Module 4A: Creating the 3D Model of Right and Oblique Pyramids

In Module 4A, we will learn how to create 3D solid models of right-axis and oblique-axis pyramid (regular or truncated) in the Autodesk Inventor program, which shall be used as Derived Parts for their Work Surface, in the creation of a sheet metal part wrapping a right or oblique (regular or truncated) pyramid, in Module 5B.

The basic steps in the creation of the 3D model of a regular right-axis pyramid (one with the vertex) are summarized as follow:

- Creating a **Sketch** with the polygonal profile of the base of the pyramid, using the **Project Geometry** to project the **Center Point** onto the **Sketch** for a snap-point; and using the **Polygon** tool to draw the polygonal profile center-snapped to the projected **Center Point**;

- Creating a prism with the polygonal base profile using the **Extrude** tool with a **Distance** that equals the height of the pyramid;

- Selecting the top surface of the prism to create a Sketch with the vertex point of the pyramid, using the **Project Geometry** tool to project the **Center Point** onto the **Sketch** as the vertex point;

- Using the **Work Plane** tool to create a 3-point **Work Plane** feature with the vertex point and two points from an edge of the pyramid's base;

- Using the **Split** tool with **Split Part** as **Method** and the **Work Plane** as **Split Tool** to remove the unneeded volume;

- Using the **Circular Pattern** tool with the Split feature as **Features** and the Y Axis as **Rotation Axis**, to duplicate the Split feature around the prism, and to change the prism into a pyramid.

The basic steps in the creation of the 3D model of an oblique-axis regular pyramid (one with the vertex) are summarized as follow:

- Creating a **Sketch** with the polygonal profile of the base of the pyramid, using the **Project Geometry** to project the **Center Point** onto the **Sketch** for a snap-point; and using the **Polygon** tool to draw the polygonal profile center-snapped to the projected **Center Point**;

- Creating a prism with the polygonal base profile, using the **Extrude** tool with a **Distance** that equals the height of the pyramid, and a 0 (degree) **Taper**, if the vertex point of the pyramid is somewhere within the top surface of the prism to be created without a **Taper**; or

- Creating a prism with the polygonal base profile, using the **Extrude** tool with a **Distance** that equals the height of the prism, and a certain degree (45° for example) **Taper**, if the vertex point of the pyramid is somewhere outside of the top surface of the prism to be created without a **Taper;**

- Selecting the top surface of the prism to create a Sketch with the vertex point of the pyramid, using the **Project Geometry** tool to project the **Center Point** onto the **Sketch** as the vertex point; and using the **Point, Hole Center** tool to create the vertex point of the oblique axis; and using the **General Dimension** tool to apply linear dimensions between the vertex point and the projected **Center Point**;

- Using the **Work Plane** tool several times to create 3-point **Work Plane** features with the vertex point and two points from edges of the pyramid's base, the number of 3-point **Work Plane** features equaling the number of edges of the base;

- Using the **Split** tool several times with **Split Part** as **Method** and each of the **Work Plane** features as **Split Tool** to remove the unneeded volumes; and to change the prism into an oblique-axis pyramid.

The basic steps in the modification of the 3D model of any regular pyramid into a frustum of pyramid (one with the vertex removed to create a top surface parallel to the base surface) are summarized as follow:

- Selecting the **Work Plane** tool and choosing the **XZ Plane** and the vertex point of the pyramid as defining elements to create a **Work Plane** parallel to the base of the pyramid;

- Selecting the new **Work Plane** that is parallel to the base of the pyramid, to start a new Sketch; using the **Center Point Circle** tool to draw a large circle of a convenient size enclosing the visually projected area of the base;

- Using the **Extrude** tool with **Cut** as **Type**, **Distance** for **Extents,** the large circle drawn in the last step as **Profile**, and a downward **Direction**, to remove the vertex tip of the regular pyramid and to change it into a frustum of pyramid.

The basic steps in the modification of the 3D model of any regular pyramid into a truncated pyramid (one with the vertex removed to create a top surface at an angle relative to the base surface) are summarized as follow:

- Selecting the **XY** or **YZ Plane** to start a new **Sketch**, using a variety of tools such as **Project Geometry**, **Line**, **Trim**, and **General Dimension** to create a closed shape with appropriate dimensions for truncating the pyramid;

- Using the **Extrude** tool with **Cut** as **Type**, **Distance** for **Extents**, the closed shape drawn in the last step as **Profile**, and **Midplane** as **Direction**, to remove the vertex tip of the regular pyramid and to change it into a truncated pyramid.

For a sheet metal project with separate **Face** panel parts to be assembled, the above procedures are enough for the 3D model to be used as **Derived Parts** for their **Work Surfaces**. If the sheet metal project is to be created as a single piece with **Bend** features, and if the 3D model of the pyramid is a "regular" one with the vertex tip, than the "regular" one must be changed into a virtual "frustum" with the removal of a small but sufficient volume of the vertex tip, using the **Extrude** tool with **Cut** as **Type,** a **Distance** of less than one inch to one inch or above, depending on the sharpness of the vertex tip, and a profile drawn on a **Work Plane** feature that is perpendicular to the axis of the pyramid, so as to allow the **Bend** features associated with the **Face** features to be created properly. In addition, if it is desirable, then solid metal part in the shape of the removed vertex tip can be designed, fabricated and welded to the installed sheet metal part.

These steps will be demonstrated in the *Section 1* and *Section 2* of this Module.

Section 1: Creating A Derived Part File For A Regular Right-Axis Pyramid With A Triangular or Other Polygonal Base

In this part of the Module, we will create a 3D model of a triangle-based pyramid as an example; pyramids with bases of other polygonal shapes (such as four-sided square or rectangle, six-sided hexagon, seven-sided heptagon, and eight-sided octagon, etc.), can be created in similar methods. The step-by-step procedures are explained below.

Step 1: Creating a triangle-based prism

Create a new **Sheet Metal (in).ipt** file under the **English** tab; click the **Return** button to dismiss the default sketch and delete it from the **Model** panel with the **Delete** key on the keyboard. Select the **XZ Plane** and click the **Sketch** button to start a new sketch; rename the sketch as "*Triangle*" in the **Model** panel; use the **Project Geometry** tool to project the **Center Point** onto the new sketch; use the **Polygon** tool with **Inscribe** option and type 3 for number of sides, to draw a triangle centered at the projected **Center Point** (*Figure 4A-4A*); click-select the **Horizontal** constraint tool and then the base edge line of the triangle (shown red in *Figure 4A-4B*) to constrain it to a horizontal position (*Figure 4A-4C*); use the **General Dimension** tool to apply a 48-inch dimension to the base line (*Figure 4A-4D*). Click the **Return** button to exit the *Triangle* sketch.

