The principle to take note of is that the edge view must be created with a view direction parallel to a TL on the oblique face. In many drawings, TL line can be identified where two faces on an object intersect.

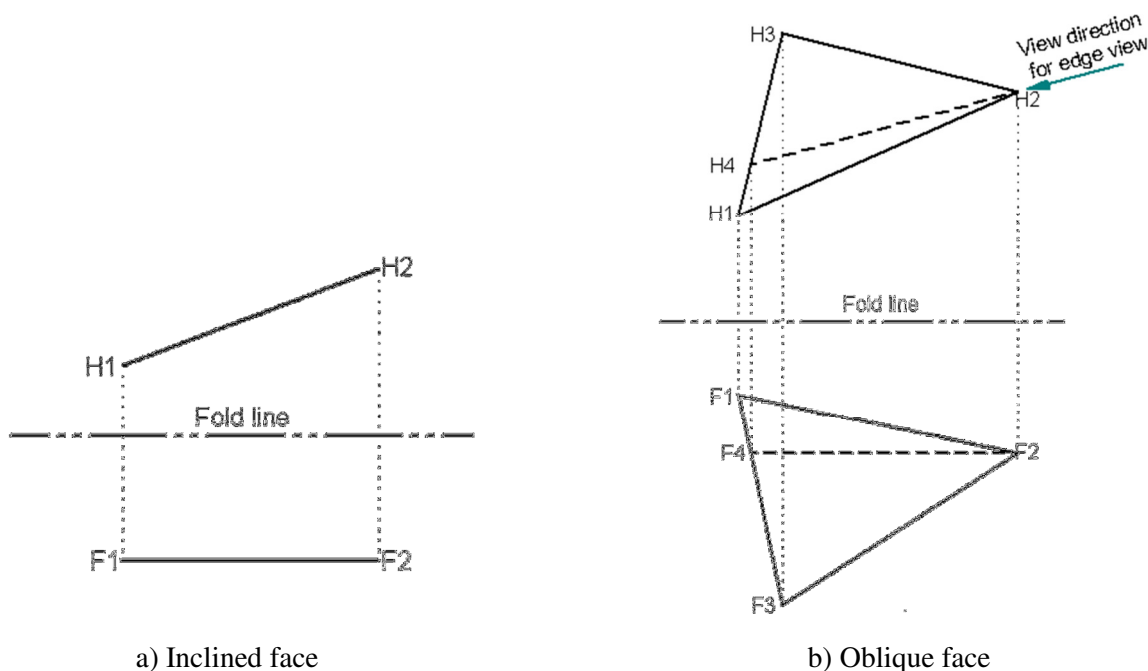


Fig. 6.2: Identifying or creating TL line

In the case of an inclined face, the TL line is the edge view of the face itself. Hence the primary auxiliary view derived from the edge view gives the true shape and size for the face and the features on it. If a TL line cannot be identified on an oblique face, one can be created as shown in Fig. 6.2b. Once a TL line is available, the edge view of the oblique can be created in a primary auxiliary view with the projection lines parallel to the TL line. The true shape

and size of the oblique face and the features on it can then be created in a secondary auxiliary view with the projection lines perpendicular to the edge view line.

### 6.2.2 Auxiliary View Image Box

An image box can be constructed with an auxiliary plane included in the principal image box. The auxiliary plane must be made parallel to the inclined or oblique face in the image box. Fig. 6.3a illustrates this concept for an inclined face. The layout of the views in the image box is shown in Fig. 6.3b. Note that the right view is omitted in the layout. It is important to maintain the same amount of distance for the nearest point on an image from all the fold lines (edges of the image box) in the layout. Auxiliary views must be aligned with the auxiliary face in layout. Also, all projection lines must be perpendicular to the auxiliary plane. The view direction is always parallel to the projection lines.

