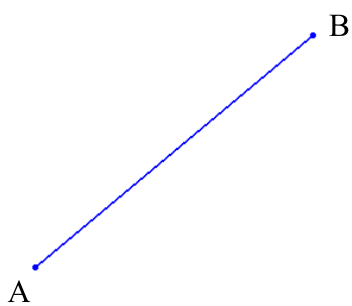
Understanding Projection Systems

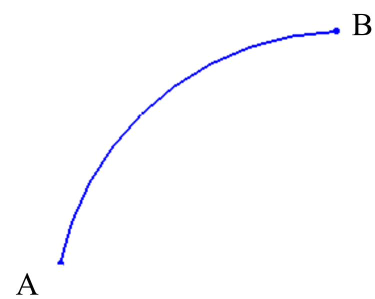
A Point: A **point has no dimensions**, a theoretical location that has neither length, width nor height.

A point shows an exact location in space. It is important to understand that a point is not an object, but a position. We represent a point by placing a dot with a pencil.

A Line: A **line** is a geometric object that has length and direction but no thickness. A line may be straight or curved. A line may be infinitely long. If a line has a definite length it is called a **line segment** or **curve segment.** A straight line is the shortest distance between two points which is known as the **true length** of the line. A line is named using letters to indicate its endpoints.



AB - Straight Line Segment



AB – Curved Line Segment

A line may be seen as the locus of a point as it travels between two points.

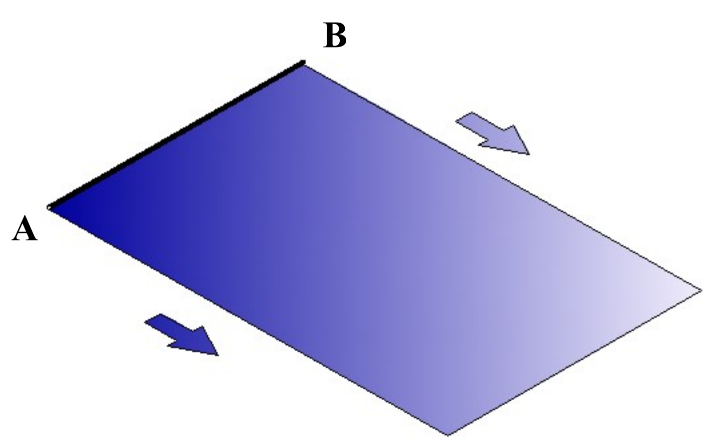
A line can graphically represent the **intersection of two surfaces**, the **edge view of a surface**, or the **limiting element of a surface**.

A Plane: A **plane** is a flat surface which is infinitely large with zero thickness.

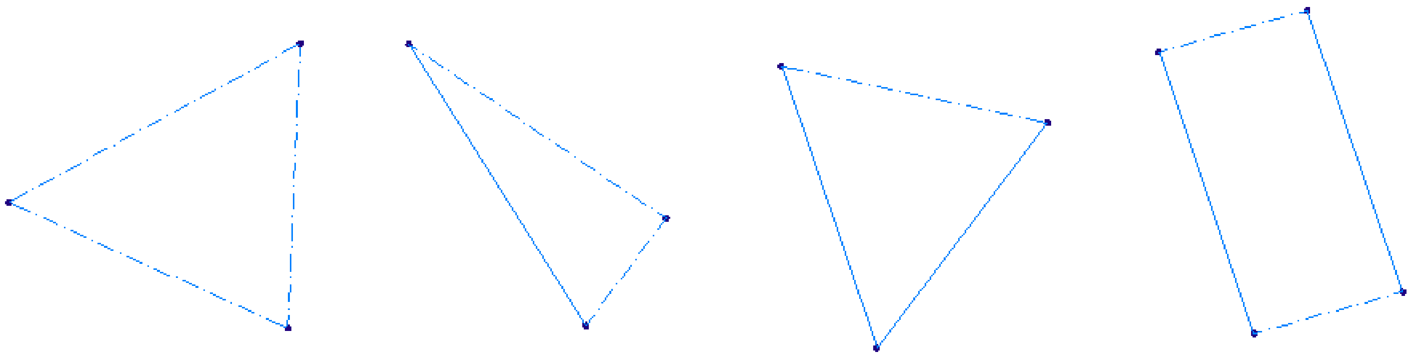
Just as a point generates a line, a line can generate a plane.

A portion of a plane is referred to as a **lamina**.

A Plane may be defined in a number of different ways.



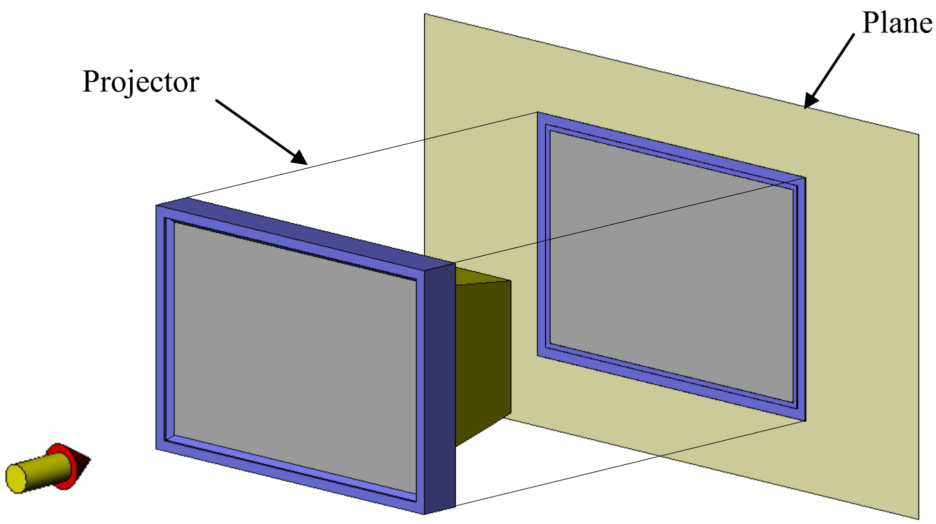
A plane may be defined by;



(i) 3 non-linear points *(ii) A line and a point (The point can not lie on the line)* *(iii) Two intersecting lines* *(iv) Two Parallel Lines*

Descriptive Geometry: refers to the representation of 3D objects in a 2D format using points, lines and planes. This format yields accurate information regarding lengths of lines and positions of objects relative to an origin.

A view is created by projecting an object onto a plane. The position of the plane and the viewing direction relative to the object will determine the resulting view.



In this case, the television is viewed from the front. The plane is placed behind the television perpendicular to the line of vision. The view is projected onto the plane at 90º. The resulting view is contained on the plane. This type of projection is known as **Orthographic Projection** or **Orthogonal Projection.**

Does one view give us the complete picture?
Pictured below are two bundles of €20 Notes, one contains significantly more than the other. Which would you choose? (a) or (b)?

(a)

(b)

The views shown do not give enough information to enable us to make a decision as to which contains the most money. What view would you require to make a confident choice?

The views below show the heights of both bundles. Bundle (b) clearly contains more than bundle (a).

(a) *(b)*

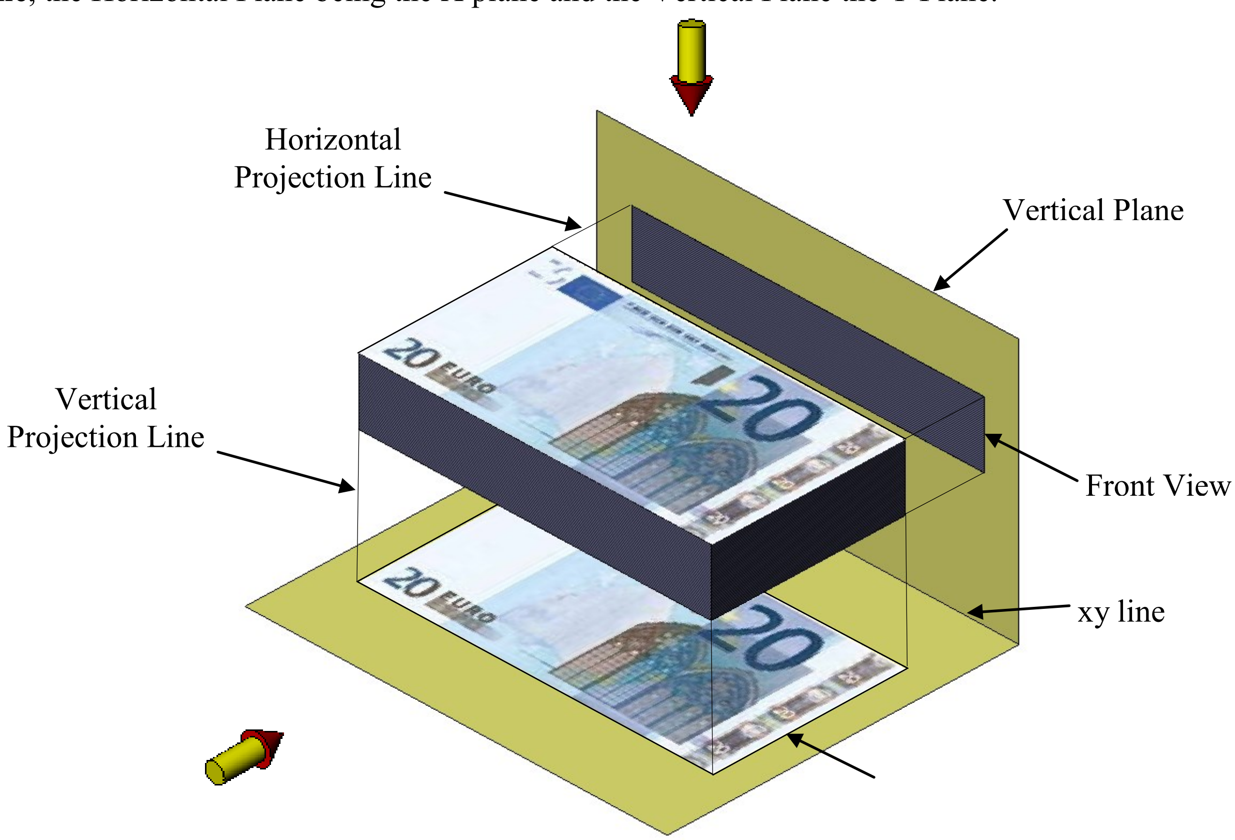
This view indicates a greater quantity of notes but leaves us undecided as to what the notes are. The top views indicate that both bundles are made up of €20 notes. The front view indicates the amount of notes in each. To confidently make a decision as to which contains the most money **both** views are required.

Creating the views: As discussed earlier, in order to create a particular view of an object a plane must be placed in a position onto which the view will be projected. The views required in this case are a front view and top view.

A plane is required behind the object onto which the front view will be projected. Because the line of vision is horizontal, and the plane is positioned perpendicular to the line of vision, this plane will be vertical.

Similarly for the Top View, a plane will be placed underneath the object. As the line of vision is vertical the plane perpendicular to the line of vision will be horizontal.

The line where the Vertical and Horizontal Planes meet is the **line of intersection** and is referred to as the **xy line**, the Horizontal Plane being the X plane and the Vertical Plane the Y Plane.

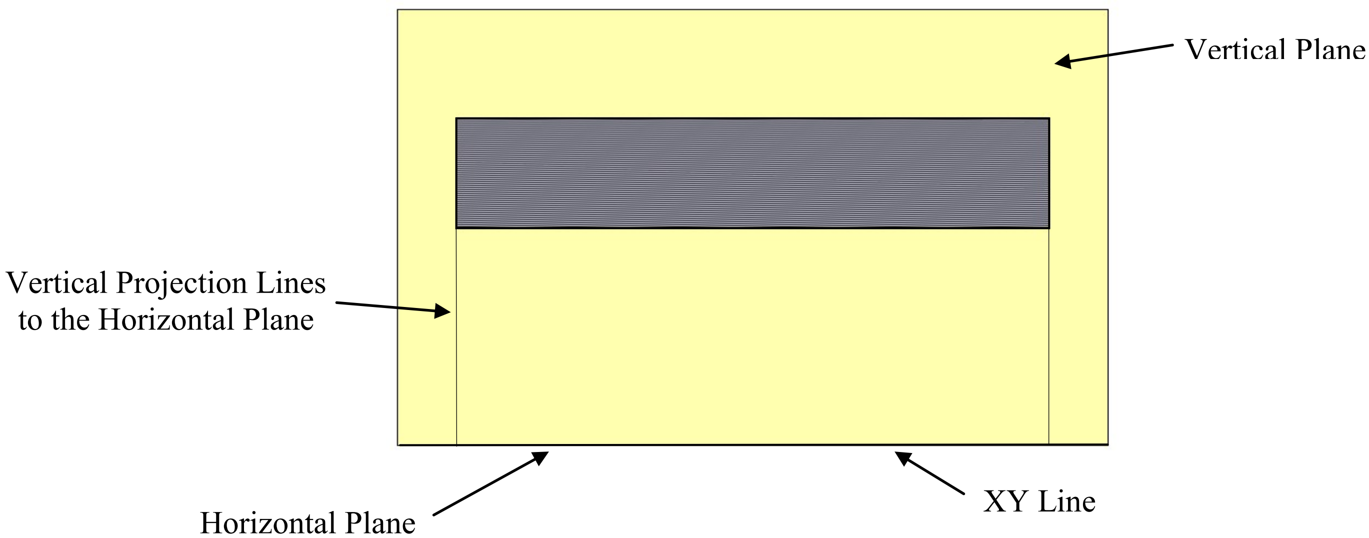


Top View

In Orthographic ProjectionHorizontal Plane l planes are used and are referred to as the **Planes of Reference.**

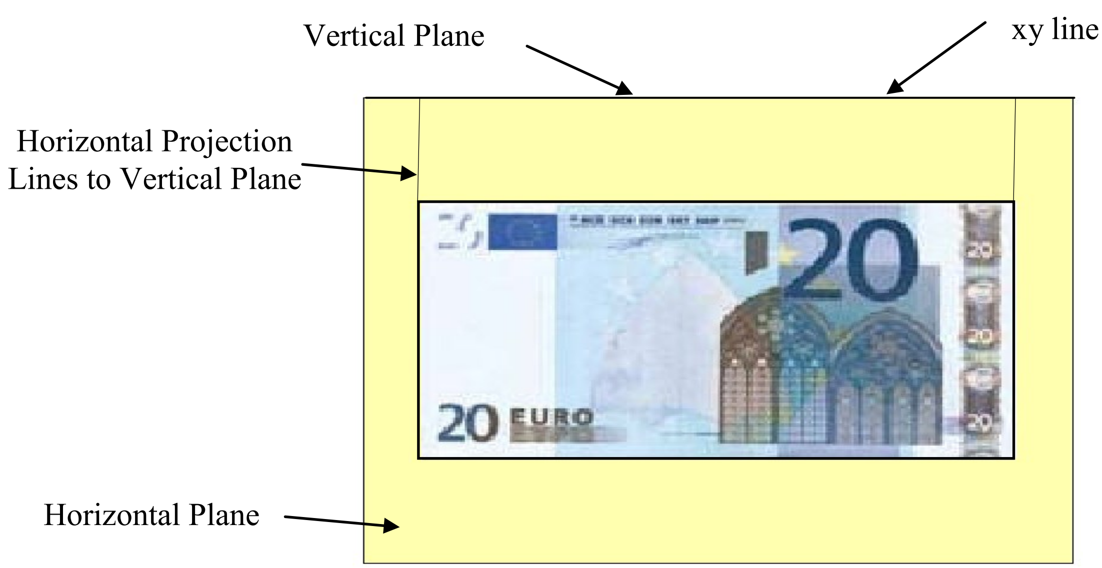
The view shown below displays the model when viewed from the **front**. It is important to note that, when viewing the model from the front, the horizontal plane does not disappear but is seen as an edge. This edge view coincides with the line of intersection between the two planes – xy line.