Next, use the **Extrude** tool with **Join** as **Type**, 48 (inches) **Distance** for **Extents**, and an upward **Direction**, create an **Extrude** feature of a triangular prism (*Figure 4A-4E*); and rename it in the **Model** panel as "*Triangular Prism*." Press Ctrl+s key combination on the keyboard to save the file; in the **Save As** window, create a new folder and name it as *Tut-Piramid*; save the file as *Tut-Right Triangular-Base Pyramid.ipt* in the new folder. Also, go to the **File→As A Copy As** menu to save other copies as *Tut-Oblique Triangular-Base Pyramid.ipt*, *Tut-Oblique Triangular-Base Pyramid Vertex Out.ipt*, and *Tut-Oblique Triangular-Base Pyramid Vertex In.ipt*, successively, all in the same folder, for additional Sections of this Module.

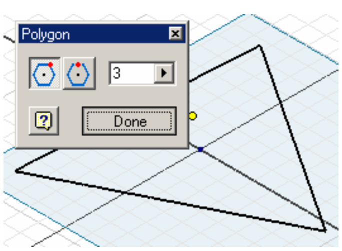


Figure 4A-4A: Draw the triangle.

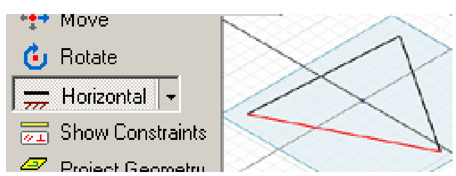


*Figure 4A-4B: The **Horizontal** constraint tool.*

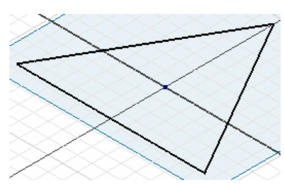


Figure 4A-4C: The base edge line constrained horizontally.

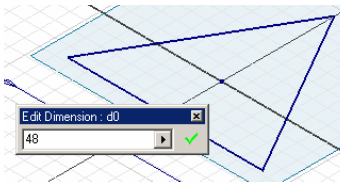


Figure 4A-4D: Apply a 48-inch dimension.

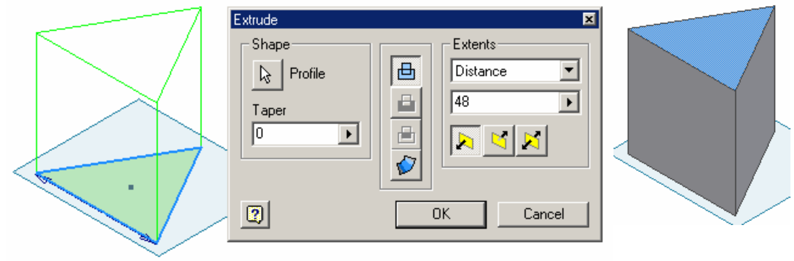


Figure 4A-4E: Creating the triangular prism.

Step 2: Cutting a pyramidal surface with the Extrude plus Work Plane and Sketch, or Split plus Work Plane tool combination

Next, draw the vertex point of the right regular triangle-based pyramid. Select the top surface of the triangle-based prism; click the **Sketch** button for a new sketch and rename it "*Vertex*;" use the **Project Geometry** tool to project the **Center Point** onto the sketch, which serves as the vertex point of the triangle-based pyramid; click the **Return** button to exit the *Vertex* sketch (*Figure 4A-4F*).

Next, create a **Work Plane** feature passing through 3 points (the vertex, and 2 endpoints of any edge line of the base). Click-select the **Work Plane** tool; move the cursor closer to the left endpoint and then the right endpoint of the base line, click each time when the yellow outlined circle point indicator appears; then move the cursor closer to the vertex point, and click when the red dot point indicator appears; a new light orange **Work Plane** feature with orange outline and light orange shade appears (*Figure 4A-4G*); rename it as "*Face Cut Plane*" in the **Model** panel.

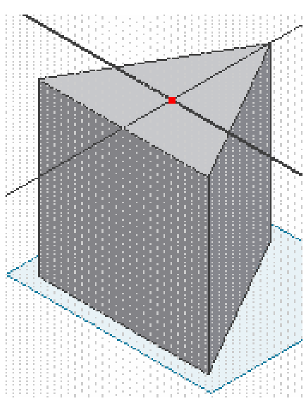


Figure 4A-4F: The vertex point.

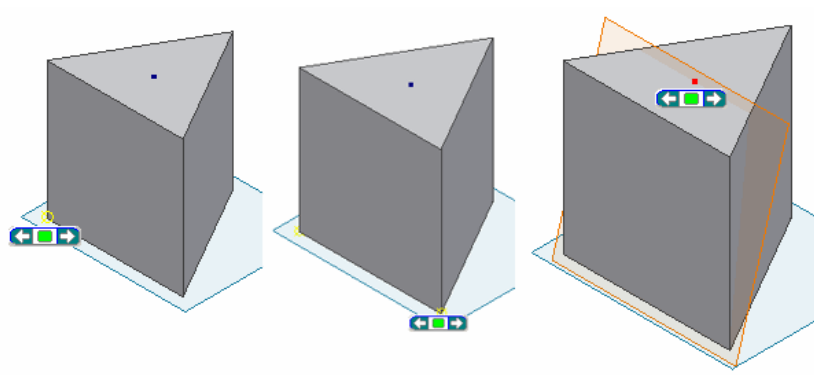


*Figure 4A-4G: Creating a 3-point **Work Plane** for cutting the prism into a pyramid.*

Next, cut the prism into a pyramid. Select the *Face Cut Plane* **Work Plane** feature and click the **Sketch** button for a new sketch; use the **Center Point Circle** tool to draw a large circle enclosing the entire 3D model of the prism (*Figure 4A-4H*); rename the new sketch "*Cut*" in the **Model** panel; click the **Return** button to exit the sketch mode. Next, select the **Extrude** tool with **Cut** as **Type**, **All** as **Extents** and a **Direction** pointing outward of the prism (*Figure 4A-4H*), to cut off an inclined surface out of the prism (*Figure 4A-4J*); rename the new **Extrude** feature "*Face Cut*" in the **Model** panel.