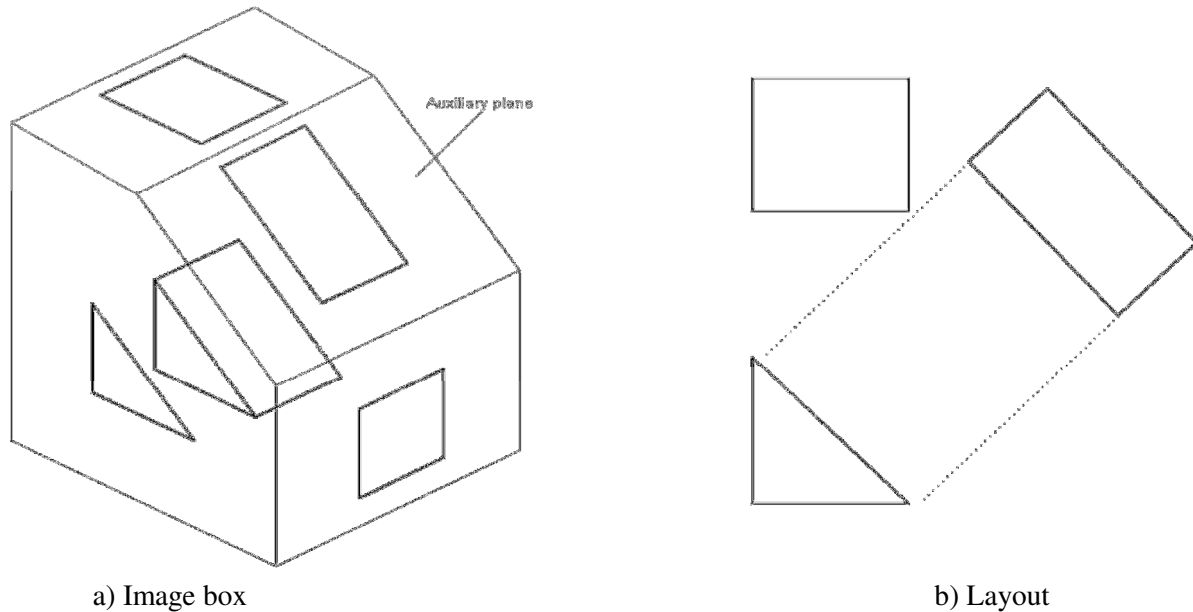


Fig. 6.3: An auxiliary image box and layout

### Full and Partial Auxiliary Views

Auxiliary views may be created as full or partial views. In a full auxiliary view, all elements and features on the object as seen from the view direction are represented on the auxiliary view. In a partial auxiliary view, only the features on an inclined or oblique face are represented on the auxiliary view. In many cases, the inclined and oblique faces are portions of a larger component, with some features appearing true shape and size in some standard views. Therefore, there is no real need to represent on auxiliary views, features that are seen in true shape and size in principal or standard views. Hence partial auxiliary views are most often needed to supplement standard views. This usually leads to a clearer presentation as additional non inclined or oblique features might actually confuse the view.

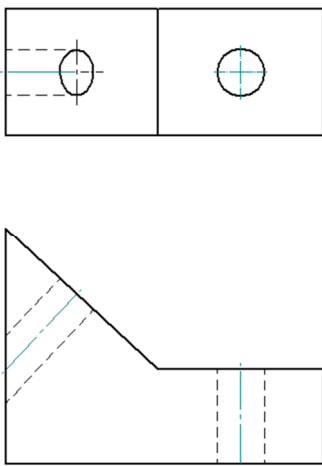


Fig. 6.4 shows two (front and top) principal views of an object with an inclined face. On the inclined face is a circular hole. It is clear that the top view gives a distorted shape (ellipse) of the circular hole on the inclined face. The main intent of precisely communicating the size and shape of the hole is not achieved in this top view. Therefore, an auxiliary view is necessary to precisely communicating the size and shape of the hole.

Fig. 6.4 Distorted feature in top view

Figs. 5a and 5b show the full and partial auxiliary views for Fig. 6.4. In a full auxiliary view, all features in the view direction on the object are represented. This means images of both foreshortened and non-foreshortened features on principal views are shown. But the real focus is on the foreshortened images on principal views. Hence the images of non-foreshortened features on principal views are not necessary in auxiliary views, they just complicate drawings.

For instance, it is obvious that the extra details in the auxiliary view of Fig. 6.5a are better revealed in the principal views of Fig. 6.4 and hence the partial auxiliary view of Fig. 6.5b is preferred. Note that in the partial auxiliary view of Fig. 6.5b, hidden lines have been omitted. This normally enhances clarity of views as can be verified by comparing the partial view of Fig. 6.5b with the appropriate portion in the full view in Fig. 6.5a.