The concept of a plane appearing as an edge will be explored further later.



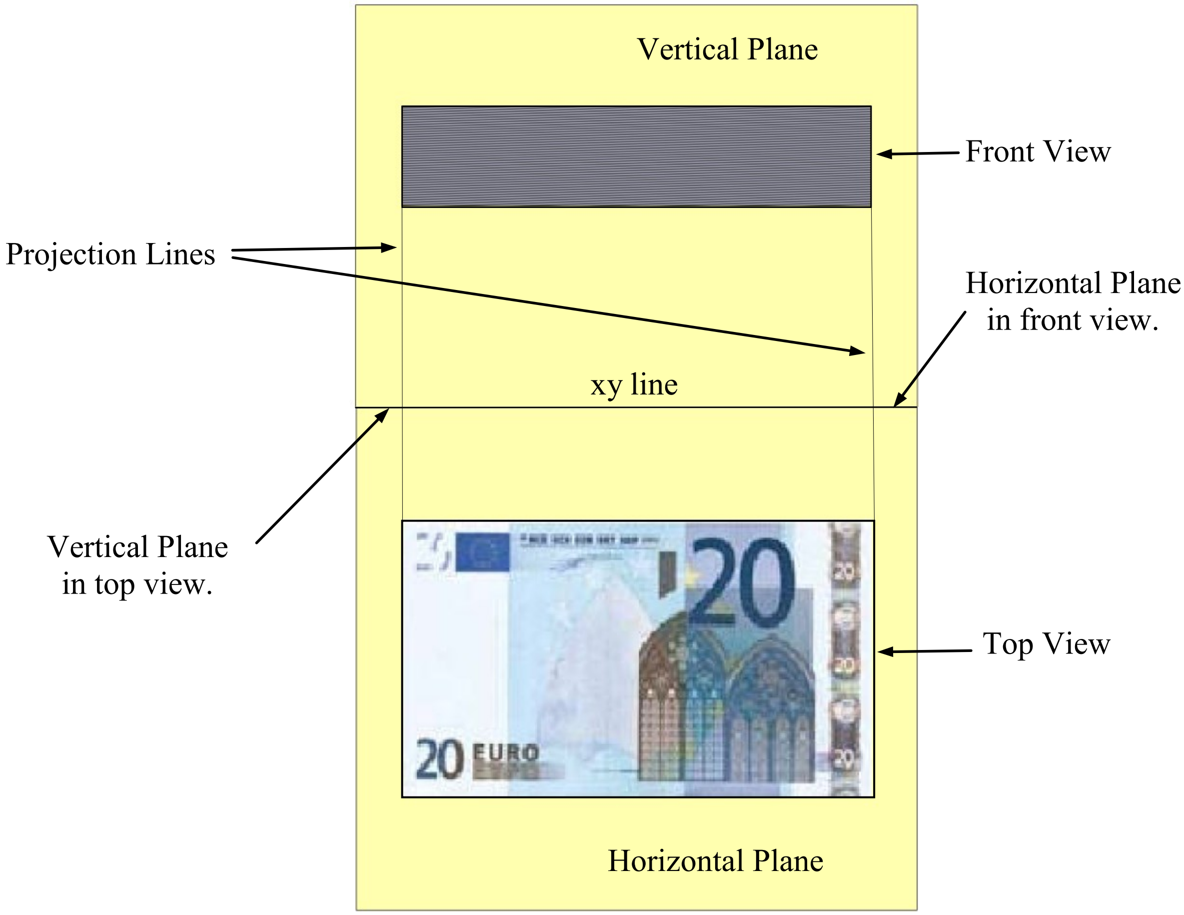
The distance of an object above the horizontal plane is equal to the distance of the front view above the xy line

When viewed from the **top** the model appears as shown below. As with the horizontal plane in the front view, the vertical plane is seen as an edge, coinciding with the xy line.



The distance of an object in front of the vertical plane is equal to the distance of the top view in front of the xy line

The two views may be presented simultaneously and a



The xy line is common to both views. The front view is presented overhead the top view. The projection lines join the front and top views and are perpendicular to the xy line.

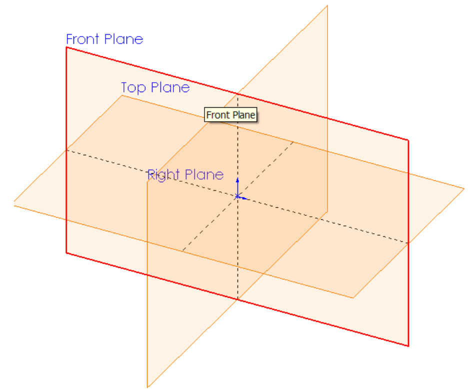
As discussed previously, the xy line represents the edge view of the vertical plane in plan view and the edge view of the horizontal plane in the front view.

In order to investigate the planes of reference further we will model a representation of them in SolidWorks. The next steps will take us through how to create the model.

Getting started

Choosing a Plane

Create a **sketch.**
The principal planes of reference are displayed, along with the Right Plane.



The Origin may be seen as the point common to all three planes.

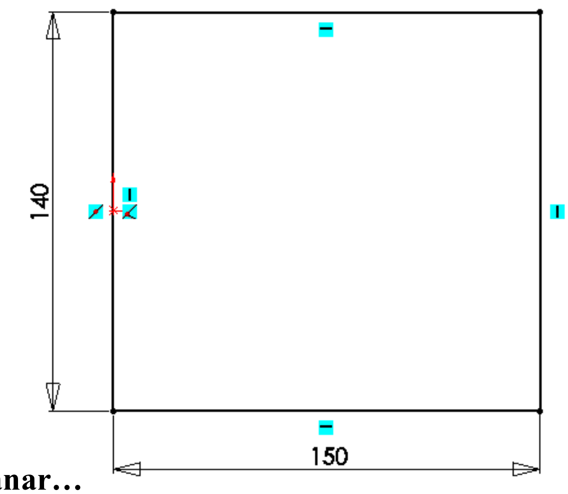
At this stage we will model only the Front and Top Plane.

Creating the sketch

Create a rectangular sketch on the Top Plane**.**

The Origin is coincident with the midpoint of the line on the left hand side.

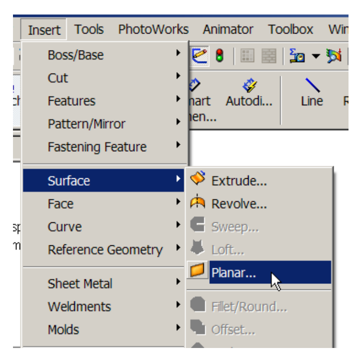
Select **Smart Dimension** from the sketch toolbar and dimension the sketch as shown.

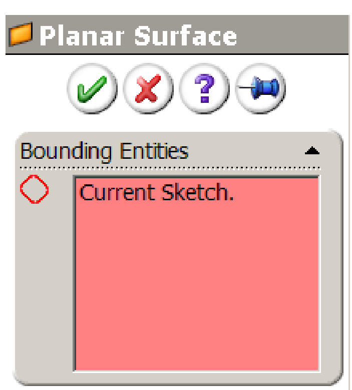


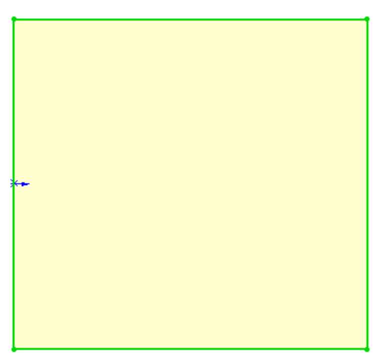
Creating the Planar Surface

To create a plane to represent the **Horizontal Plane** choose **Insert, Surface, Planar…** from the drop down menu.

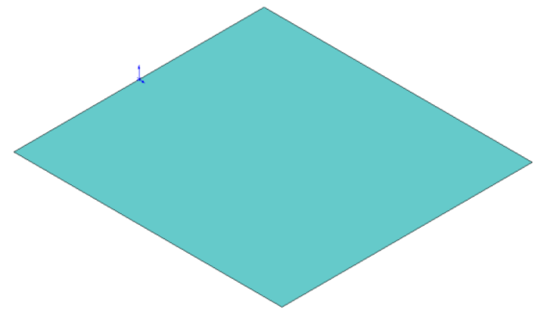
The bounding rectangle will be chosen automatically. If not, choose one of the extremities of the sketch.







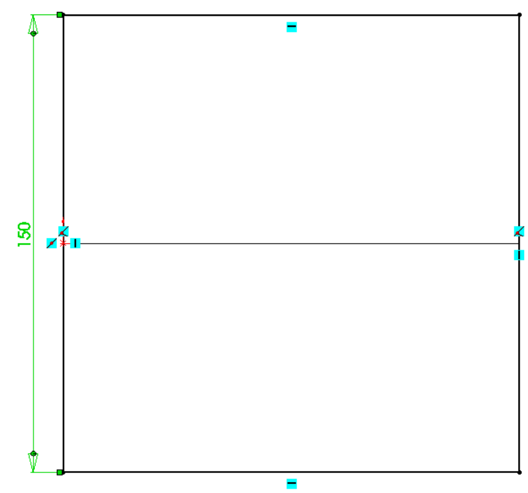
Edit Appearance A grey colour is applied to the planar surface by default.
Edit the appearance to reflect a more appropriate colour.



Rename Feature Rename the feature Horizontal Plane in the Feature Manager.

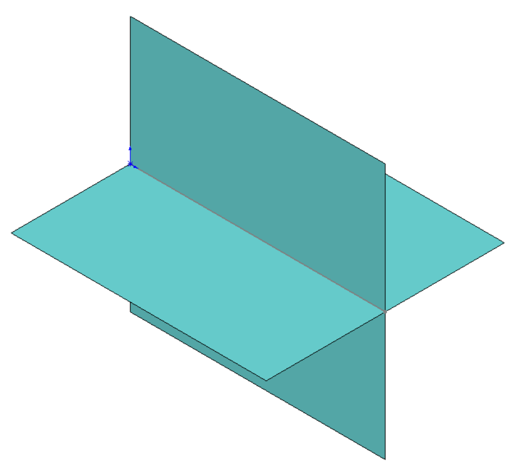
Creating the Vertical Plane Create the sketch shown on the front plane, using only the dimension shown.
The midpoint of the left hand side is coincident with the origin.

The sketch is fully defined by adding a coincident relation between the right hand side and the horizontal plane, as shown



Planar Surface Create a **Planar Surface** using this sketch to represent the **Vertical Plane.**

Edit Feature Rename the feature **Vertical Plane.**
Edit the colour to reflect that of the **Horizontal Plane.**



Representing the xy line Once modeled, you will notice that the xy line is not clearly defined. It is possible to see the line of intersection between the two planes but it is not possible to pick it.

Intersection Curve In order to determine the line of intersection **Intersection Curve** will be used.

Intersection Curve will open a sketch and create a sketch line at the intersection of the two planar surfaces

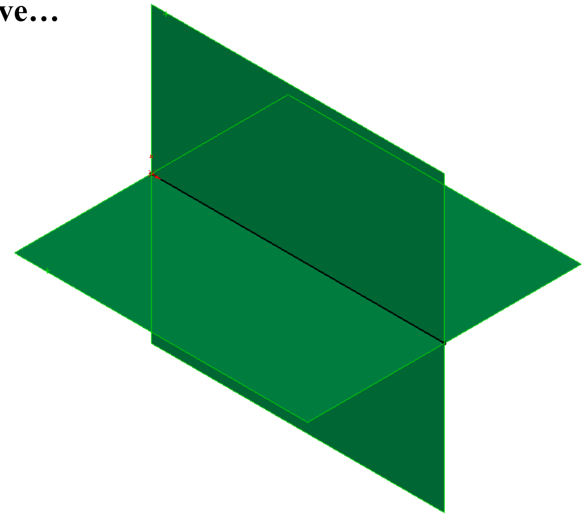
Creating the sketch Choose **Tools, Sketch Tools, Intersection Curve…** from the drop down menu.
A new 3D Sketch will appear in the Feature Manager Design Tree.

Highlight the two planar surfaces.

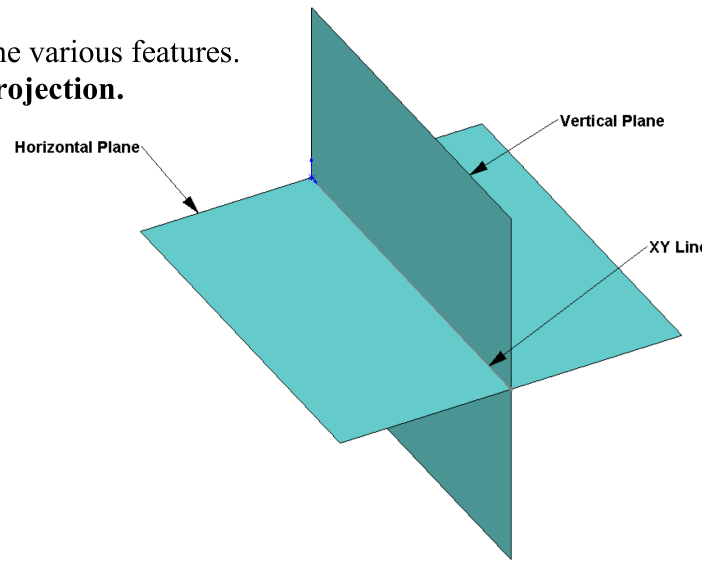
The 3D Sketch **(xy line)** will be created representing the **line of intersection** between the **Vertical and Horizontal Planes.**

Rename the feature **xy line**

Edit the **appearance, color** to **black**



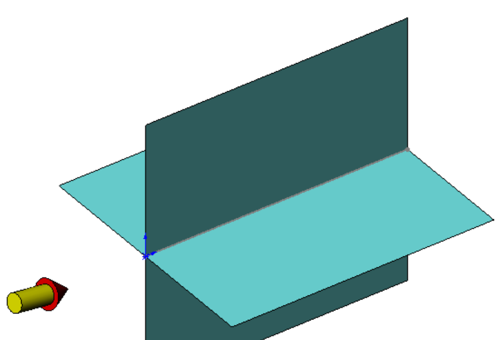
Adding Annotation Add the **Notes** shown to represent the various features.
Save the model as **Orthographic Projection.**

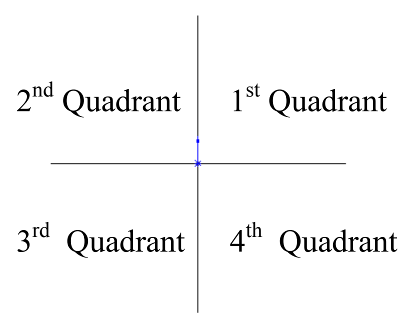


Basic Principles These two principal planes are used in orthographic projection, one horizontal and one vertical. The two planes divide space into 4 quadrants.