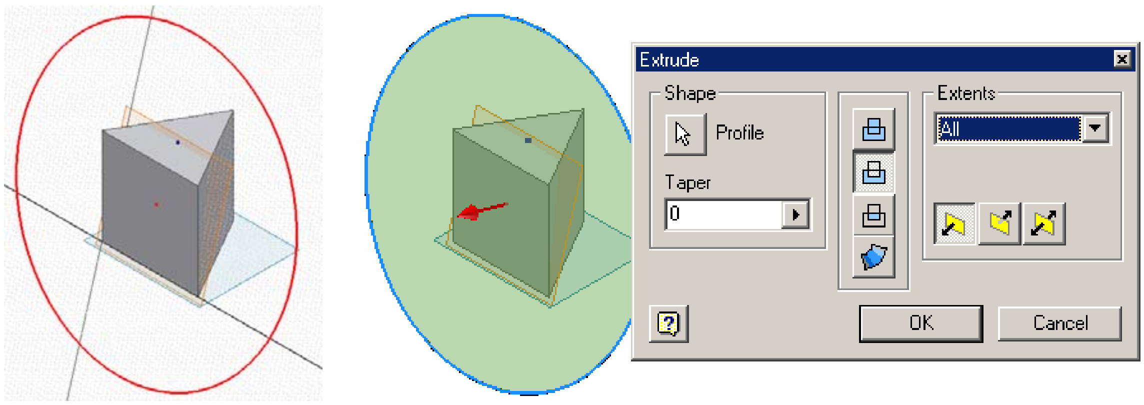


*Figure 4A-4H: Using the Cut **Sketch** feature (left) and the **Extrude** tool to create the pyramidal surface cut (right).*

The alternative of using the **Extrude** tool with a profile **Sketch** is to use the **Split** tool with a **Work Plane**. Select the **Split** tool from the **Features** panel; in the tool's dialog window, click the **Split Part** button in the **Method** section; click the **Split Tool** arrow button and click-select the and click-select the *Face Cut Plane* **Work Plane** feature on the screen or from the **Model** panel; click the **Direction** buttons in the **Remove** section to make sure that the red **Removal** arrow is pointing outwards from the prism; click the **OK** button to remove the unneeded volume from the prism (*Figure 4A-4I*); and rename the **Split** feature *Face Cut Split* in the **Model** panel. In this case, the inclined surface split off the prism is the same as that created by the **Extrude** tool with a profile **Sketch;** in other cases, the two approaches yield different results and offer different advantages, as shown in *Figure 4A-4J*.

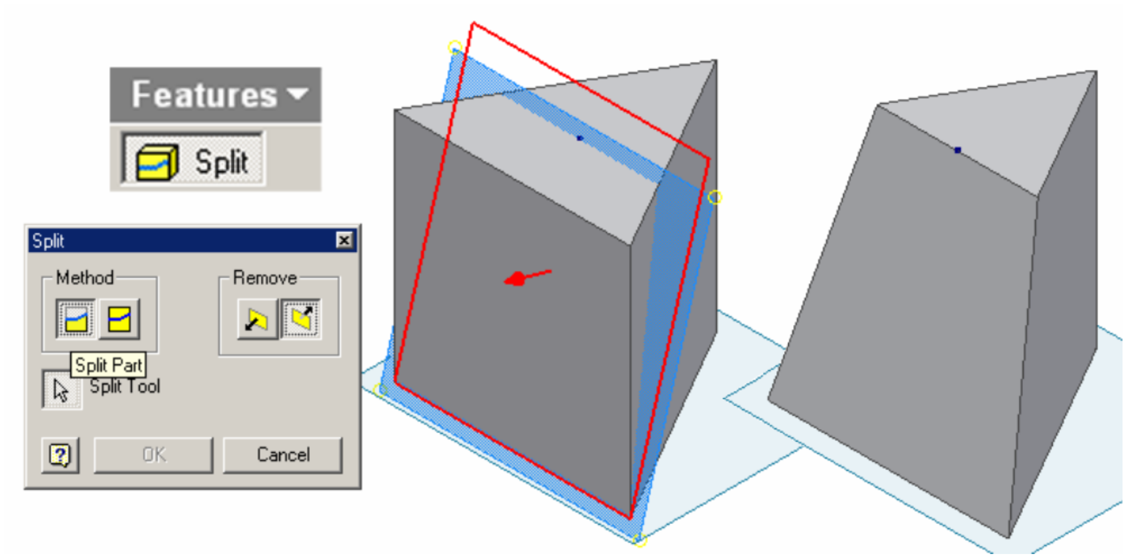


Figure 4A-4I: Using the Face Cut Plane ***Work Plane*** *feature and the* ***Split*** *tool to create the pyramidal surface cut (left). The resulted prism (right).*

Step 3: Removing the remaining excessive volume to change the prism into a pyramid with the Circular Pattern tool

You can repeat the same procedures to cut off the remaining two inclined surfaces and transform the triangle-based prism into a triangle-based regular right pyramid; however, since this is a right pyramid, the faster way is to use the **Circular Pattern** tool from the **Features** panel; click-select the tool, in its dialog window, click the **Features** button and click-select the "*Face Cut*" **Extrude** feature (or the "*Face Cut Split*" feature); next, click the **Rotation Axis** button and click-select the **Y Axis** feature from the **Model** panel's **Origin** folder; type 3 ul in the **Count** text field and 360 (degrees) in the **Angle** text field; green outlined geometric indicator and blue arrowed circular rotation indicator appear; click the **OK** button to remove all unneeded volumes from the prism and to change the prism into a pyramid (*Figure 4A-4K*); rename the **Circular Pattern** feature "*3 Face Cuts*" in the **Model** window.