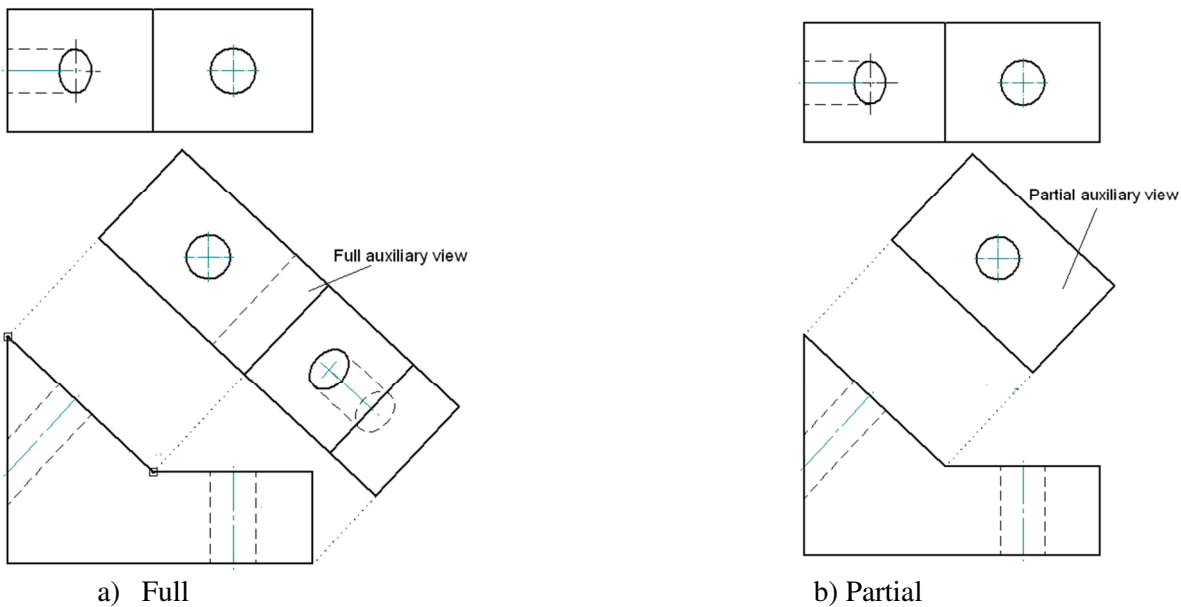


Fig. 6. 5 Types of auxiliary views

#### 6.4 Construction of Auxiliary Views

This section discusses techniques for constructing auxiliary views for features on inclined faces, oblique faces, and irregular shapes. The true size and shape of features on an inclined plane needs one auxiliary plane, a primary auxiliary plane for development. However, the true size and shape of features on an oblique plane can be developed with a minimum of two auxiliary planes; namely a primary auxiliary plane and a secondary auxiliary plane.

##### *Constructing Features on Inclined Faces*

When a feature is on an inclined plane, the edge view of the plane will be revealed in one of the principal views. This view should be chosen as the base view for developing the auxiliary view that will show the true shape of the feature. Since the auxiliary view is created from a principal view, it is a primary auxiliary view. The steps to employ in constructing the auxiliary view are outlined below.

**Step 1: Create two principal adjacent views.**

Create two adjacent principal or standard views. All the features on the two views need not be completed in order to proceed to the auxiliary view. One of the standard views should show the edge view (line) of the inclined face as in Fig. 6.6. Identify this view as the base view (front view in Fig. 6.6) for auxiliary view creation.

Right view

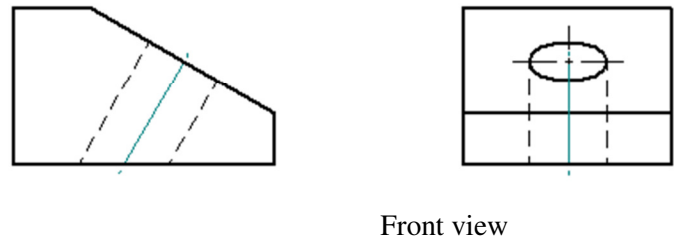


Fig. 6.6: Two principal views

**Step 2: Draw projection lines for auxiliary view.**

Identify the vertices of the face and use them to draw projection lines. In Fig. 6.6, the vertices of the face are the two end points of the inclined line or edge view of the face. Key points on features on the face may be used also in drawing projection lines. The key points on the circular feature are the edges and the center line of the hole. Draw projection lines from the identified vertices and key points perpendicular to the face as shown in Fig. 6.6. A fold line may be drawn and used as a reference line for the transfer of dimensions between adjacent views. A fold line must be parallel to the edge view of the inclined face at a convenient distance. A fold line is not shown in Fig. 6.6.

Projection lines for auxiliary view

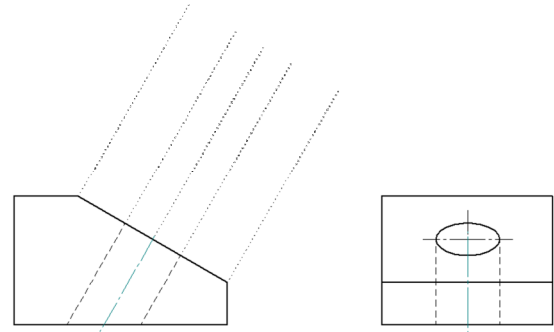


Fig. 6.7:

**Step 3: Draw the outline of inclined face.**

Establish the distance of each vertex on the auxiliary view from the adjacent principal view (right view in Fig. 6.6) to the base view. Transfer the distance of each vertex to the auxiliary view and draw the outline of the inclined face. Fig. 6.8 shows the construction of the inclined face outline.