Choose **Left View,** the xy line appears as a point and the planes appear as edges.
The angle between the planes, 90º, is shown in this view also. This is referred to as the **Dihedral Angle**

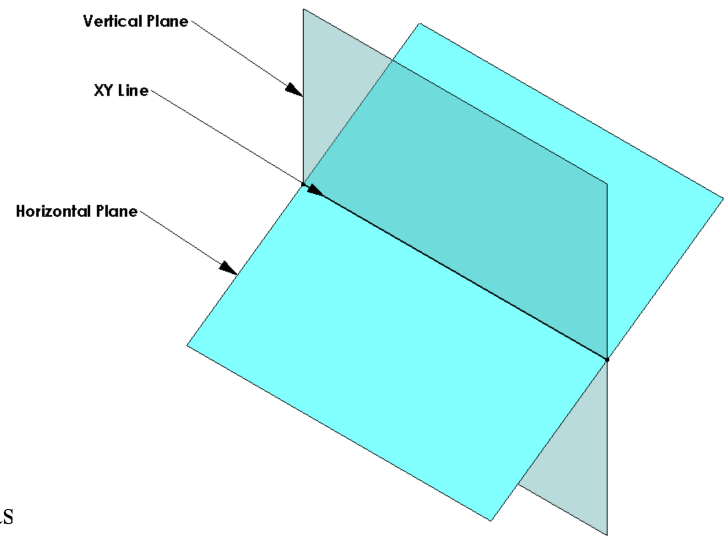
The quadrants are numbered as shown.





Left View

In descriptive geometry the object is positioned in one of these quadrants. It is represented by its projections onto the vertical and horizontal planes, yielding the front and top views respectively. The front view is called the **elevation**, the top view is called the **plan**



When the object is placed in the 1st quadrant the resulting projection is known as **First Angle Projection.** When placed in the 3rd quadrant the projection is referred to as **Third Angle Projection**

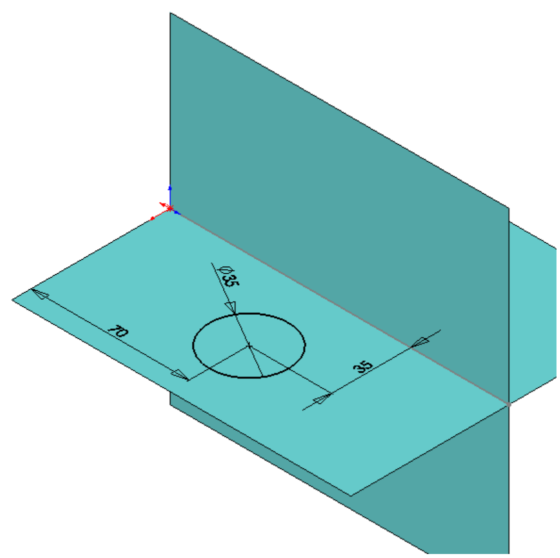
To show these views on a single plane the horizontal and vertical planes are opened out to coincide with one another.
It is convention that the 1st quadrant is always opened out

The 2nd and 4th Angle Projections are not commonly used as the rabatment would result in superimposed views.

We will now investigate the different outcomes when an object is positioned in either the 1st or 3rd quadrant ie First and Third Angle Projection

For the purpose of this exercise we will use a cylinder.

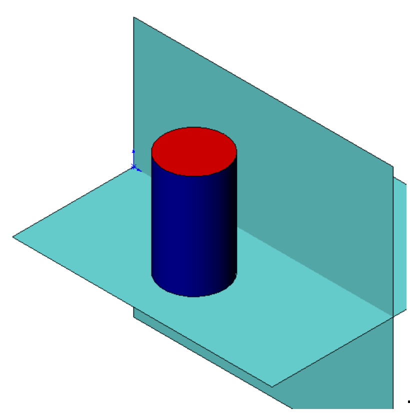
Creating the cylinder in the 1st quadrant



Sketch details Create the sketch shown on the **Horizontal Plane** in the **1st Quadrant.** *(A sketch may be created on a planar surface)*

Creating the Feature Extrude the sketch to a **depth** of **60mm** to create the cylinder.

Appearance Edit the **face appearance colors** of the cylinder to reflect those shown below. Rename the feature **Cylinder**



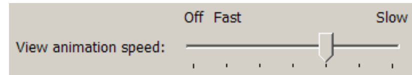
View Rotation **View Rotation** allows the speed of transition from one view to another to be changed.

For the purpose of demonstration it is best to slow down the speed of rotation.

To edit the View Rotation setting choose: **Tools/Options…**

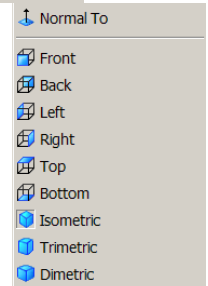
Select the **View Rotation tab** on the LHS

Drag the **view animation speed** to the position shown. Choose **OK**



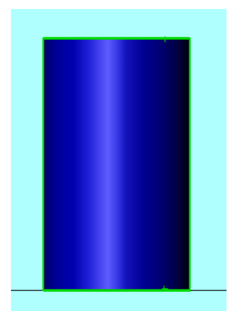
Orthographic Views Investigate the various orthographic views of the object using Top, Front, Right, Left and Isometric Views.

The slower transition speed allows us to clearly see the creation of each view.



Projecting onto the Planes In order to create the orthographic projection onto the planes of reference we will use a command called **Convert Entities**

Convert Entities: One or more curves may be created in a **sketch** by projecting the geometry of a solid onto a sketch plane

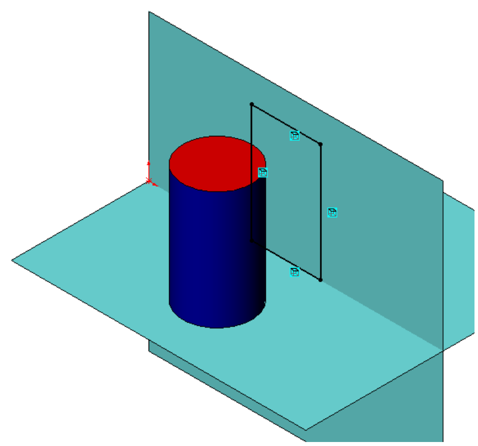


Projecting the Front View. Choose **Front View.**
Create a sketch on the **Vertical Plane**

Pre-select the edges shown

Hold down the shift key whilst picking to make multiple selections.

It may be necessary to move to an isometric view in order to choose the base.

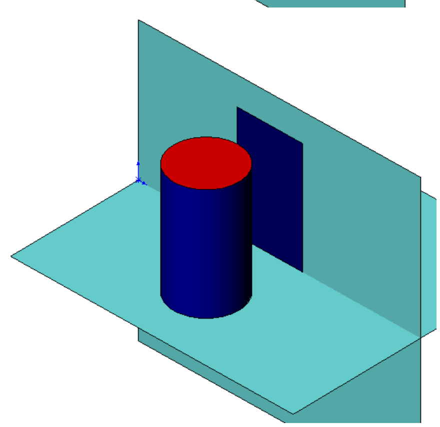


Choose **Isometric View**

From the Sketch toolbar choose **Convert Entities** Convert

The extremities of the cylinder, front view, are projected onto the front plane, resulting in a rectangular shaped projection.

Exit the sketch.



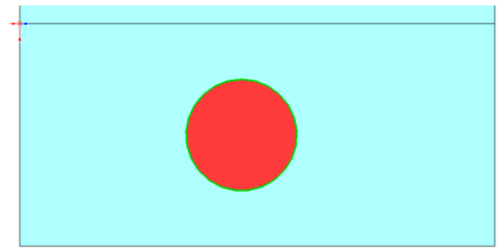
Extruded Boss/Base Extrude the sketch outwards to a **depth** of **.01mm**

Appearance Edit the **Face Appearance Color** to reflect that of the surface of the cylinder.

Rename the feature as **Elevation.**

Projecting the Top View.

Choose **Top View.**
Create a sketch on the **Horizontal Plane.**



Pre-select the circular extremity of the cylinder.

From the Sketch toolbar choose **Convert Entities**

Choose **Isometric View**

Because the cylinder is sitting on the horizontal plane the projected view will coincide with its base.

To see the projected view we will **hide** the model.

Hide the cylinder

To hide the cylinder **right click** on '**Cylinder'** in the feature manager design tree and select **Hide**. The cylinder has been hidden but it is not deleted

The circular projection of the cylinder is now exposed on the Horizontal Plane

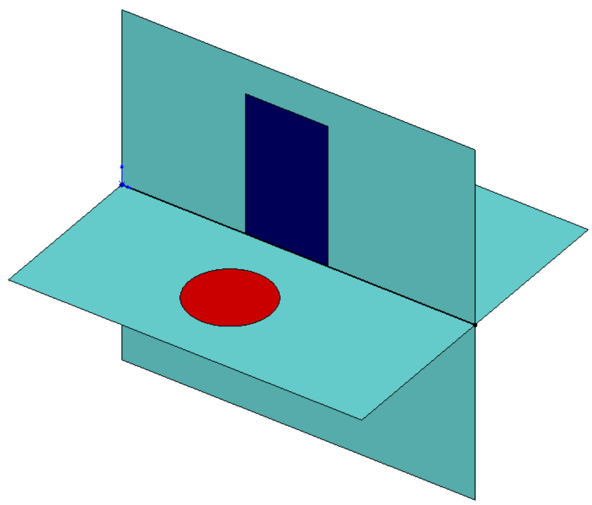
Extruded Boss/Base

Extrude the sketch to a **depth** of **.01mm**
De-select **Merge Result**

Appearance

Edit the **Face Appearance Color** to reflect that of the top of the cylinder.

Rename the feature as **Plan**

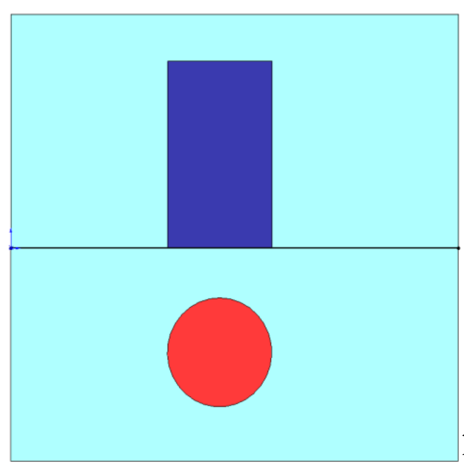


Rabatment

To represent this projection on a planar surface we must visualise the rabatment of the planes.

Convention tells us that the 1st quadrant is always opened out, thereby rotating the horizontal plane to a vertical position, positioning the top view underneath the front view, on a single plane.

The orthographic projection of the cylinder in **First Angle Projection** is shown opposite

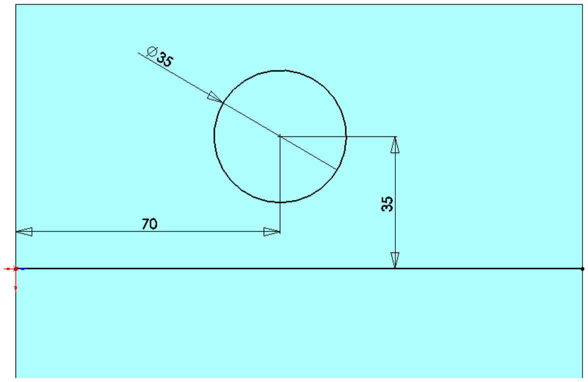


Representing the cylinder in Third Angle Projection

To represent the cylinder in third angle projection we must first place the cylinder in the 3rd quadrant. We will do this by editing both the feature **'Cylinder'** and the sketch used to create it.

Editing the sketch

Choose **Top View.**
Right Click on **Cylinder** and select **Edit Sketch.**

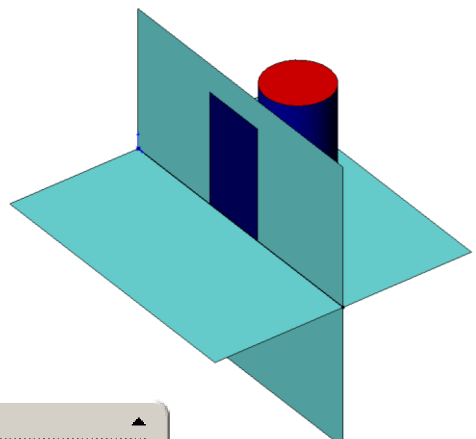


Delete the dimension 35mm from the Vertical Plane

Select the circle centre and drag it behind the vertical plane.

Dimension it 35mm behind the plane as shown.

Exit the sketch. Right Click on 'Cylinder' and select **Show.**



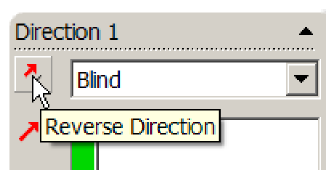
The cylinder is now positioned in the 2nd Quadrant.

Editing the Feature

To place the cylinder in the 3rd quadrant we will edit the direction of extrusion of the feature.

Right Click on 'Cylinder' and select **Edit Feature**

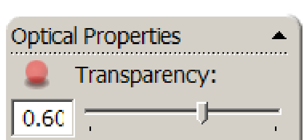
Reverse the direction by selecting

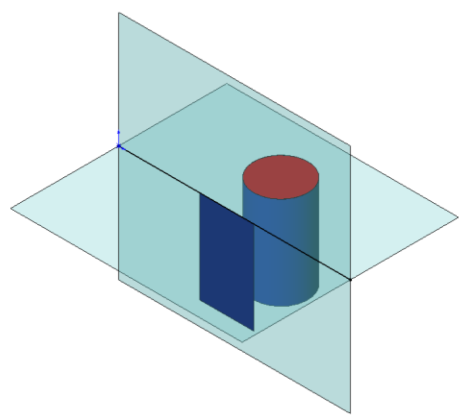


Select OK

Transparency

Reduce the **transparency** of both planes to **0.6**
Transparency settings are found under;
Face Appearance, Color.., Optical Properties

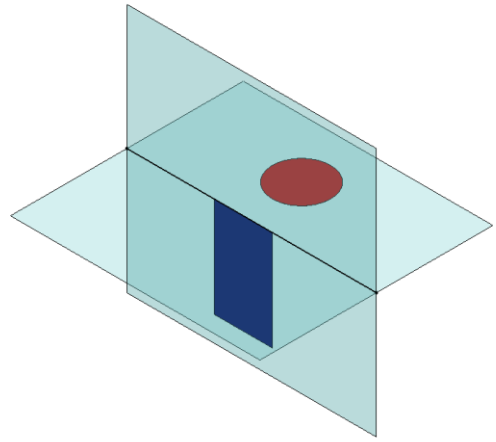




Third Angle Projection

In Third Angle Projection the planes are positioned in front and overhead the object respectively. For that reason it is assumed that the planes are transparent.