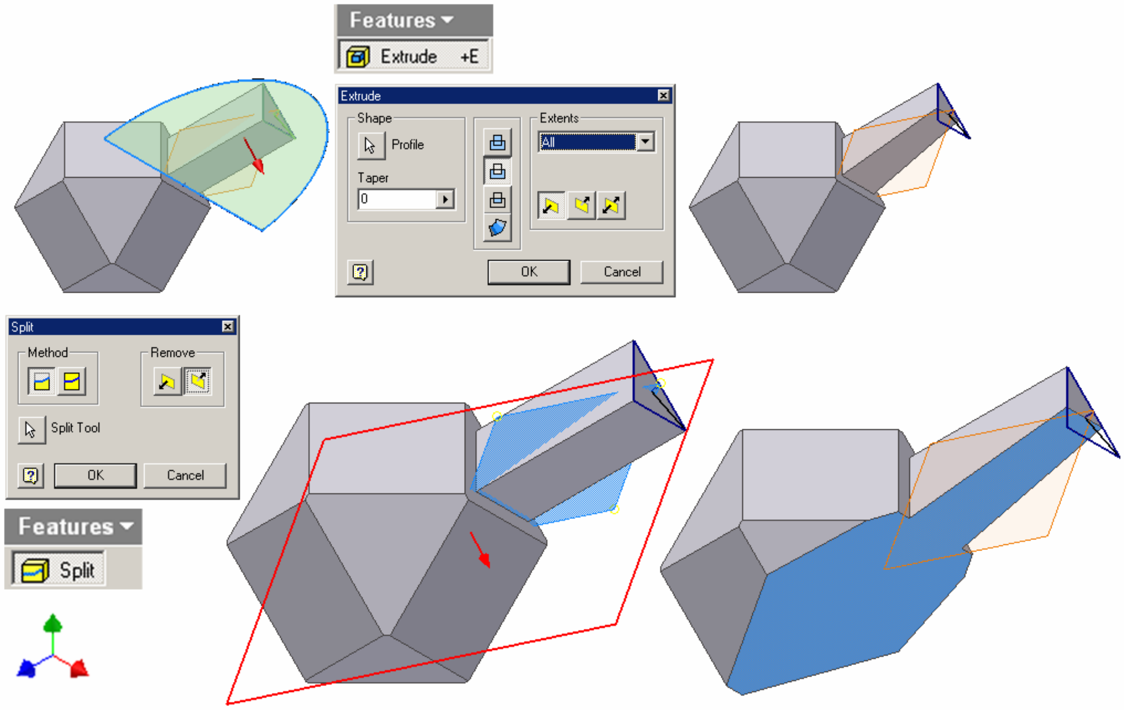


*Figure 4A-4J: The **Extrude** tool plus **Sketch** approach cuts off a volume of a definite depth (under the **Distance** option) or indefinite depth (under the **All** option), which is perpendicular to the profile (top). The **Split** tool plus **Work Plane** approach removes the entire volume on one side of the **Work Plane** feature (bottom).*

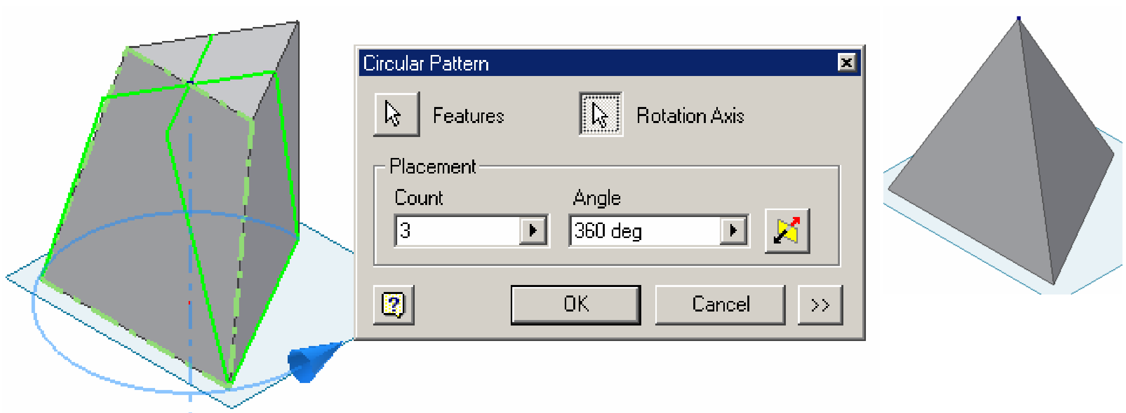


*Figure 4A-4K: Using the **Circular Pattern** tool (left) to complete the creation of the pyramid (Right).*

Use the **Rotate** tool with Common View [SPACE] option to rotate the 3D model to the top view; the vertex of the pyramid is located at the intersection of 3 edge lines each connecting one corner of the base triangle and the vertex point of the pyramid; and these edge lines can be extended the mid points of their opposite edges (*Figure 4A-4L*), indicating that the pyramid created here is a regular right triangle-based pyramid. Now, save the file; and also, go to the **File→Save A Copy As** menu to save another copy under the name of *Tut-Frustum of Right Triangular-Base Pyramid.ipt*, and another copy as *Tut-Truncated Right Triangular-Base Pyramid.ipt* in the same *Tut-Pyramid* folder, for further learning in later Sections of this Module.

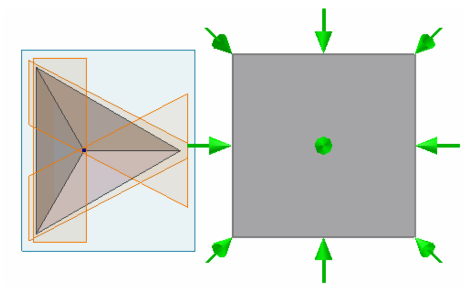


Figure 4A-4L: The top view of the pyramid.

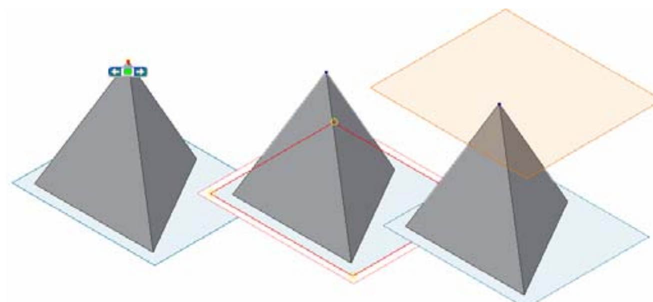


Figure 4A-4M: Creating the Vertex Cutoff Work Plane.

Step 4: Removing a small volume off the vertex tip to provide corner relief for a single-piece sheet metal part with Bend features

So far, the 3D model of a regular right triangle-based pyramid has been completed. However, if a single-piece sheet metal part enclosing such a solid is to be created, then a technical factor called “corner relief” in sheet metal design must be taken into consideration. Because of the way sheet metal parts are bended, there needs to be a gap at the vertex point of the pyramid. For this objective, we will cutoff the vertex tip of the pyramid by a depth of three times the thickness of the sheet metal material, or 0.12 in X 3 = 0.36 in (the depth depends on many factors, such as the thickness of the sheet metal material, the dihedral angles between congruent lateral **Face** surfaces, the sharpness of the vertex tip, etc.; through trial-and-errors, this is the minimum depth that works in this case).