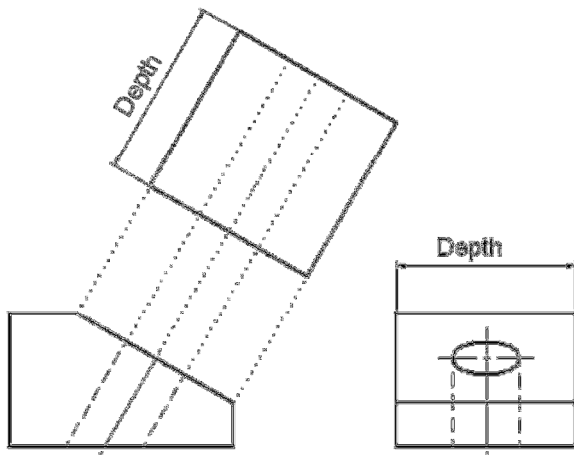


Fig. 6.8: Draw outline of face

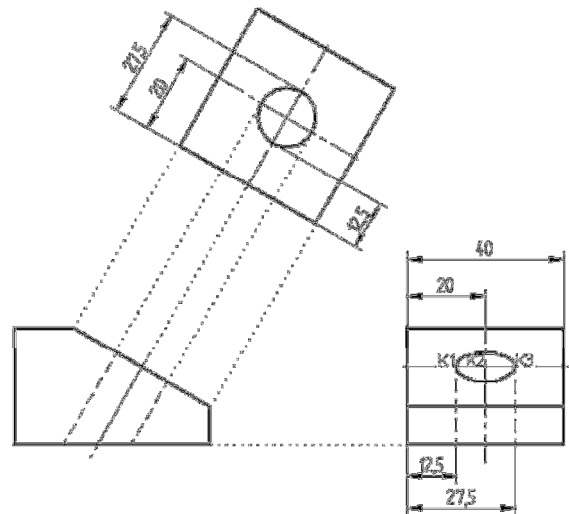


Fig. 6.9: Draw the feature

**Step 4: Draw the feature on inclined face.**

Establish the distance of key points of the feature on the inclined face (K1, K2, and K3 in the right view of Fig. 6.9) from the adjacent principal view to the base view. In this example, these are two horizontal quadrants on the ellipse on the right view and the center line of the hole. Transfer the distance of the each key point to the auxiliary view and draw the feature. Fig. 6.9 shows the construction of the circle feature on the auxiliary view. It is very important that the principle of size transfer be properly understood: transfer size from the second view prior to the current auxiliary view.

**6.4.2 Constructing Features on Oblique Faces**

Sometimes a feature may lie on an oblique face. In this case, both a primary and a secondary auxiliary view will be needed to establish the true shape and size of the face and the features on it. The primary auxiliary view is used to develop the edge view of the face and the secondary auxiliary view shows the true shape and size of the face and feature(s). The steps to solve this problem are:

**Step 1: Create two principal views.**

In Fig. 6.10, two adjacent principal or standard views are created. Again, the full views need not be created in order to construct the auxiliary views. It may in fact be necessary to criss-cross between the principal and auxiliary views during the development. Remember that none of these principal views will show the edge view of the oblique face. Some judgment is needed in selecting elements that can reduce time and effort in the construction process. This comes with practice and experience.

**Step 2: Identify a line element of true length (TL) on the oblique face in the base view.**

If no line can be identified as of true length on the oblique face on any view, then create a horizontal line on the oblique face in one principal view, draw the true length of this line in the adjacent principal view; Fig. 6.2 gives more information on creating a TL line. Choose the view with the true length line as base view. In Fig. 6.10, we can identify a true length line on the oblique face in the top view as indicated in Fig. 6.11. This is the front edge between the top face and the oblique face. Hence the base view for auxiliary views creation is the top view in Fig. 6.10.

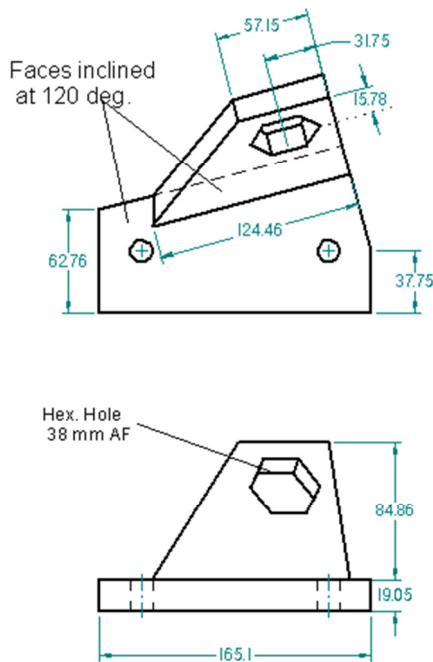


Fig. 6.10: Principal views

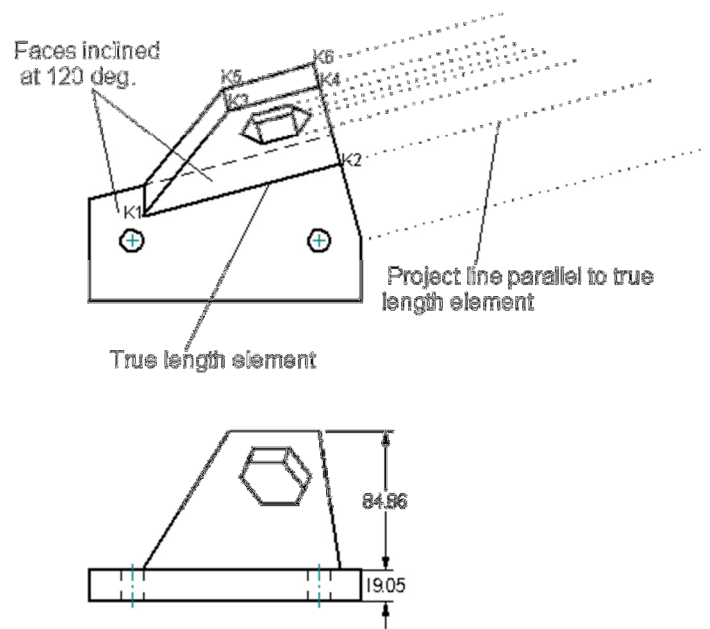


Fig. 6.11: TL line and projection lines

**Step 3: Draw projection lines for primary auxiliary view.**

Identify the vertices of the oblique face and use them to draw the projection lines. In Fig. 6.10, the vertices of the face are the end points of the base line (points K1 and K2 in Fig. 6.11) and the top line on the front end of the oblique face (points K3 and K4 in Fig. 6.11). The key points K5 and K6 are identified for the projection of object thickness. Draw projection lines from the identified vertices parallel to the true length line element, see Fig. 6. 11. Note that all projection lines must be parallel to each other.