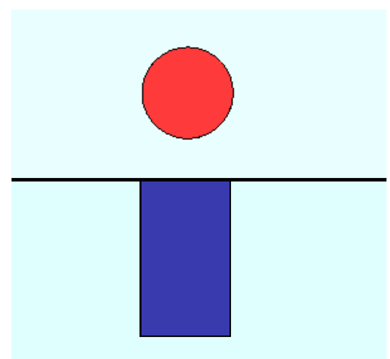
Hide the cylinder Hide the cylinder as before. The projections of the cylinder remain on the planes.



Rabatment Following convention the planes rabat in such a way that the first quadrant is opened out.

This results in the top view rotating to a position above the front view, contained on a single plane.

The orthographic projection of the cylinder in **Third Angle Projection** is shown opposite



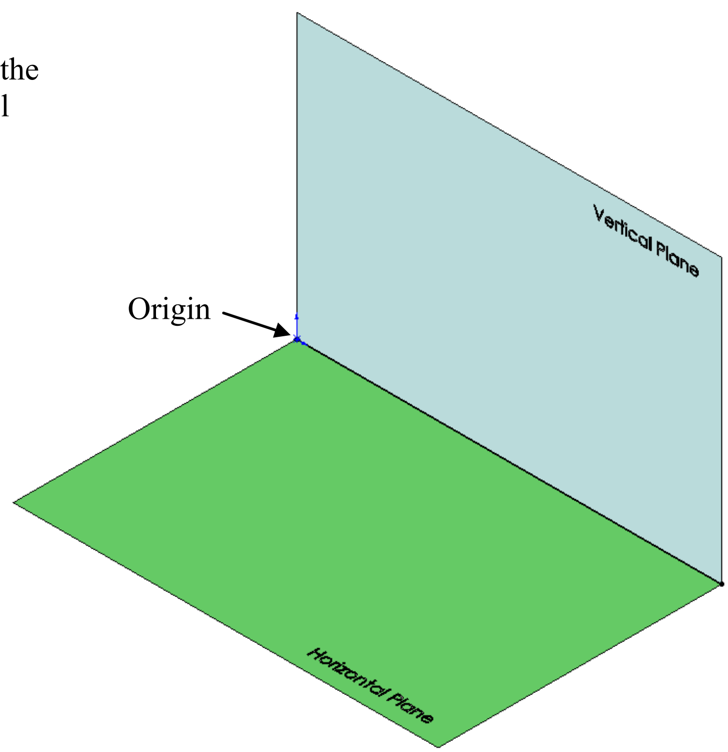
For the remainder of this document we will pursue the fundamental concepts of projection systems using First Angle Projection.

Using a similar method to that used in the creation of the planes of reference model, we will create a new model based on the first quadrant only.

<u>Note:</u> The origin will be located as shown.
The planar surfaces will measure 100mm X 150mm
The xy line is generated using Intersection Curve.

Add extruded text to both the vertical and horizontal planes to identify them.

For clarity the appearance colour of both planes is chosen differently



The xy line

xy line as a true length

As discussed previously, the xy line is the **line of intersection** between the vertical plane and the horizontal plane. The line is therefore contained on both planes.

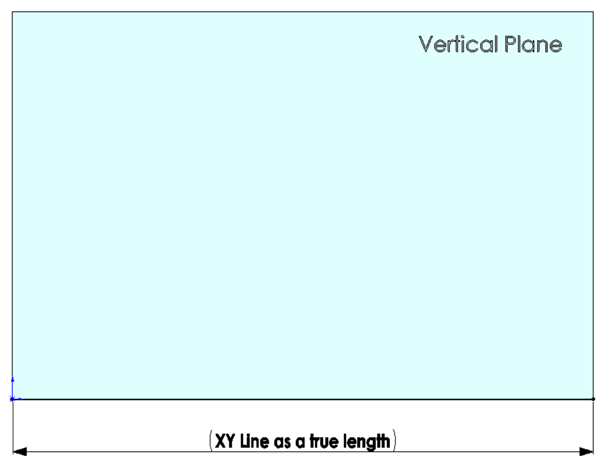
A definition of a straight line states that it is "the shortest distance between two points which is known as the **true length** of the line".

> A line will be seen as a true length when it is parallel to the projection plane it is projected on to.

Choose Front View.

When we look at the elevation of the planes of reference we are looking perpendicular to the front plane. Because the xy line is contained on the plane it will appear as a true length in elevation.

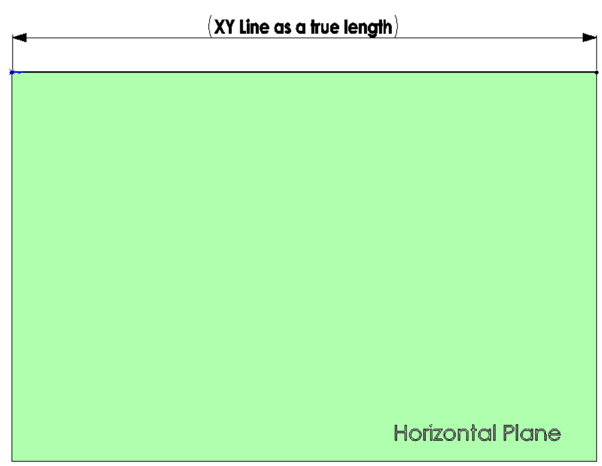
Note: The horizontal plane appears as an edge coinciding with the xy line



Choose Top View.

Similarly in plan, because we are looking at 90º to the horizontal plane, and the xy line is contained on the horizontal plane, the resulting view of the xy line will be a true length.

Note: The vertical plane appears as an edge coinciding with the xy line

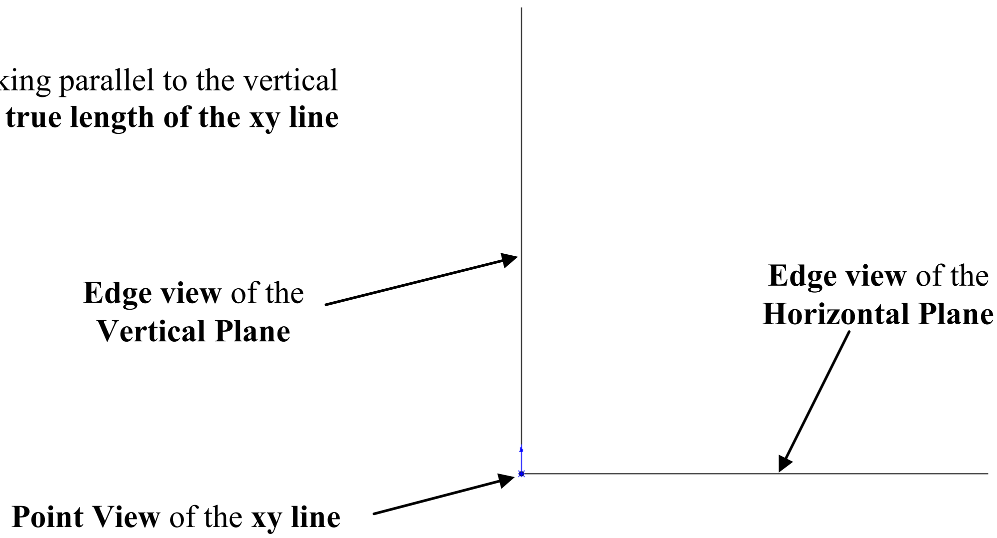


Activity – using the reduced view animation speed flick between the front, top and isometric views and note the concepts discussed above.

xy line as a point.

Choose Left View.

In choosing left view we are looking parallel to the vertical and horizontal planes, **along the true length of the xy line** and we see it as a **point.**



A line will be seen as a point when a view is taken along its true length.

When a point view of the xy line is taken you will notice that the vertical and horizontal planes appear as edges.

A plane will appear as an edge when a line contained on it projects as a point

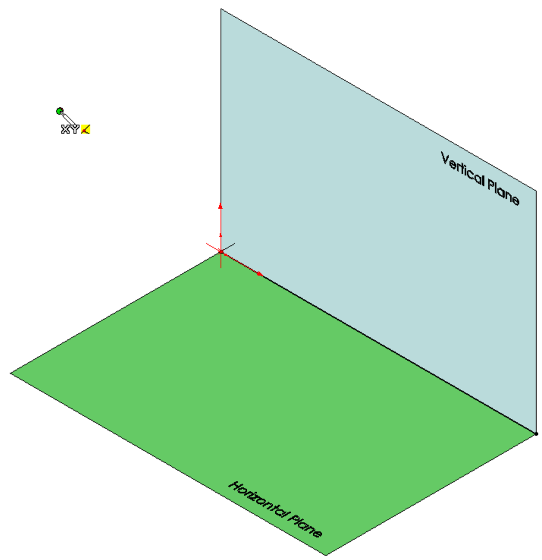
The xy line projects as a point when we look along its true length. The xy line is contained on both the vertical and horizontal planes. Therefore the vertical and horizontal planes will appear as edge views when we view the xy line as a point.

We will now use the first angle projection planes model to investigate the projections of points and lines.

Co-ordinates of a Point

Choose **3D Sketch.** Select **Point.**

Position the point as shown opposite.

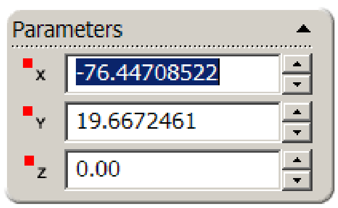


If the point is positioned with the front or top plane in the background it will automatically be created coincident with that plane

Deselect point to end the command.

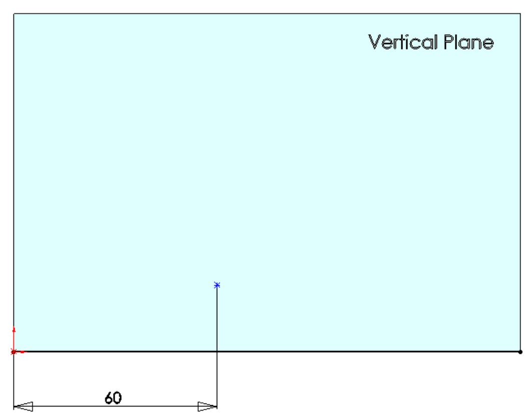
Rename the feature **Point**

Highlight the point. The XYZ co-ordinates of the point appear in the Point Property Manager.



These co-ordinates refer to the position of the point relative to the origin. The origin refers to the intersection of the front, top and right planes.

X Co-ordinate



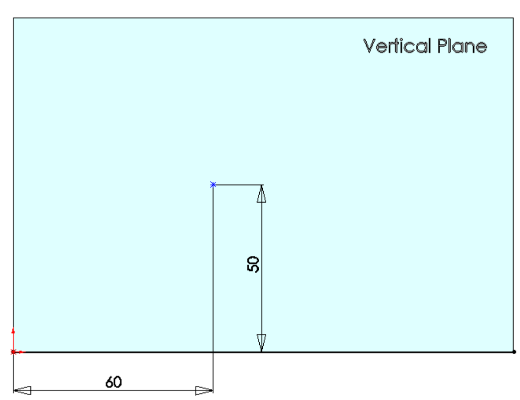
Choose **front view**. You will notice that the point is positioned to the left of the origin, hence the X co-ordinate is minus.

Change this value to **60**. The point moves to the right.

Smart dimension from the origin to the point.

You will notice that this value is 60, therefore the X co-ordinate refers to the distance left or right of the origin, or right plane.

Y Co-ordinate



Highlight the point.

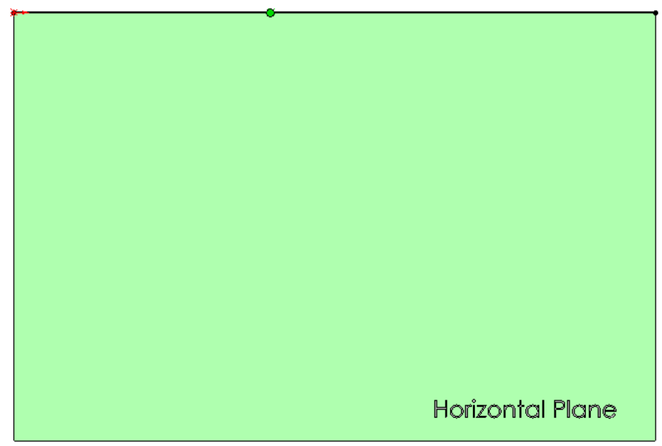
Change the Y co-ordinate to 50. The point moves upwards. Smart dimension from the xy line to the point.

You will notice that this value is 50, therefore the Y co-ordinate

refers to the distance above or below the origin, or the top plane.

Delete these dimensions

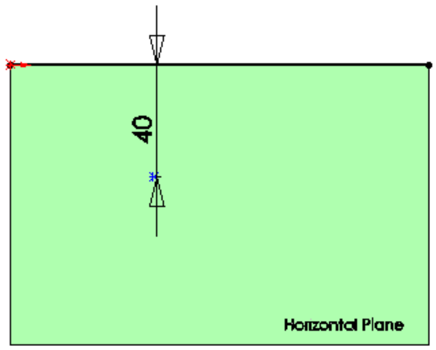
Z Co-ordinate



Highlight the point. Choose Top View.

The co-ordinate value for Z is 0 and as we can see it is coincident with the vertical plane.

Change the Z co-ordinate to 40. The point will move to a position 40mm in front of the vertical plane and the origin.



Delete the 40mm dimension.

It is important to be clear that a point shows an exact location in space. It is important to understand that a point is not an object, but a position, with XYZ co-ordinates relative to a fixed point, known as the origin.