First, create a work plane perpendicular to the axis of the pyramid. Since this is a right pyramid, the axis is perpendicular to the base, which is on the **XZ Plane**; therefore, such **Work Plane** feature must be parallel to the **XZ Plane** as well. Select the **Work Plane** tool; click-select the vertex point and then the **XZ Plane** on the 3D model or from the **Model** panel, a new **Work Plane** appears (*Figure 4A-4M*); rename it “*Vertex Cutoff Work Plane*” in the **Model** panel. Next, select the *Vertex Cutoff Work Plane* and click-select the **Sketch** tool to start a new sketch; rename the new sketch "*Vertex Cut*" in the **Model** Panel, use the **Center Point Circle** tool to draw a circle of a convenient size centered at the vertex point (*Figure 4A-4N*); click the **Return** button to exit the *Vertex Cut* sketch.

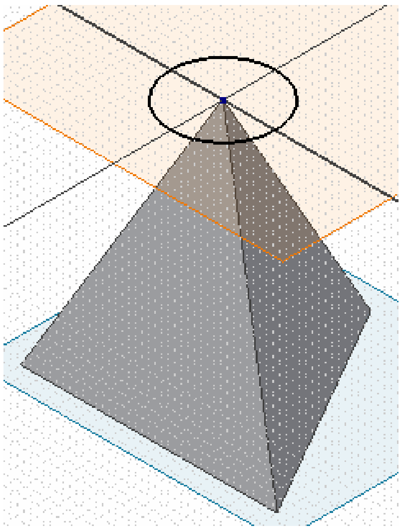


Figure 4A-4N: The Vertex Cut sketch.

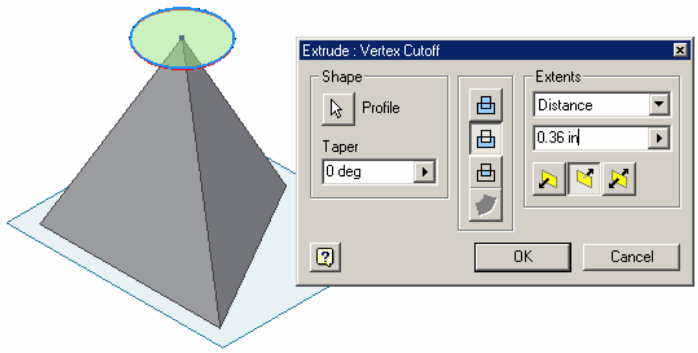


*Figure 4A-4P: The **Extrude** tool.*

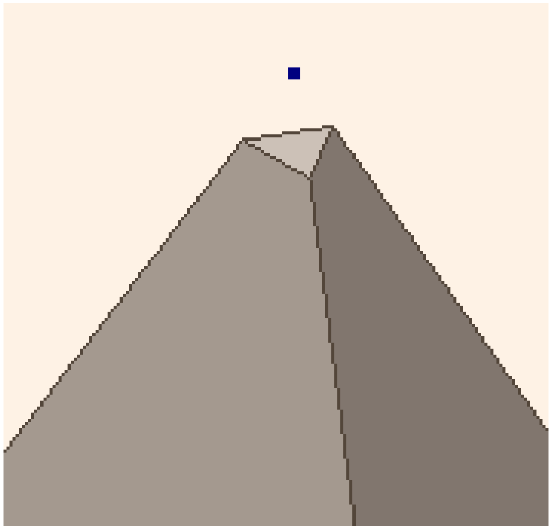


Figure 4A-4Q: The vertex tip cutoff.

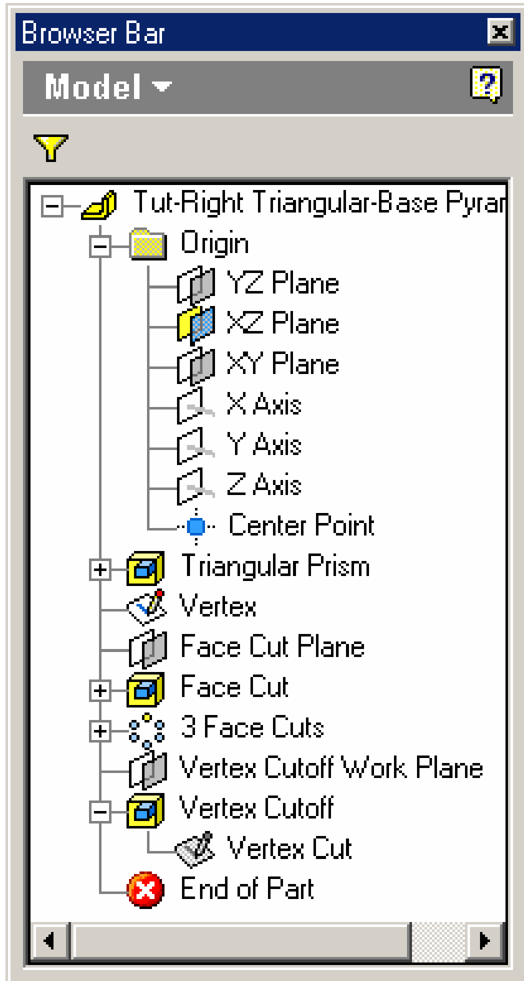


*Figure 4A-4R: The features listed in the **Model** panel.*

Next, use the **Extrude** tool with **Cut** as **Type**, the circle as **Profile**, 0.36 **Distance** for **Extents**, and a downward **Direction** (*Figure 4A-4P*), cut the vertex tip off the pyramid (*Figure 4A-4Q*); rename this **Extrude** feature "*Vertex Cutoff*" in the **Model** panel. All features of the resulted 3D model are listed in the **Model** panel (*Figure 4A-4R*). Save and close the file.

Section 2:
Create a Derived Part File for a Frustum of a Pyramid with a Triangular or Other Polygonal Base

A frustum of any pyramid is one which vertex is chop off by a plane parallel to its base. Open the file *Tut-Frustum of Right Triangular-Base Pyramid.ipt* from the *Tut-Pyramid* folder; click-select the **Work Plane** tool; move the cursor closer to the **XZ-Plane**, a red outline of the **XZ-Plane** and an orange outline of the suggested new work plane appear, click the mouse button once and the **XZ-Plane** turns blue; move the cursor closer to the vertex point, which turns red, click the mouse button again, and a new **Work Plane** parallel to one existing plane (the XZ-Plane) and passing through a point (the vertex) is created (*Figure 4A-5A*). Rename it as "*Top Work Plane*" in the **Model** panel. Next, select the "*Top Work Plane*" and click the **Sketch** button to start a new sketch; rename it as "*Frustum*" in the **Model** panel; use the **Center Point Circle** tool to draw a circle large enough to enclose the existing 3D model (*Figure 4A-5B*); click the **Return** button to exit the *Frustum* sketch.