**Step 4: Draw the edge view.**

A reference or fold line may be drawn and used for the transfer of dimensions between adjacent views. A fold line must be perpendicular to projection lines, see Fig. 6.12. Once the reference line is drawn, the edge can then be created by transferring dimensions of key points or vertices from two views behind as explained earlier. It is sufficient to draw only the lines of the edge views without adding thickness sizes. In Fig. 6.12, the material thicknesses of the two faces have been added. These dimensions could have been omitted without loss of accuracy. This view is the primary auxiliary view which shows the edge view of the oblique face.



Step 5: *Draw projection lines for secondary auxiliary view.*

From the vertices and key points on the edge view, draw projection lines for the secondary auxiliary view. These projection lines must be perpendicular to the edge view line. This step is shown in Fig. 6.13.

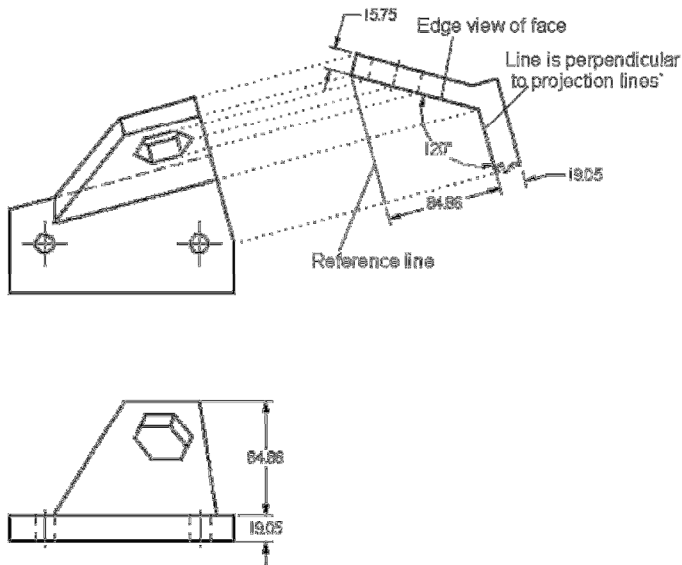


Fig. 6.12: Reference line and edge view

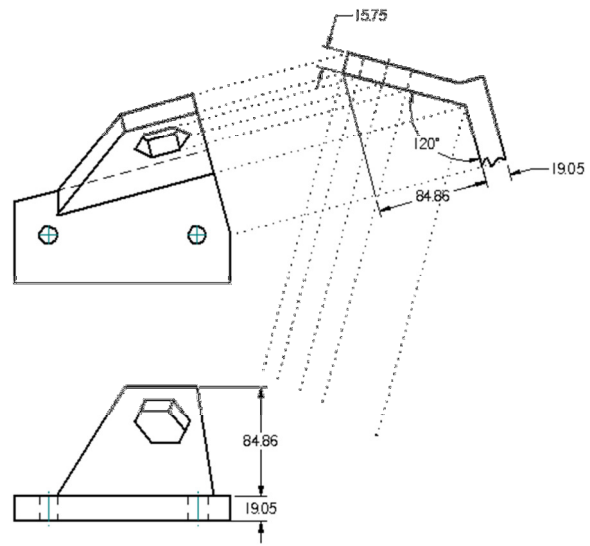


Fig. 6.13: Projection from edge view

Step 6: *Draw the outline of oblique face.*

Establish the distance of each vertex on the oblique face from the base view in Fig. 6.10. Transfer the distance of each vertex to the auxiliary view and draw the outline of the oblique face as shown in Fig. 6.14.

Step 7: *Draw the feature (s) on oblique face.*

Establish the distance of each key point on feature(s) on the oblique face from the base view in Fig. 6.10. Transfer the distance of each key point to the secondary auxiliary view and draw the feature(s) as shown in Fig. 6.15.