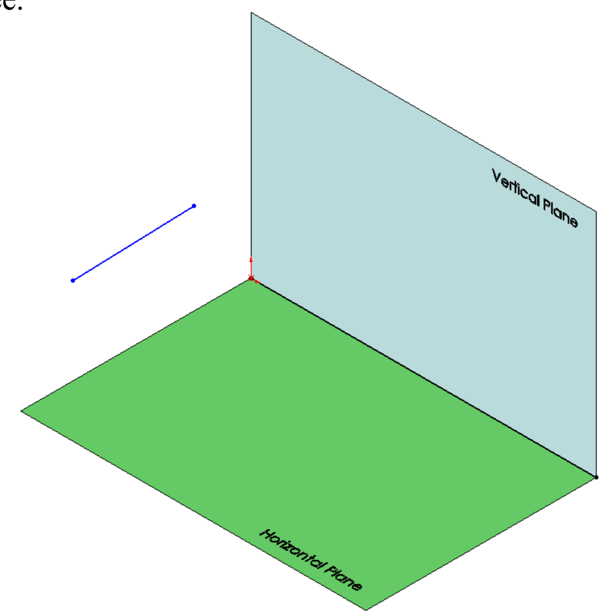
Activity – Experiment with the front and top views, along with various co-ordinate values, to gain an appreciation for the significance of XYZ values and the points location relative to the origin and the chosen views.

Delete the feature **Point** from the Feature Manager Design Tree.

Projections of a line

Choose **3D Sketch.** Select **Line.**

Create **a 3D Sketch line** as shown opposite.



A straight line is the shortest distance between two points

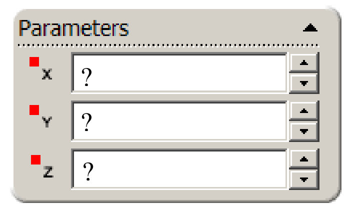
Just as with a point, to edit the line, select the endpoints individually and edit the co-ordinates of the point which appear in the Point Property Manager.

Activity – input various XYZ values for both endpoints and note the positioning of the line relative to the origin. Experiment with positive and negative values.

Traces of a line

These are the points where the line, extended if necessary, intersects the vertical and horizontal planes. When a line intersects a plane the trace produced is a point.

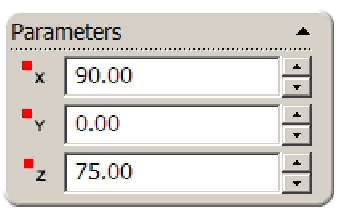
The trace on the horizontal plane is called the horizontal trace (HT) and the trace on the vertical plane the vertical trace (VT)

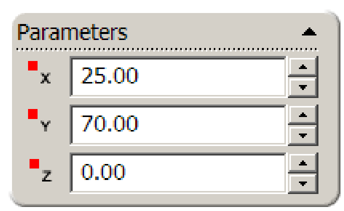


What co-ordinates would ensure that the lines intersect both the vertical and horizontal planes?

From our experience of the co-ordinates, the Y co-ordinate refers to the distance above/below the horizontal plane, and Z co-ordinate the distance in front of or behind the vertical plane. If either of these values are set to 0 then the point will sit on that plane.

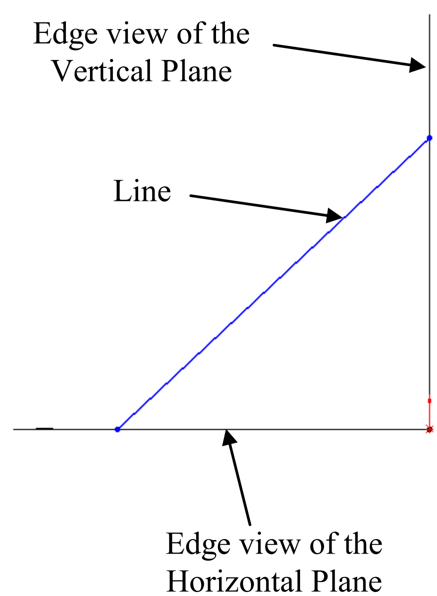
Edit the endpoints individually to reflect the co-ordinates shown below.

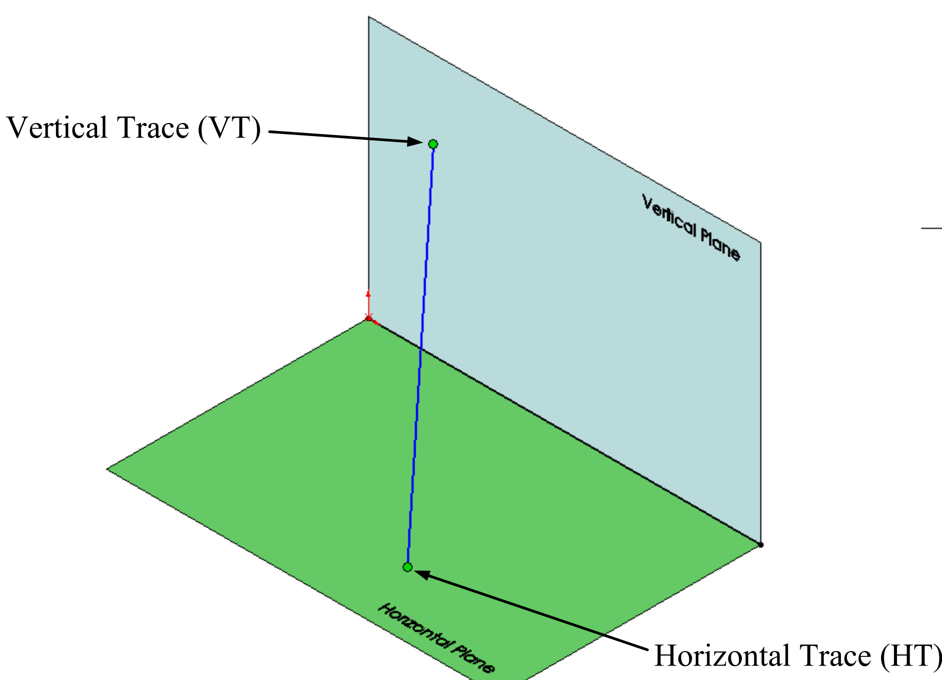




Choose **Right View**

We can see that the line intersects both the vertical and horizontal planes.

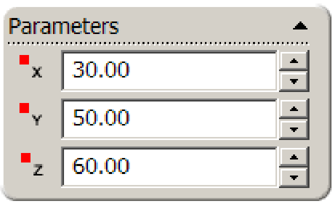




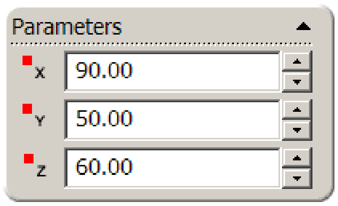
Projections of a line

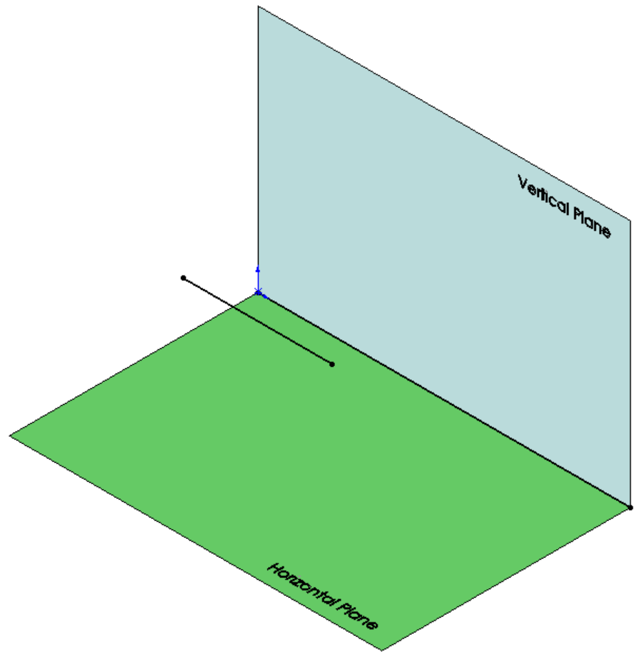
Edit the co-ordinate endpoints to reflect those outlined below.

Endpoint 1.



Endpoint 2





The Y and Z Co-ordinate values are the same.

The Y value refers to the distance above the horizontal plane.
The Z value refers to the distance in front of the vertical plane.

Therefore the line will be parallel to both the vertical and horizontal planes, as shown opposite.

What views could be used to further confirm this?

We will now use **Convert Entities** to create the lines projection onto both the vertical and horizontal planes.

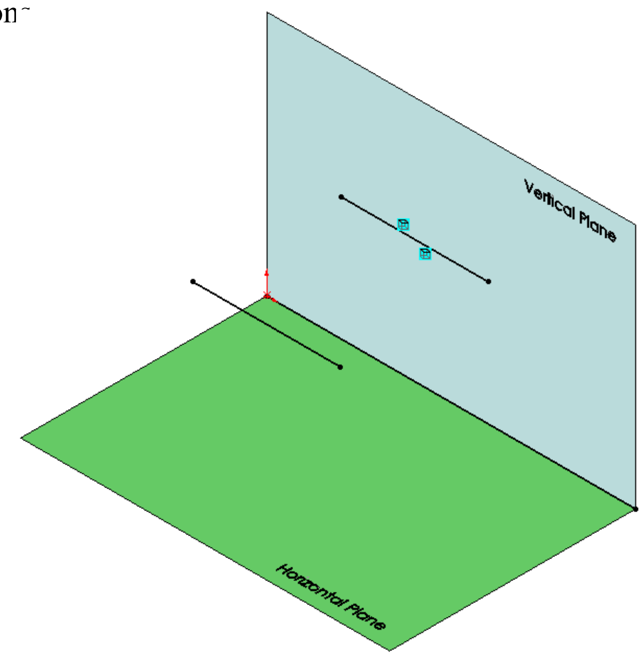
Projecting the Elevation

Choose **front view.**

Create a sketch using the **Vertical Plane**

Select the line and choose **Convert Entities.**
The line has been projected on to the vertical plane behind it.

Move to an **Isometric View**, the projection will be displayed as shown



> The distance of the object above the horizontal plane is equal to the distance of the front view above the xy line

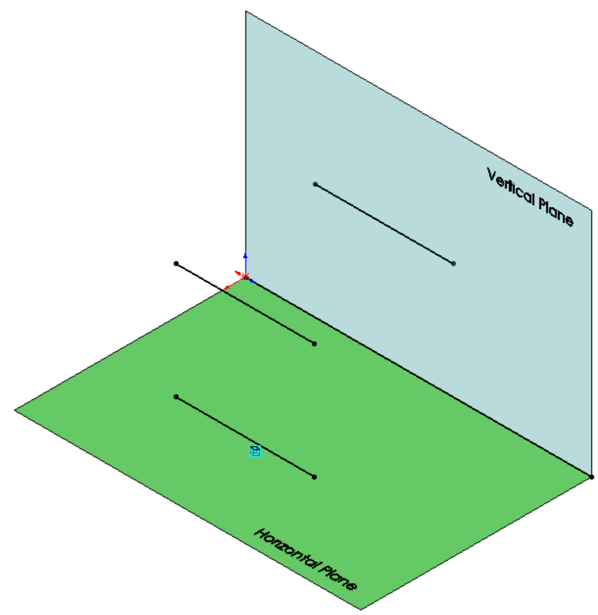
Projecting the Plan

Choose **top view.**

Create a sketch using the **Horizontal Plane**

Select the line and choose **Convert Entities.**
The line has been projected on to the horizontal plane underneath it.

Move to an **Isometric View**, the projections will be displayed as shown



The distance of the object in front of the vertical plane is equal to the distance of the top view in front of the xy line

True length of the line

The line was initially created 60mm long using the co-ordinates. This is the **true length** of the line.

If we smart dimension the projected lines created in both the elevation and plan view sketches we will find that they too are 60mm long. Therefore the elevation and plan show the line as a true length. Why?

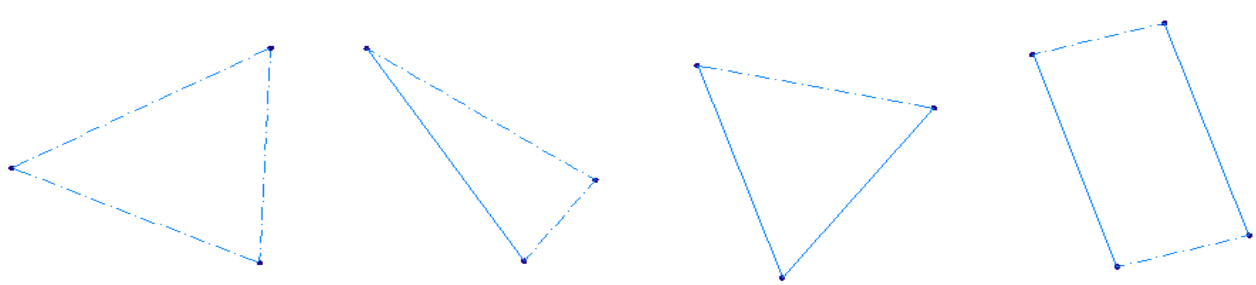
Because the line is parallel to both the front and top plane the line is seen as a true length in both the elevation and plan.

A line will be seen as a true length when it is parallel to the projection plane it is projected on to.

Point view of the line

In order to get a point view of the line we will first create a plane on which to project onto. The plane is positioned perpendicular to the line.

As discussed previously, a plane may be defined in 4 ways;

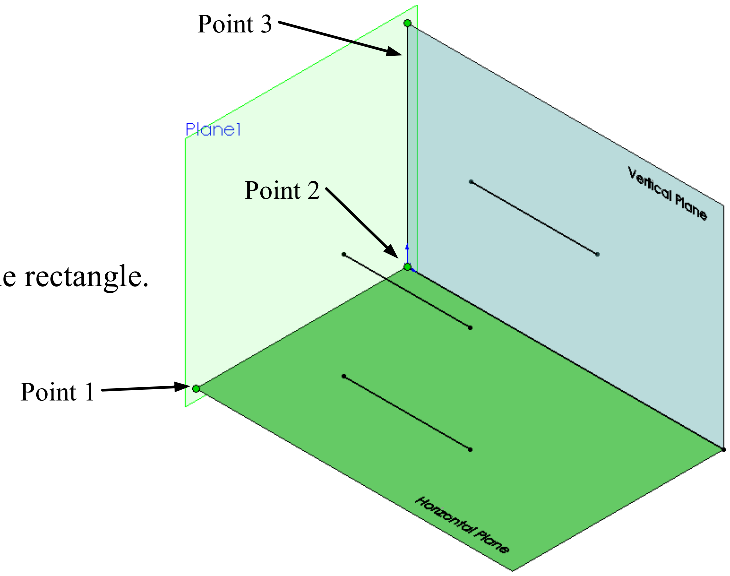


(i) 3 non-linear points *(ii) A line and a point (The point can not lie on the line)* *(iii) Two intersecting lines* *(iv) Two Parallel Lines*

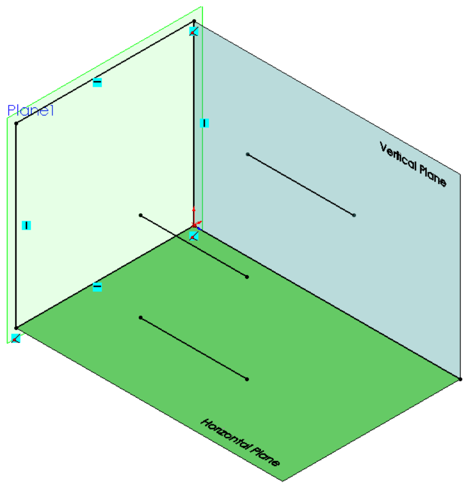
In this case we are going to define the plane using 3 points

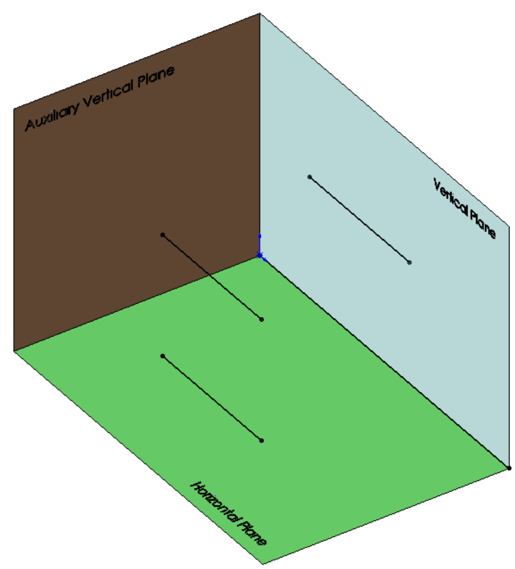
Choose **Insert, Reference Geometry, Plane…**

Choose the 3 points shown opposite to define the plane.