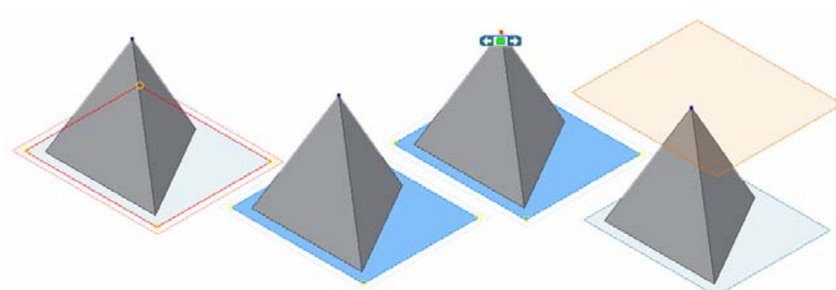


Figure 4A-5A: Creating a work plane parallel to an existing plane and passing through a point.

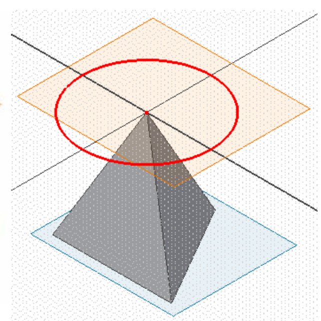


Figure 4A-5B: The frustum cut-off profile.

Next, use the **Extrude** tool with **Cut** as **Type**, 20 (inches) **Distance** for **Extents** and a downward **Direction**, cut the regular triangle-based right pyramid into a frustum (*Figure 4A-5C*); rename the **Extrude** feature as "*Frustum Cut*" in the **Model** panel. All features of the resulted 3D model are listed in the **Model** panel (*Figure 4A-5D*). Next, use the **Rotate** tool with **Common View [SPACE]** option to rotate the 3D model to the top view; the shape of the top surface is an offset of the shape of the base surface, with parallel corresponding edge lines (*Figure 4A-5E*), indicating that this is a frustum of a triangle-based pyramid. Save and close the file.

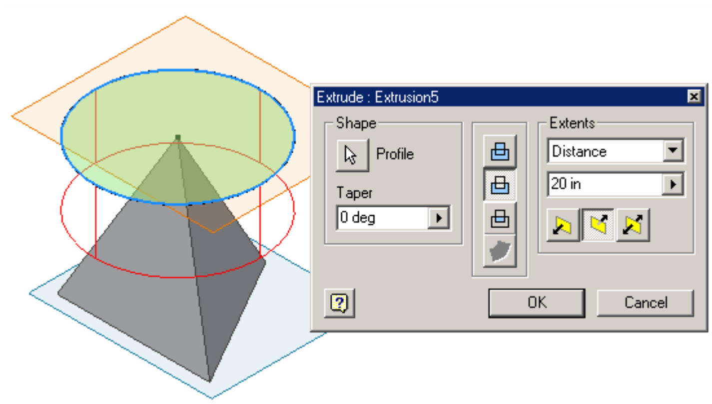


Figure 4A-5C: Cut the regular pyramid into a frustum.

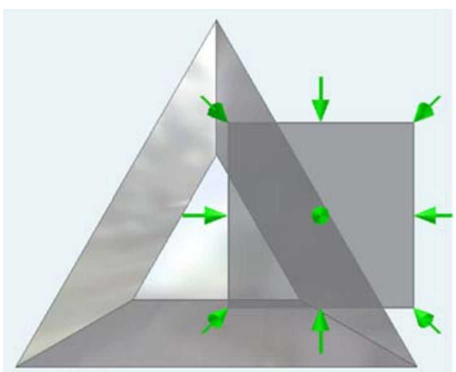


Figure 4A-5E: The top view.

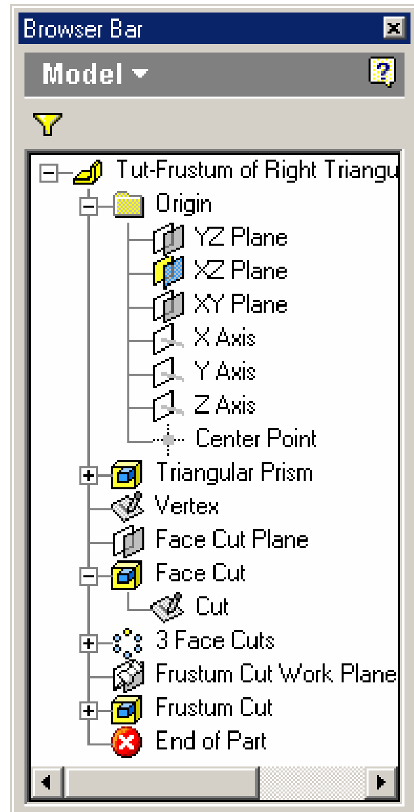


Figure 4A-5D: The features listed in the ***Model*** *panel.*

Section 3:
Creating A Derived Part File For A Truncated Right-Axis Pyramid With A Triangular or Other Polygonal Base

Step 1: Creating the truncated pyramid

A truncated pyramid is one which vertex is chop off by a plane inclined to its base. Open the file *Tut-Truncated Right Triangular-Base Pyramid.ipt* from the *Tut-Pyramid* folder; click-select the **YZ Plane** in the **Model** panel, right-click for the shortcut menu and turn on **Visibility** (*Figure 4A-6A*); click the **Sketch** button to start a new sketch; rename the sketch "*Truncation 1*" in the **Model** panel; use the **Look At** tool to switch the sketch to an orthographic view; use the **Project Geometry** tool to project the base edge line onto the sketch (*Figure 4A-6B*), and use the **Line** tool to draw an inclined line close to the vertex of the pyramid; draw two horizontal lines and a vertical line from the top and bottom endpoints of the projected base edge line; use the **Trim** tool to trim off the excessive segments of all lines, so that the sketch on the screen matches *Figure 4A-6C*; next, select the **General Dimension** tool, click on the projected base edge line and the endpoint of the inclined line (*Figure 4A-6C*), and apply a linear dimension of 36 inches (*Figure 4A-6D*), and an angular dimension of 30º between the base edge line and the inclined line; right-click for the shortcut menu and choose **Done** to exit the **General Dimension** tool. Next, use the **Trim** tool again to trim off all excessive line segments and to leave a clean profile for the truncation cut; click the **Return** button to exit the *Truncation 1* sketch.