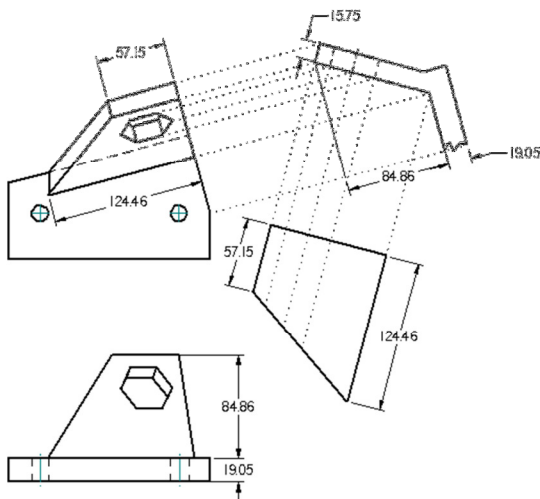


Fig. 6.14 Draw outline of oblique face

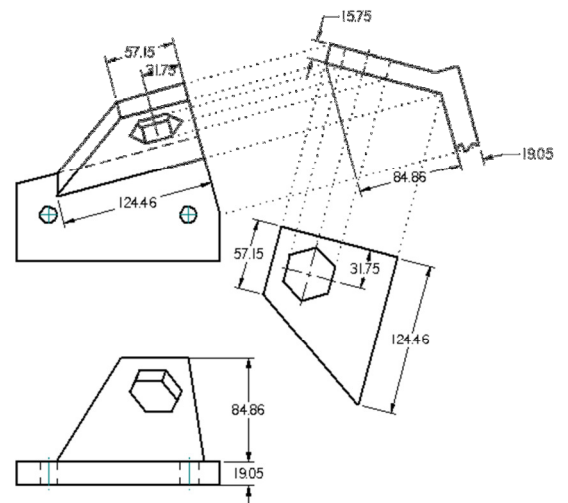


Fig. 6.15 Draw feature(s) on oblique face

## 6.5 Generating Auxiliary Views from Solid Models

Creating auxiliary views is less cumbersome with solid models using CAD packages. The shapes of inclined and oblique faces and the features on them present little difficulty with solid models. Most modern CAD packages with

solid modeling capability include routines that can be used to create auxiliary views easily from solid models. The details in the process of creating auxiliary views vary with each CAD product. In most cases, creating an auxiliary view for an inclined face is a one or two step process while creating an auxiliary view for an oblique face is a two or three step process after the base views are created or identified.

The concept of planes and faces should be properly understood when dealing with solids. A plane is a flat surface of infinite length and width. A face is a surface on an object and may be flat or curved. A cylindrical face on a pipe is curved surface, for example. A flat face is a portion of an imaginary flat plane. Auxiliary views are generated from flat planes by CAD packages. The user must specify a plane when creating an auxiliary view. CAD software creates full auxiliary and partial views depending on the length of the cutting plane defined. Some “dressing” of the auxiliary view may be needed. The view direction is assumed to be perpendicular to the plane that is selected when generating the auxiliary view.

### 6.5.1 Generating Auxiliary Views for Inclined Face

As an illustration, we will revisit Fig. 6.6 in discussing the technique for generating an auxiliary view for an inclined face. Care is needed when selecting the auxiliary plane; it must be perpendicular to the view direction. Solid Edge package was used in this example.

#### Step 1: Create two standard views

First generate two adjacent principal views from the solid model as shown in Fig. 6.21. Identify the base view as the principal view showing the edge view of the face. In this example, the front view is the base view while the left view is the adjacent principal view.

#### Step 2: Select the auxiliary view button

In some CAD packages, a command might be needed to invoke the auxiliary view routine. In many cases, a button is available in the paper space environment that can be selected to invoke the auxiliary view routine. Once this routine is active, it will request the user to select the plane for the desired auxiliary view. In Fig. 6.22, the plane of interest is indicated. The line segment of the face was selected as a line feature on the plane.