Create the rectangular sketch shown, adding a coincident relation between the 3 defining points and the corners of the rectangle.





Create a **Planar Surface** using this sketch to represent the Auxiliary Vertical Plane.

Edit the **Appearance, Color…** to a suitable colour.

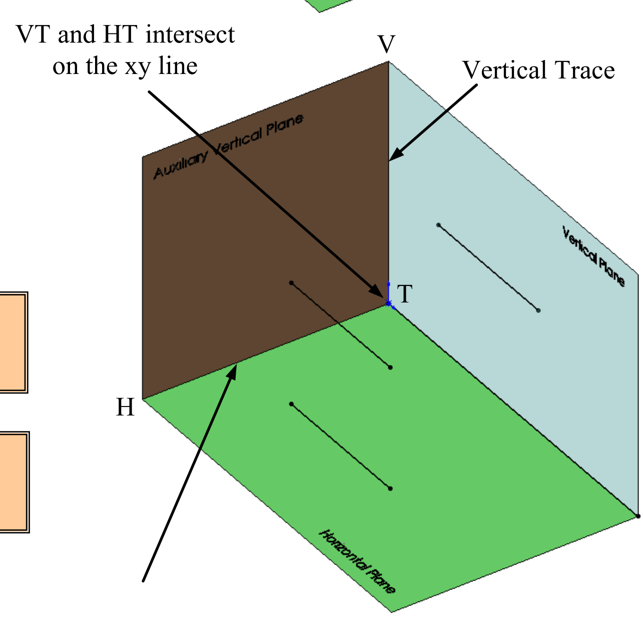
Rename the feature **'Auxiliary Vertical Plane'**

Add extruded text to identify the Auxiliary Vertical Plane (AVP).

Traces of the plane

Two planes intersect on a line.

Just as the vertical and horizontal planes intersect on the xy line, the traces created when the AVP intersects both the vertical and horizontal planes are lines.



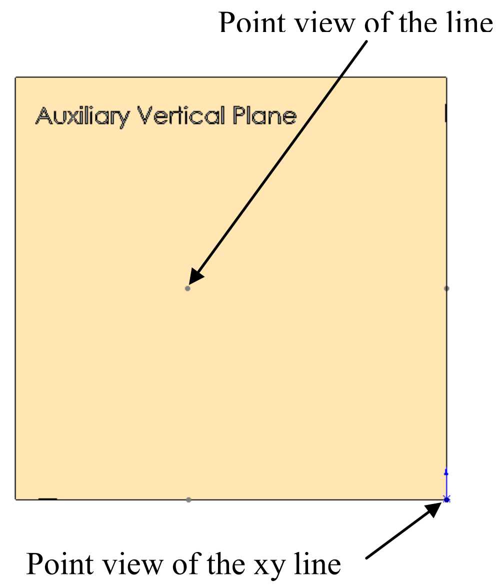
Horizontal trace (HT) of a plane is the line of intersection of that plane and the horizontal plane.

Vertical trace (VT) of a plane is the line of intersection of that plane and the vertical plane.

Unless the traces of a plane are parallel to the *xy* they will, extended is necessary, intersect on the *xy*

Horizontal Trace

This right view yields a point view of the line, a point view of the xy line and an edge view of both the horizontal and vertical planes.



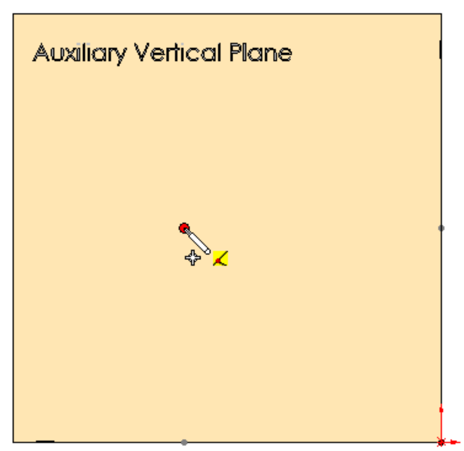
The xy line appears as a point because it is parallel to the line.

This view is created by looking along the true length of the line or parallel to a plane which projects the line as a true length.

As we have discovered already, this line, along with the xy line, is projected as a true length in both elevation and plan.

A line will be seen as a point when a view is taken along its true length or parallel to a plane which projects it as a true length.

Projecting the point onto the AVP



Create a sketch on the AVP Planar surface.

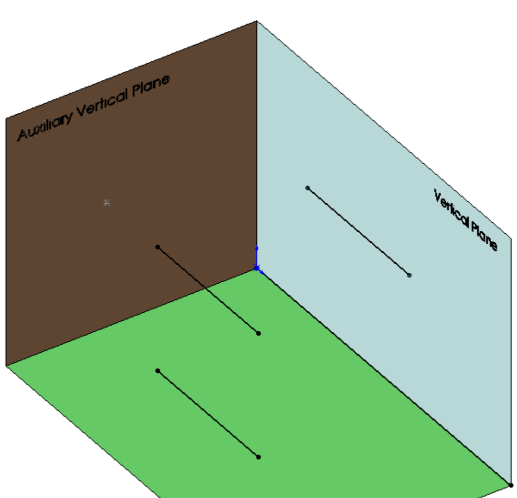
Choose Point and position a point coincident with the point view of the line. Rename the sketch end view.

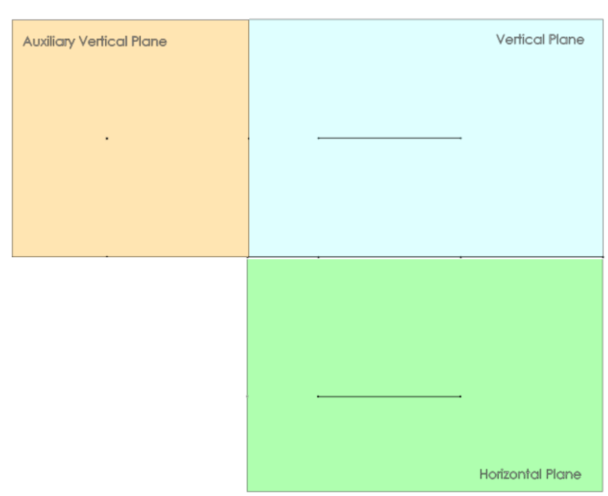
Convert Entities will not project a point view of a line onto a sketch plane.

Rabating the planes

The planes rabat as shown, to display the views on one single plane.

Note – The view displaying the line as a point is viewed from the right, but when rabated, appears on the left.

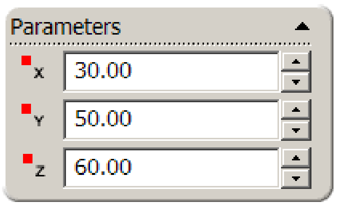




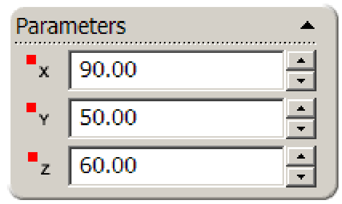
Line co-incident with the vertical plane

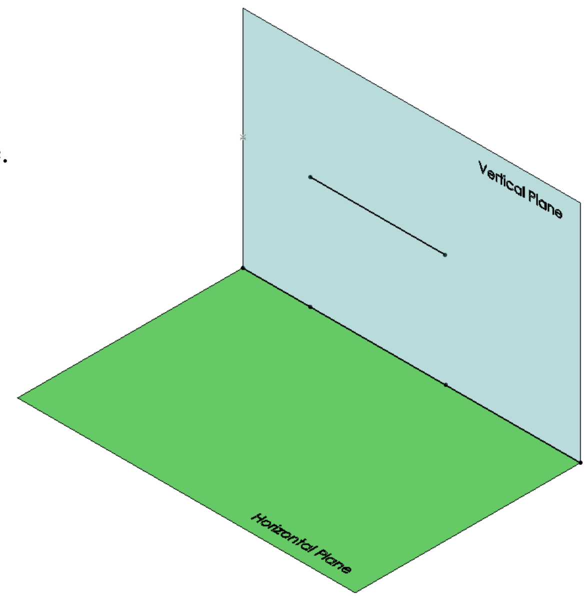
We wish to edit the co-ordinates of the line so that it sits on the vertical plane but remains the same height above the ground.

Endpoint 1



Endpoint 2





Which of the co-ordinates do we change?

The Z co-ordinate refers to the distance away from the vertical plane. Changing these values to zero will position the line on the vertical plane.

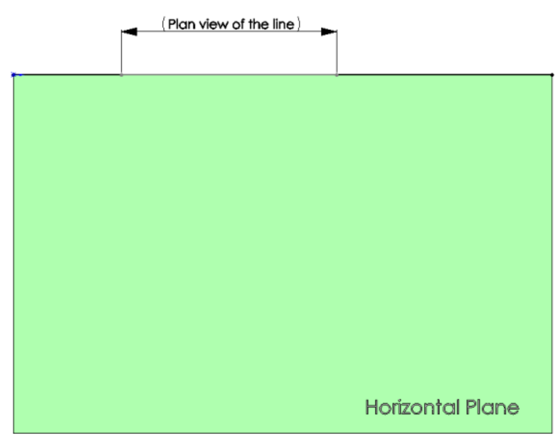
Hide the Auxiliary Vertical Plane and text by right clicking on the feature and selecting **Hide**.

The line is now positioned on the vertical plane.

Choose **Front view**.
Because the lines distance above the ground has not changed the elevation appears unchanged.

> The distance of the object above the horizontal plane is equal to the distance of the front view above the xy line

The line is contained on the vertical plane, perpendicular to the line of vision and therefore appears as a **true length**



On initial examination it looks as though the projection of the line onto the horizontal plane has disappeared. However on closer inspection we can see that it is coincident with the XY line.

Choose **Top View**.

In plan the line will coincide with the XY line or the edge view of vertical plane.
Because the line is contained on the vertical plane then it will coincide with the edge view of that plane in plan.

Because the object is zero distance in front of the vertical plane,

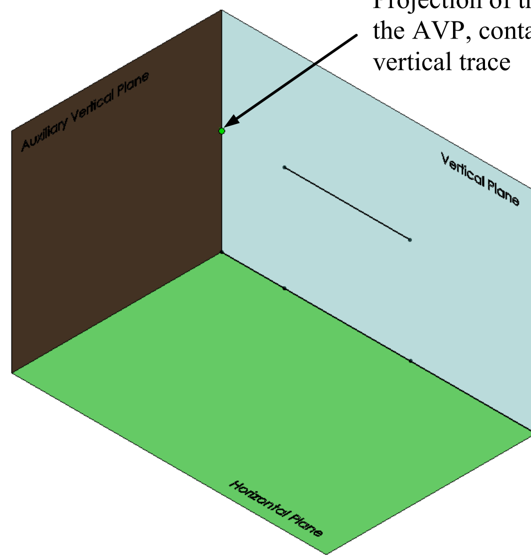
i.e. contained on the plane, then it will be zero distance below the XY line.

End View of the line

The distance of the object in front of the vertical plane is equal to the distance of the top view in front of the XY line

Show the AVP and the AVP text by right clicking the feature and selecting **Show.**

The projection of the line onto the AVP appears as a point, on the vertical trace.

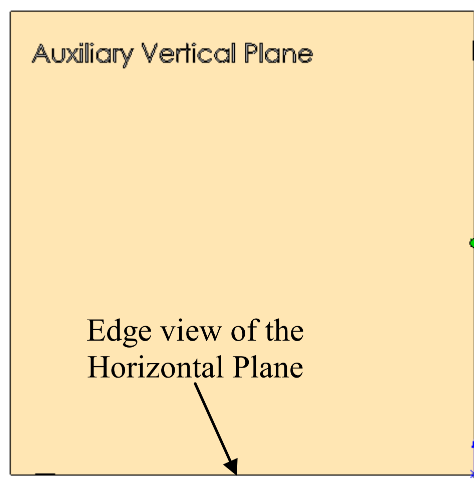


End View of the line

Choose **Right View**

In choosing the right view we are looking along the true length of the line. Therefore the line appears as a point.

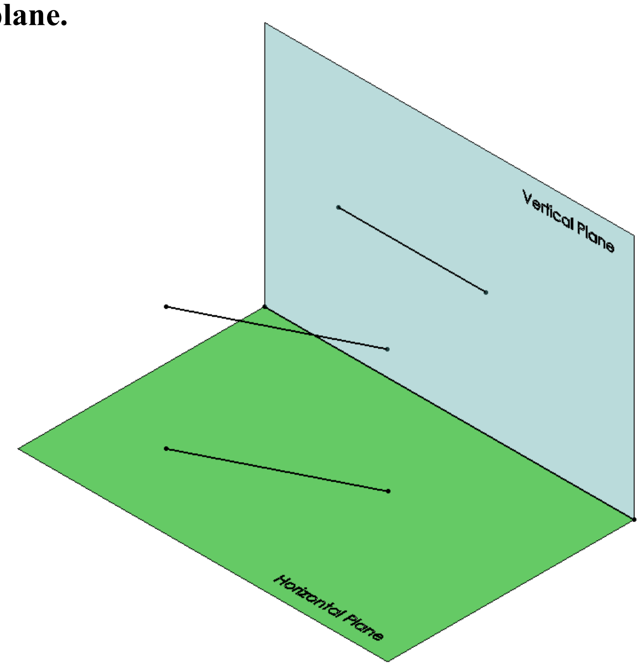
The vertical line containing the point not only represents the edge view of the vertical plane but also the end view of the vertical trace of the AVP.