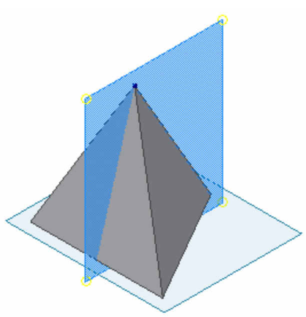


*Figure 4A-6A: Selecting the **YZ Plane**.*

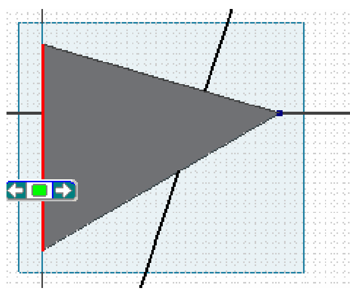


Figure 4A-6B: Projecting the base edge line.

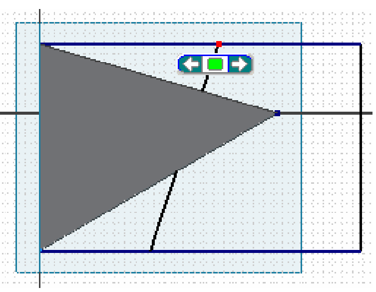


Figure 4A-6C: Picking the projected base edge line and the endpoint of the inclined line.

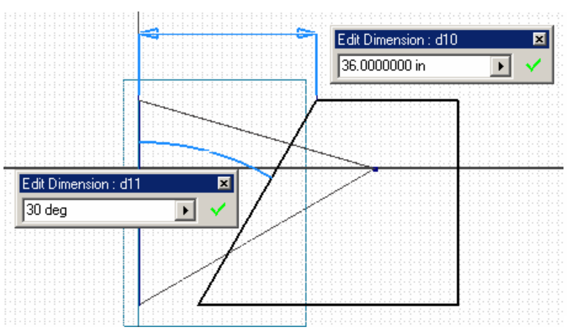


Figure 4A-6D: Applying linear and angular dimensions and trimming off excessive line segments.

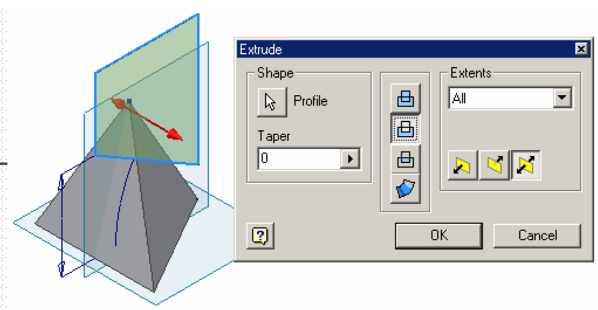


Figure 4A-6E: The truncation cut.

Next, use the **Extrude** tool with **Cut** as **Type**, **All** as **Extents** and **Midplane** as **Direction** to apply a truncation cut to the pyramid (*Figure 4A-6E* and *Figure 4A-6F*). Rename the **Extrude** feature as "*Truncation Cut 1*" in the **Model** panel. Use the **Rotate** tool with the **Common View [SPACE]** option to rotate the 3D model to the top view;

between the truncated top surface and the base surface, one pair of edges that are perpendicular to the **YZ Plane** are parallel, but the other two pairs are not; and the shape of the top surface is not an offset of the shape of the base surface, like the one seen in *Section 2* of this *Module* (*Figure 4A-6G*), indicating that this is a truncated triangle-based pyramid. Save the file.

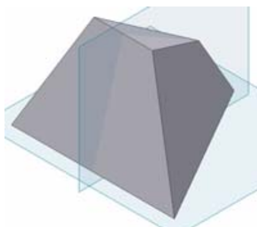


Figure 4A-6F: The truncated pyramid.

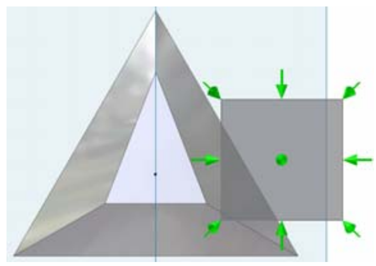


Figure 4A-6G: The top view of the truncated pyramid.

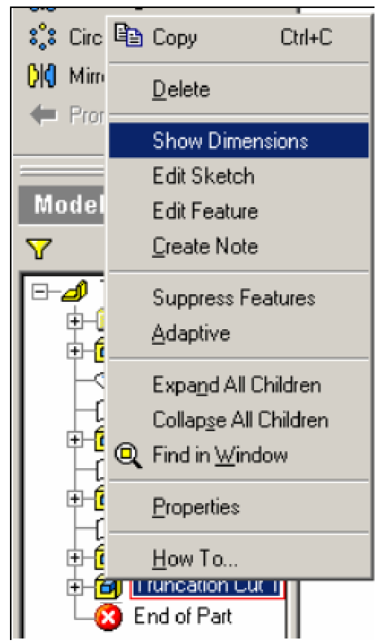


Figure 4A-7A: The Show Dimensions option.

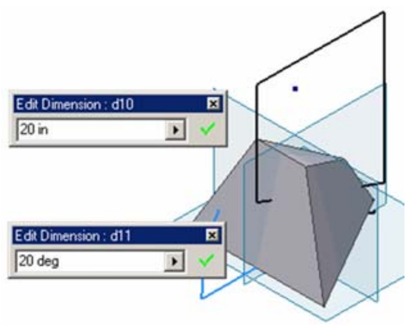


Figure 4A-7B: Editing the dimensions.

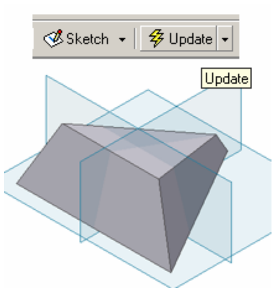


Figure 4A-7C: Updating the 3D model after editing dimensions.

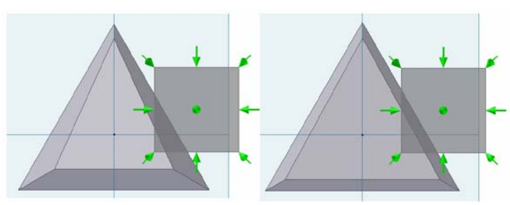


Figure 4A-7D: Comparing the effects of truncating angles on the top view. 20º (left); 5º (right).