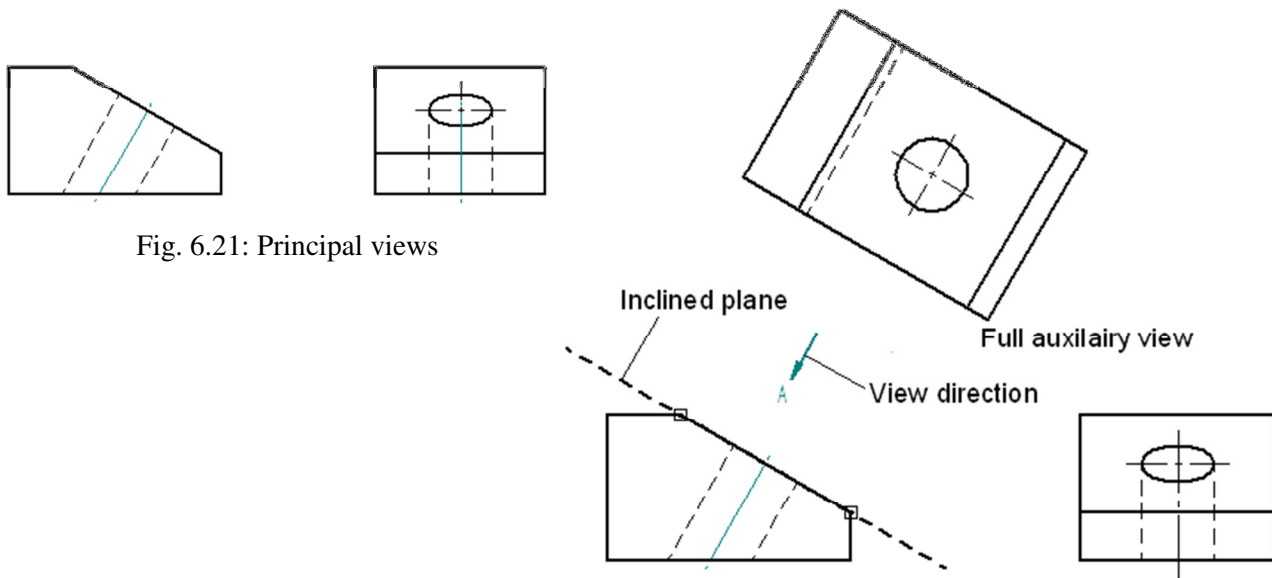


Fig. 6.22: Full auxiliary view

#### Step 3: Place the auxiliary view.

With the plane selected, the routine requests the user to select a position for the auxiliary view. Drag the cursor to a convenient position and click to place the view. In Fig. 6.22, the view direction is indicated but this was generated by the software. The full auxiliary view created by the software is shown. The inclined face will show on the view. Likewise, all the features on the face will show.



### 6.5.2 Generating Auxiliary Views for Oblique Face

As an illustration, we will revisit Fig. 6. 10 in discussing the technique for generating an auxiliary view for an oblique face. Solid Edge package was used in this example.

#### Step 1: Create two standard views

As in the inclined face problem, generate two adjacent principal views from the solid model as shown in Fig. 6.23. Identify the base view as the principal view showing a TL element. If no TL element is found on a principal view, one must be created. In this example, the top view is the base view while the front view is the adjacent principal view.

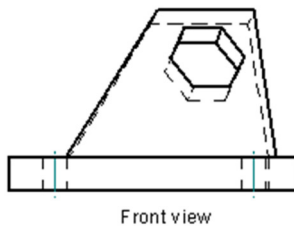
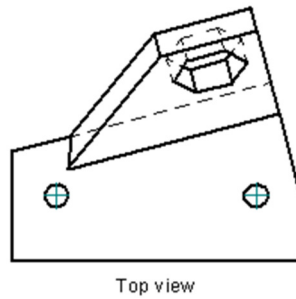


Fig. 6.23: Standard view

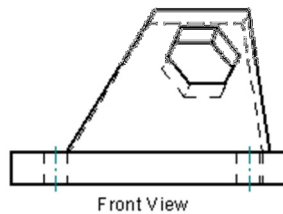
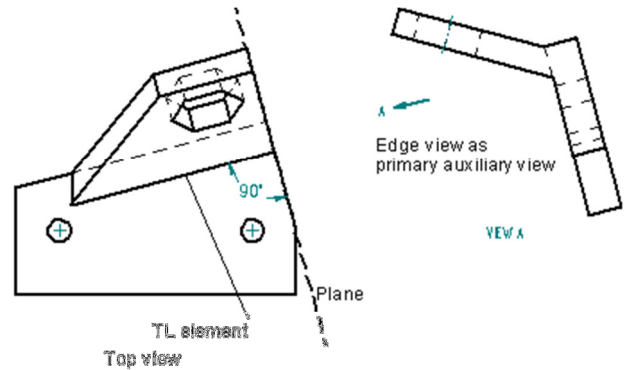


Fig. 6.24: Edge view from base view

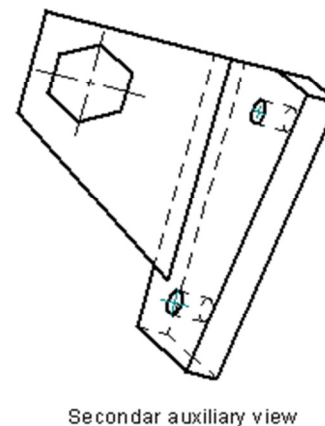
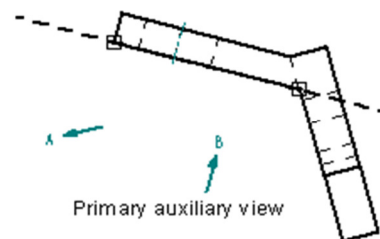
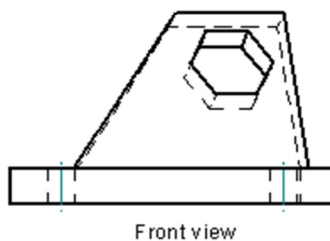
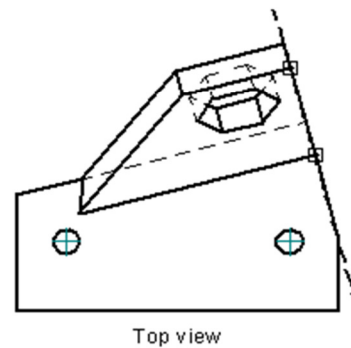


Fig. 6.25: Full auxiliary view for oblique face

#### Step 2: *Define primary auxiliary plane*

Once a true length (TL) is identified, see Fig. 6.24, the primary auxiliary plane can be defined. This plane must be perpendicular to the TL element. If no such line exists on the base view, then one must be created. In Fig. 6.24, the primary auxiliary plane is indicated in the top (base) view.