Activity – Edit the coordinates of the line to position the line on the horizontal plane parallel to the vertical plane. Investigate the projections of this line in elevation, plan and end view, the line as a true length and point view.

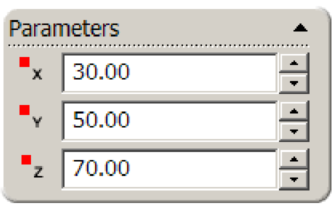
Hide the **AVP** and **AVP text.** Delete the sketch **End View.**

Line parallel to the horizontal plane inclined to the vertical plane.

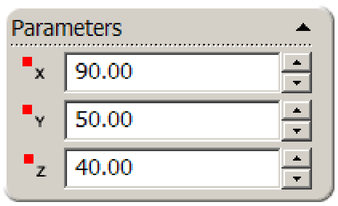


Edit the coordinates of the line to reflect those below.

Endpoint 1



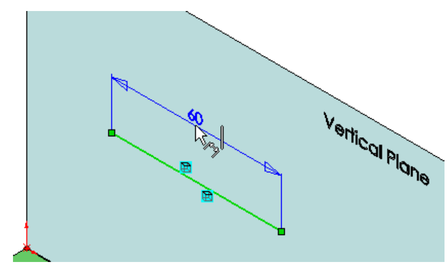
Endpoint 2



The Y co-ordinate values are equal therefore the line will be parallel to the horizontal plane.

The Z co-ordinate values differ therefore the line will not be parallel but inclined to the vertical plane.

True length of the line.

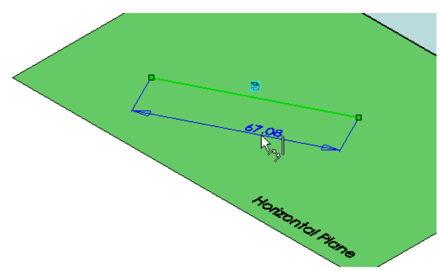


Projections of line in elevation.

If we examine the projected sketches in elevation we discover that they project as two different lengths; 60mm in elevation and 67.08 in plan. **Why?**

A line will be seen as a true length when it is parallel to the projection plane it is projected on to.

The line is parallel to the horizontal plane and projects in plan as a true length.

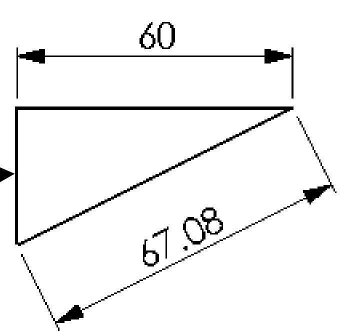


Projections of line in plan.

However, the line is inclined to the vertical plane and when projected will not appear as a true length but smaller. This reduction in size in elevation is known as **foreshortening**.

If the true length is set against the foreshortened distance, the distance that one point is in front of the other may be established.

One endpoint of the line is this distance further away from the vertical plane than the other.



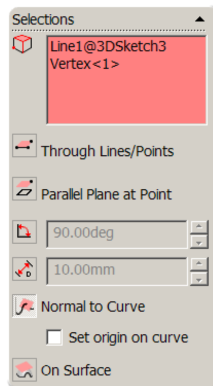
Point view of the line

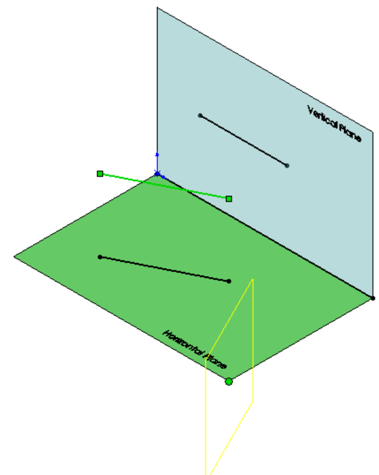
Select **Right View.** The line no longer appears as a point in the end view because we are no longer projecting along the true length of the line.

Is the line a true length in the end view.
No, the line is not parallel to the AVP and will therefore not project as a true length. It will appear foreshortened.

In order to get a point view of the line we must setup a view which is looking along the true length of the line. To achieve this we must setup a plane which is perpendicular to this line of vision i.e. perpendicular to the line.

Creating the plane perpendicular to the line





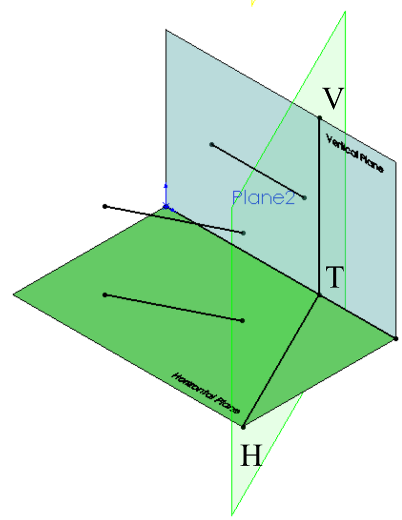
Choose **Insert, Reference Geometry, Plane…**

Select the line and the endpoint shown as **Reference Entities.** (The endpoint positions the plane)

The plane is previewed as shown. Choose **OK**

If the plane is not displayed choose **View, Planes.**

Extend the plane beyond the vertical and horizontal planes by dragging on the grips



Establishing the traces of the plane.

The traces will be found using intersection curve.

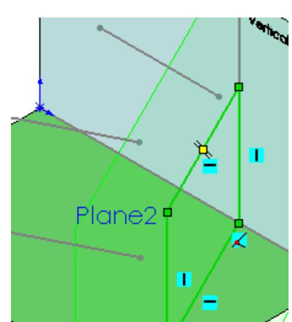
Choose **Tools, Sketch Tools, Intersection Curve.**
A new 3D sketch is created.

Select the plane, the vertical plane and the horizontal plane.

The traces of the plane, VT and HT, are produced as shown.
The horizontal trace is also referred to as the x_1y_1 **line** or the **ground line.**

Creating a laminar surface to represent the plane.

Create a rectangular sketch on the plane with the corner coincident with the intersection of the traces on the XY line.

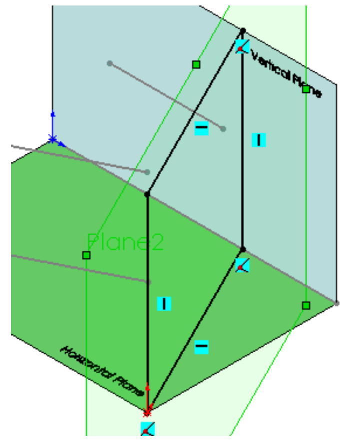


Add a coincident relation between the corners of the rectangle and the endpoints of the traces as shown.

Create a **Planar Surface** using this sketch to represent the Auxiliary Vertical Plane.
Edit the **Appearance, Color…** to a suitable colour
Reduce the transparency to 0.5.

Rename the feature **'Auxiliary Vertical Plane 2'**
Add extruded text to identify Auxiliary Vertical Plane 2.

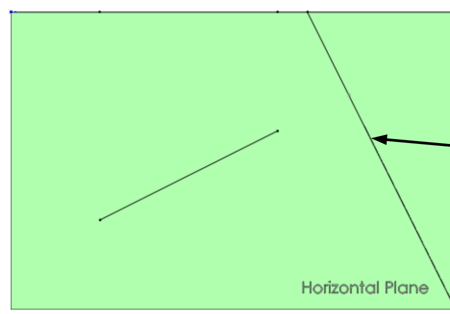
Hide the plane



The plane generated is a vertical plane and is referred to as an **Auxiliary Vertical Plane**. It is at right angles to the horizontal plane but inclined to the vertical plane. The vertical trace is vertical because the line of intersection between two vertical planes is a vertical line.

Choose **Top View**

The AVP appears as an edge. Why?



AVP as an edge and plan view of the HT and the x_1y_1

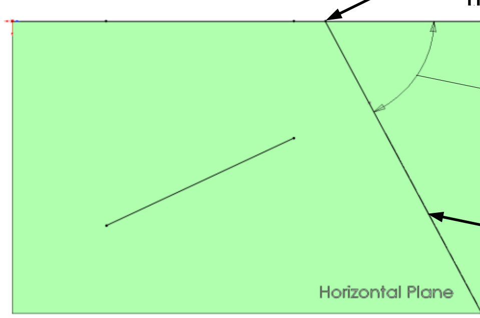
Because the VT is vertical, it appears as a true length in elevation.

When we choose a plan view we are looking along the true length of the VT and see it as a point.

Because the VT is contained on the AVP it appears as an edge

A plane will appear as an edge when a line contained on it projects as a point

Point view of the VT



True inclination of the AVP with the VP

AVP as an edge and plan view of the HT

In the top view the vertical plane and the auxiliary vertical plane are presented as edge views therefore, the true angle between them is displayed.

The edge view of the plane also represents the plan view of the horizontal trace.

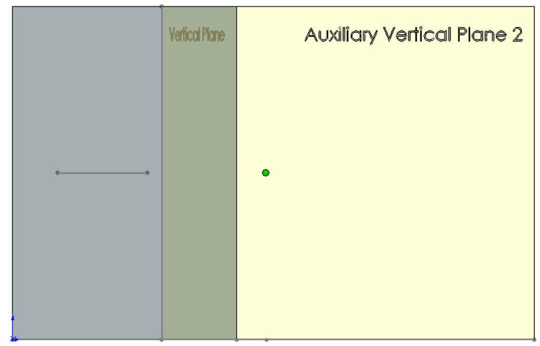
When the VT is perpendicular to the *xy*, the inclination of the plane to the vertical plane is given by the angle between the horizontal trace and the *xy*

Select the **Auxiliary Vertical Plane**

Choose **Normal To**.

This will give a normal to view from behind the plane.
Choose **Normal To** again to view from the opposite side.

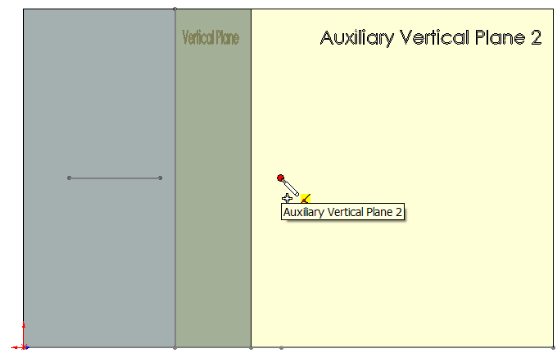
The line is viewed as a point because we are looking along the true length of the line projecting onto a plane at right angles to it.



Create a sketch using Auxiliary Vertical Plane 2.

Position a point co-incident with the point view of the line.

Rename the sketch **Auxiliary Elevation**

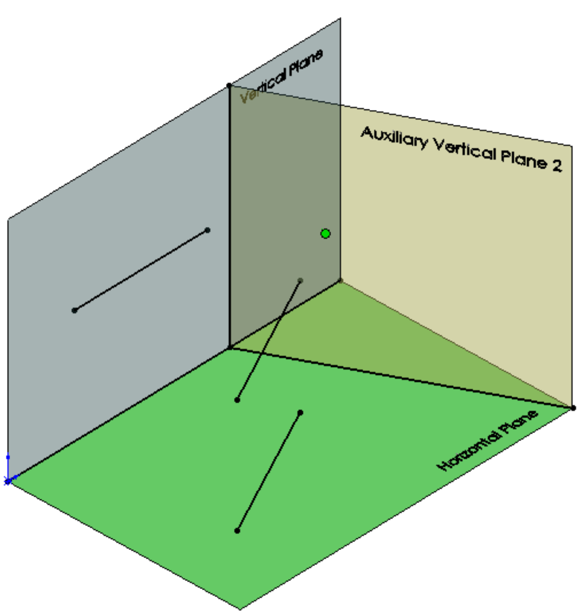


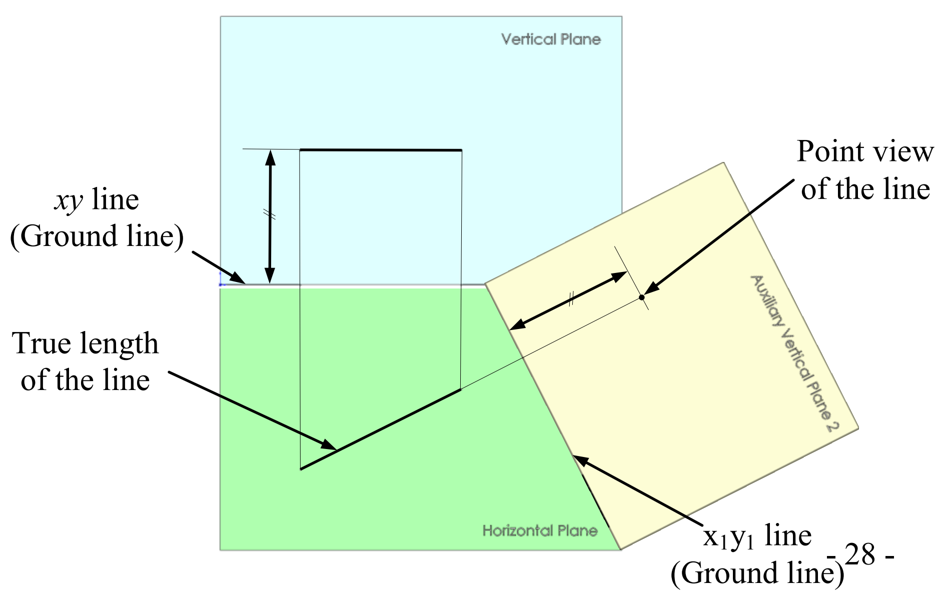
An auxiliary elevation is a projection on any auxiliary vertical plane not parallel to the vertical plane.

Note the distance of the line above the xy in both the elevation and auxiliary elevation are equal.

The distances of all elevations of the same point from the corresponding ground lines are equal.