#### Step 3: *Create the primary auxiliary view.*

Invoke the auxiliary view routine either with a command or by selecting a button. The routine will request the user to select the plane for the desired auxiliary view, so select the plane accordingly. With the plane selected, the routine requests the user to select a position for the auxiliary view. Drag the cursor to a convenient position and click to place the view as shown in Fig. 6.24. A full auxiliary edge view should be created by the software.

#### Step 4: *Define the secondary auxiliary plane.*

With the edge view line as TL element, use the same procedure as explained in step 2 to define the secondary auxiliary plane. Fig. 6.25 illustrates this step.

#### Step 5: *Create the secondary auxiliary view.*

Invoke the auxiliary view routine either with a command or by selecting a button. Then select the secondary auxiliary plane. Next place the view in position by dragging the cursor to a convenient position and click. A full secondary auxiliary view should be created by the software as shown in Fig. 6.25. The oblique face will show on the view. Likewise, all the features on the face will show. As can be noticed, centerlines and center marks are not automatically added to auxiliary views generated from solid models by some packages. These must be added as desired in standard drafting practice. These features were added in the two examples (Fig. 6.22 and Fig. 6.25).

### 6.6 Combined Standard and Partial Views

When constructing views for a drawing, time and effort can be saved by use of partial views. For example consider Fig. 6.26 in which two standard views (top and right) are shown as partial views. Also, the auxiliary view is shown as a partial view. Thus three partial views and one full standard (front) view can adequately convey the necessary shape and dimensional information about the component. If a solid model is not available, so that the views are drawn from a sketch or isometric drawing, a lot of time and effort will be saved drawing the partial views instead of the full views for the four necessary views. The isometric insert is added in Fig. 6.26 to aid visualization. The use of partial views should be kept in mind by design drafters as productivity is an important concern for supervisors and employers.

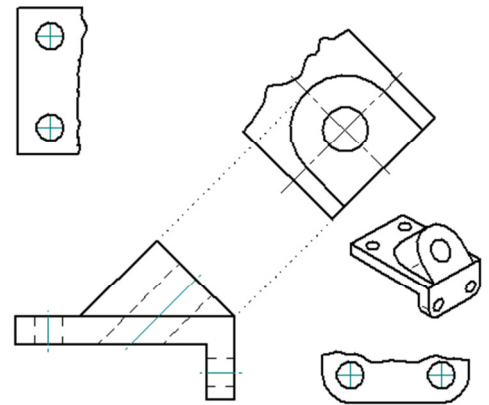


Fig. Combined views

If views are generated from solid models, the standard views obtained will always be full views. These standard views may be converted to partial views by modifying them manually. However, some CAD packages allow partial auxiliary views to be created from solid models by defining an edge view length that spans only the portion of interest. Fig. 6.26: Drawing with partial views. When features appear on inclined and oblique faces of an object in standard orthographic views distorted images of the faces and features result. Auxiliary views are thus employed to reveal the true shape and size of the features. An auxiliary view is constructed by looking perpendicularly on the inclined or oblique face. It is an orthographic view. A section view is an orthographic projection view created by defining an imaginary cutting plane or planes on an object so that the observer can see internal details. Auxiliary and section views are used to supplement standard views in order to clarify views, improve visualization of designs, and facilitate dimensioning of drawings. Both part and assembly sections can be created. Auxiliary and section views are discussed later. Pictorial drawings show all three principal dimensions of an object in one view. They are easy to interpret and non-technical personnel can understand them but do not reveal much of hidden details. Hence, when objects have hidden features or are relatively complex in form and shape, a single view is usually not able to describe it adequately; especially for manufacturing and inspection purposes. Examples of pictorial drawings are isometric, dimetric, trimetric, and perspective drawings.

## 6.7 SUMMARY

Faces on objects not perpendicular to line of sight appear foreshortened. An inclined plane has its edge view in one principal plane and an oblique plane has no edge view in any principal view. Inclined or oblique faces along with features on them will appear foreshortened on principal views. Foreshortened views are not clear or accurate representation of features so auxiliary views are used to correct the distortions. An auxiliary view is an orthographic view that shows the true size and shape of inclined or oblique face with its features. In creating auxiliary views, projection lines are always at 90 degrees to fold lines. A primary auxiliary view is constructed from two principal views and a secondary auxiliary view is constructed from one principal and primary auxiliary view. Successive auxiliary views are views obtained from one principal view and a primary auxiliary view or from two other auxiliary views. Auxiliary views are used to find: 1) true length of an inclined or oblique line; 2) true size and shape (TSS) of an inclined or oblique face 3) edge view of oblique face; 4) point view of inclined or oblique line; 5) true size and shape of features on incline or oblique faces.

The edge view of an inclined plane is shown in one of the principal views. The view showing the edge view of an inclined plane is chosen as a base view for developing the primary auxiliary view. The TSS of a feature on an inclined plane is developed in a primary auxiliary plane. A feature on an oblique plane needs primary and secondary auxiliary views to establish its true size and shape.

The basic types of auxiliary views are partial and full auxiliary views. Partial auxiliary view gives the TSS of only the foreshortened features. A full auxiliary view shows all features of object, some TSS and others not TSS.