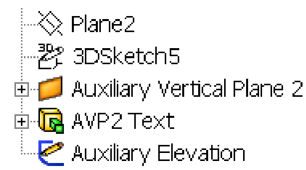
The auxiliary projection is shown orthographically by rabating the auxiliary vertical plane about t he x_1y_1





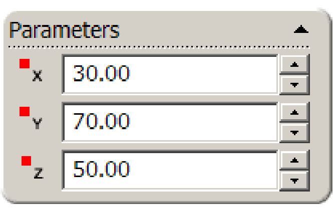
Save the file as **Auxiliary Elevation**

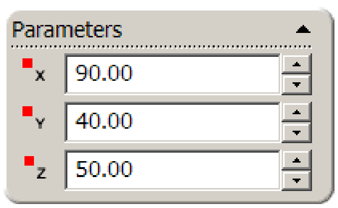
Delete the following features and save the file as **Auxiliary Plan**

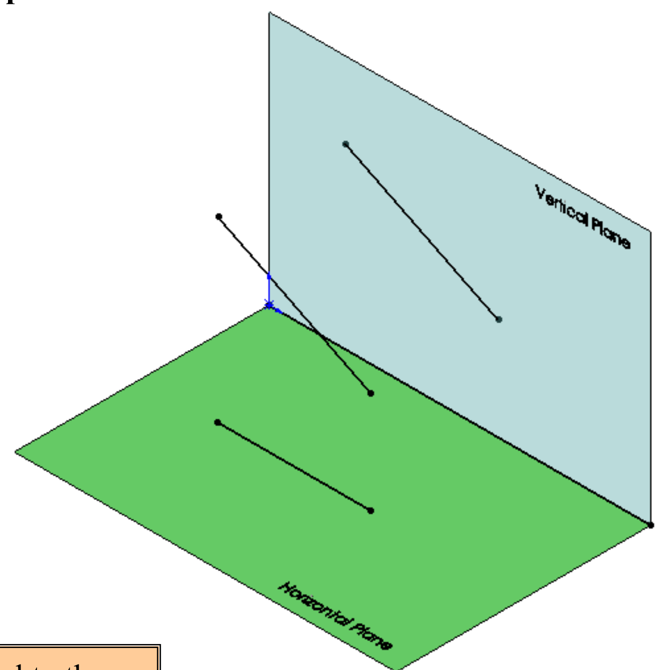


Line parallel to the vertical plane inclined to the horizontal plane.

Edit the coordinates of the line to reflect those below.







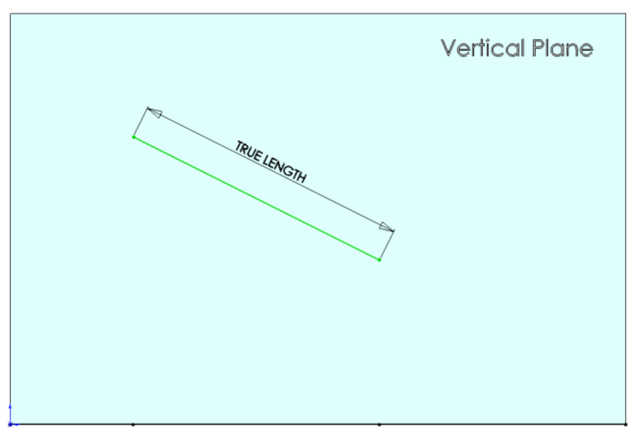
The Z co-ordinate values are equal therefore the line will be parallel to the vertical plane.

The Y co-ordinate values differ therefore the line will not be parallel, but inclined, to the horizontal plane.

Which view will project the line as a true length?

A line will be seen as a true length when it is parallel to the projection plane it is projected on to.

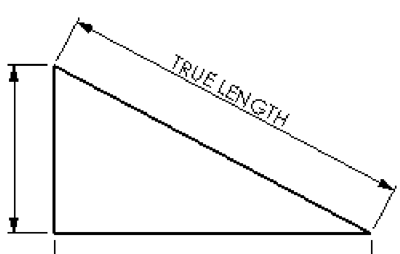
The line is parallel to the vertical plane and therefore will appear as a true length in elevation.



The line is inclined to the horizonatal plane and when Projected will appear foreshortened in the plan view. The apparent length of a foreshortened line is referred to as the **plan distance**

If the true length is set against the plan distance, the height of one endpoint relative to the other is given.

Height of one point relative to the other



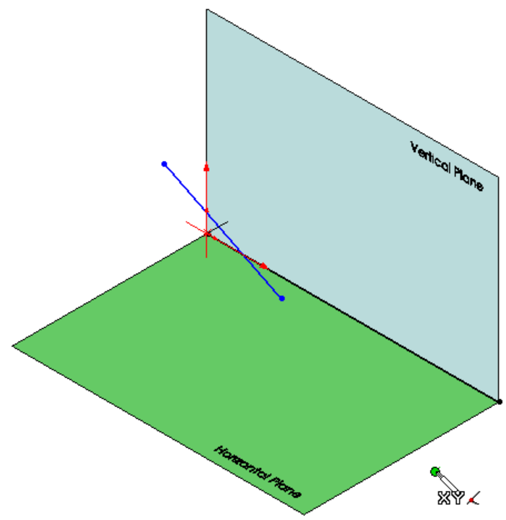
Point view of the line

In order to get a point view of the line we must setup a view which is looking along the true length of the line. To achieve this we must setup a plane which is perpendicular to this line of vision i.e. perpendicular to the line.

To create a plane perpendicular to the line we must first edit the 3D Sketch and position a point collinear with the line.

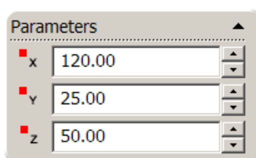
The new plane will pass through this point and will be perpendicular to the line.

Right click on the 3D sketch and select **Edit**
Position a point as shown.



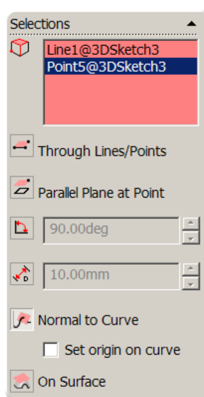
Selct the point and input the following coordinates

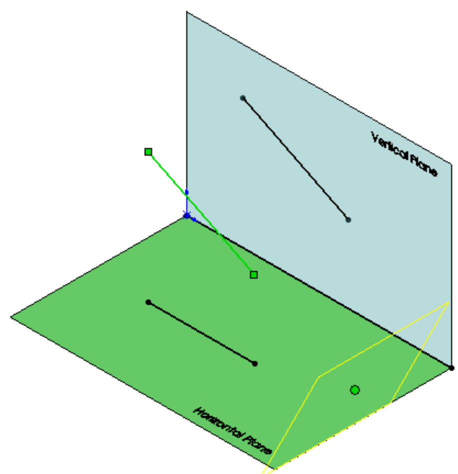
Because the z-value is the same as the endpoints of the line, the line and the point will be collinear



Exit the sketch

Choose **Insert, Reference Geometry, Plane…**





A plane is generated passing through point p and perpendicular to the line.

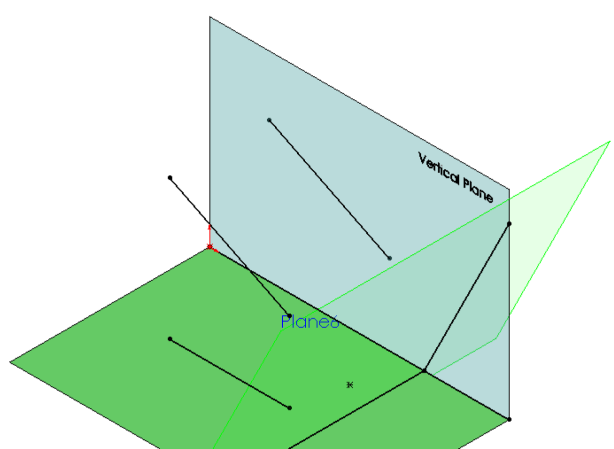
Extend the plane beyond the vertical and horizontal planes by dragging on the grips

If we edit the 3D sketch and reposition the point the planes position will update accordingly.

Adding the VT and HT.

Choose **Tools, Sketch Tools, Intersection Curve.**
A new 3D sketch is created.

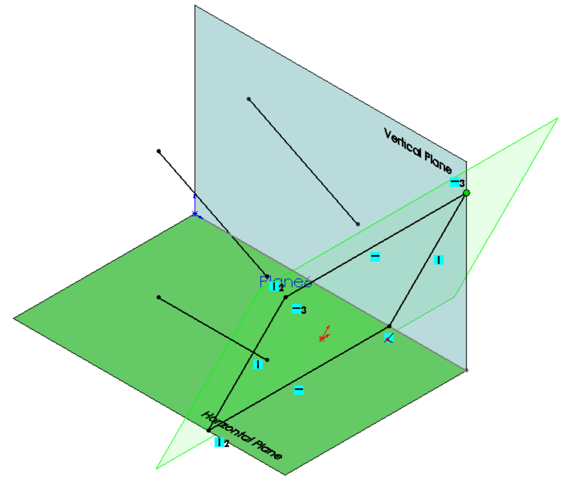
Select the plane, the vertical plane and the horizontal plan



The traces of the plane, VT and HT, are produced as shown.

The vertical trace is also referred to as the **x_1y_1 line**

Creating a laminar surface to represent the plane.



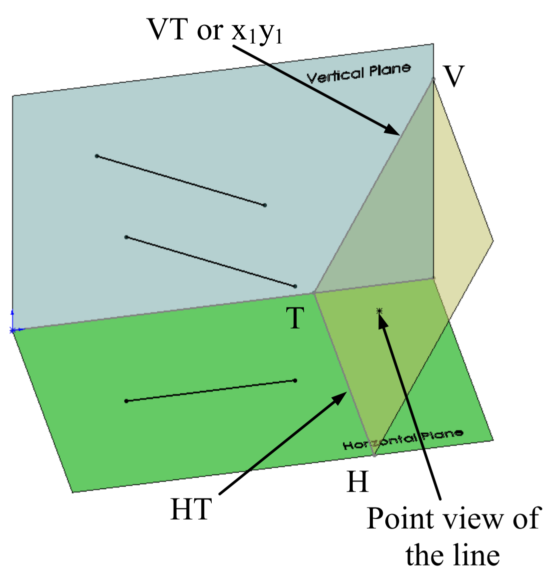
Create a rectangular sketch on the plane with the corner coincident with the intersection of the traces on the XY line.

Add horizontal and vertical relations between the corners of the rectangle and the endpoints of the traces as shown.

Create a **Planar Surface** using this sketch to represent the Inclined Plane.

Edit the **Appearance, Color…** to a suitable colour
Reduce the transparency to 0.5.

Rename the feature **'Inclined Plane'**



Hide the plane

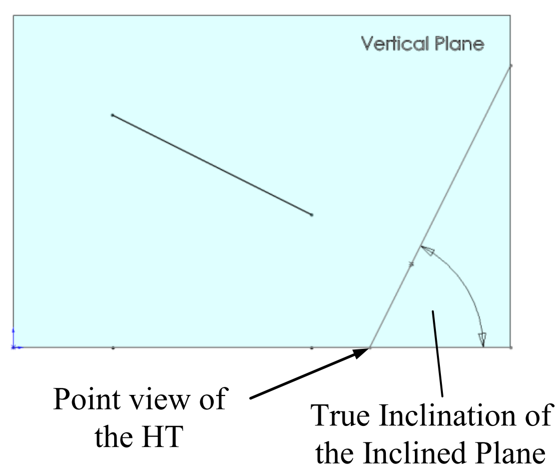
The plane generated is an **inclined plane**.

An **inclined plane** is perpendicular to the vertical plane and inclined to the horizontal plane.

The horizontal trace is contained on the horizontal plane and therefore appears as a true length.

The horizontal trace is perpendicular to the *xy* line.

In the front view the HT appears as a point, as we are looking along its true length.



The horizontal trace is contained on the inclined plane and the plane therefore appears as an edge.

A plane will appear as an edge when a line contained on it projects as a point

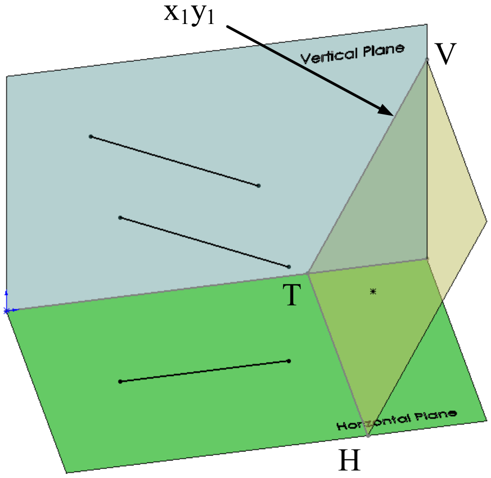
In the front view the horizontal plane and the inclined plane are presented as edge views therefore, the true angle between them is displayed.

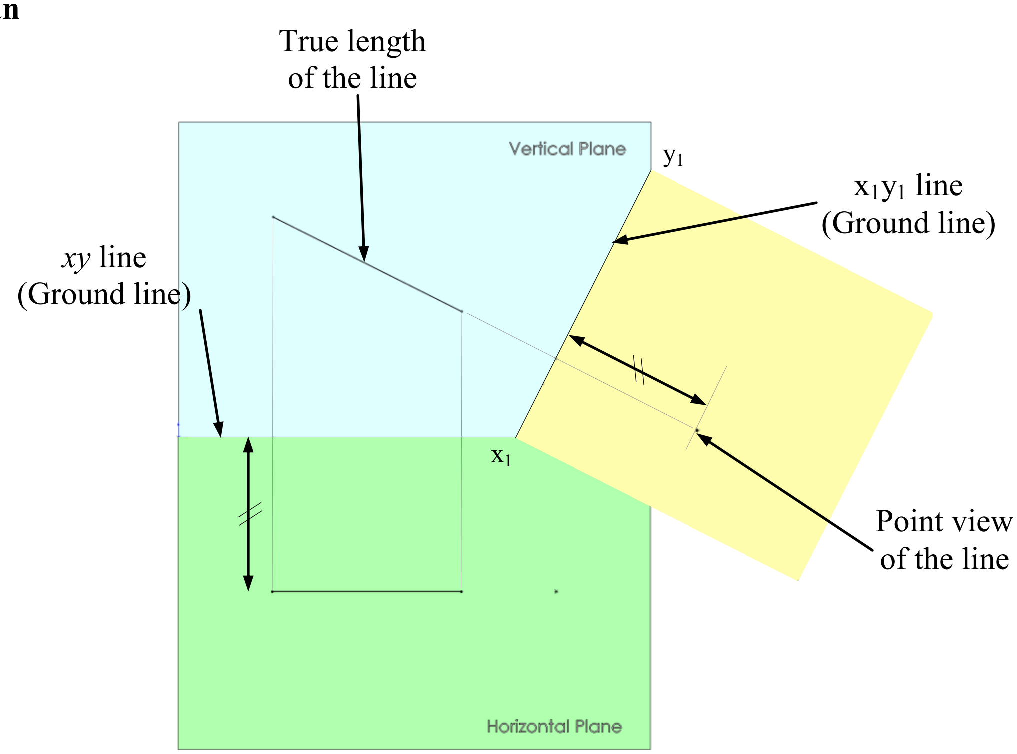
The edge view of the plane also represents the front view of the vertical trace.

When the HT is perpendicular to the *xy*, the inclination of the plane to the horizontal plane is given by the angle between the vertical trace and the *xy*

The pictorial view below shows the line with its three projections.

The rabatment of the planes results in the views shown on the right. The point view is rabated about the x_1y_1. This view is called the **Auxiliary Plan**





The distances of all plans of the same point from the corresponding ground lines are equal.