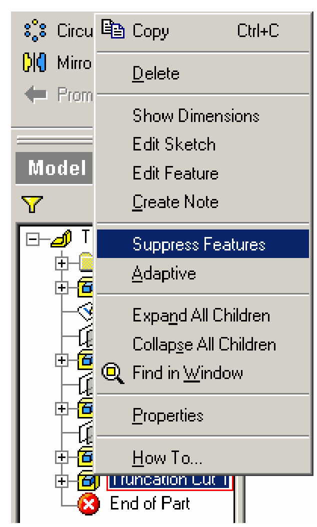


*Figure 4A-7E: The **Suppress Features** option.*

Step 2: Exploring the effects of changes of height and angle of the truncating profile on the truncated pyramid's 3D model

We will now study the effects of the height and the angle of truncating plane on the top view of the 3D model of pyramids. Switch to an isometric view. Click-select the "*Truncation 1*" **Extrude** feature in the **Model** panel, right-click for the shortcut menu and choose **Show Dimensions** option (*Figure 4A-7A*), the sketch and dimensions connected to the **Extrude** feature appear on the 3D model; double-click the linear and then the angular dimension features, type new values (20 in and 20 deg for linear and angular dimensions respectively, as shown in *Figure 4A-7B*), then click the green checkmark to apply the change; next, click the **Update** button in the **Command Bar** (*Figure 4A-7C*), the 3D model updates. Next, use the **Rotate** tool with the **Common View [SPACE]** option to rotate the 3D model to the top view; the shape of the top surface is enlarged and appears closer to the shape of the base surface (*Figure 4A-7D*), indicating that a smaller height gives a larger top truncated surface. Next, switch to isometric view again; change the angular dimension to 5 (degrees); and use the **Update** tool in the **Command Bar** to update the 3D model again; and rotate the 3D model back to the top view using the **Rotate** tool with the **Common View [SPACE]** option; the shape of the truncated top surface looks more "parallel" to the shape of the base surface; and if the angular dimension is changed to 0º, then the truncated pyramid becomes the frustum of a pyramid and the shapes of both top and base surfaces will be exactly offsets of each other, with exactly parallel corresponding edge lines. Hold the **Shift** key on the keyboard and press the **Z** key to undo the changes. Save the file.

Step 3: Learning how to use the Suppress Features and Unsuppress Features options

Next, we will apply a truncation to the pyramid from a profile drawn on the **XY Plane**, which is not perpendicular to any edge of the triangular base of the pyramid. We will first suppress the first truncating feature. Click-select the "*Truncation Cut 1*" **Extrude** feature in the **Model** panel; right-click for the shortcut menu and choose the **Suppress Features** option (*Figure 4A-7E*); the regular right triangular-based pyramid without the truncation reappears (*Figure 4A-8A*). In Inventor, the **Suppress Features** function temporarily removes targeted and associated features from the 3D model; and after they are "suppressed," the **Suppress Features** option is changed into **Unsuppress Features** option in the same shortcut menu, and the suppressed features can be brought back into the 3D model by the **Unsuppress Features** option.

Select the **XY Plane** and click the **Sketch** button to start a new sketch; rename it "*Truncation 2*" in the **Model** panel. Switch to orthographic view with the **Look At** tool; draw a similar truncation profile as shown in *Figure 4A-8B*; using similar methods as in the last step; click the **Return** button to exit the *Truncation 2* sketch; and apply a similar

Extrude cut to truncate the pyramid (*Figure 4A-8C*). Name the new **Extrude** feature "*Truncation Cut 2*" in the **Model** panel. Next, use the **Rotate** tool with the **Common View [SPACE]** option to rotate the 3D model to the top view; between the shape of the truncated top and the shape of the base surface, no pair of corresponding edges is parallel (*Figure 4A-8D*).

Next, select the *Truncated Cut 2* feature in the **Model** panel, right-click for the shortcut menu and choose the **Suppress Features** option to suppress it; next, select the *Truncated Cut 1* feature in the **Model** panel, right-click for the shortcut menu and choose the **Unsuppress Features** option and to unsuppress it. The isometric view of the model will look like *Figure 4A-8E*. All features of the model are listed in the **Model** panel (*Figure 4A-8F*). Save and close the file.

*Figure 4A-8A: Selecting the **XY Plane**.*

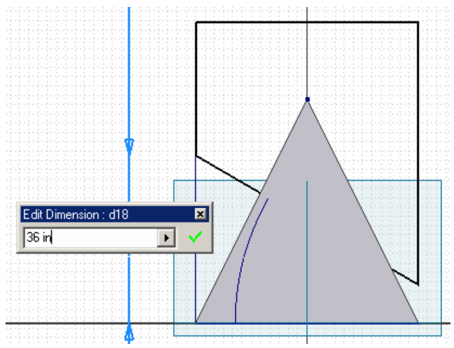


Figure 4A-8B: Drawing the truncating profile.

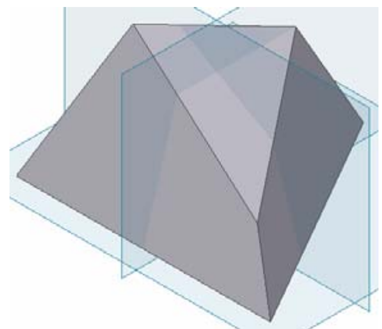


Figure 4A-8C: The new truncated pyramid.

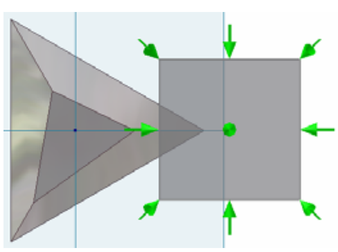


Figure 4A-8D: The top view.

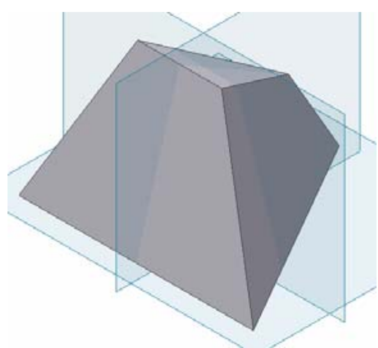


Figure 4A-8E: The last look of the model.

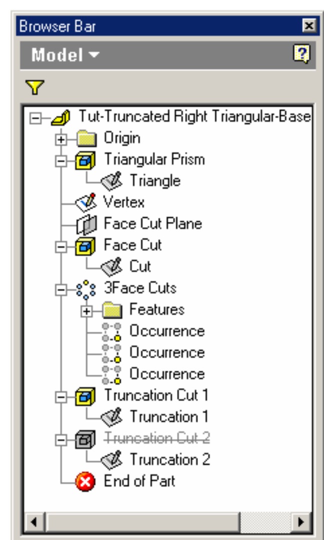


Figure 4A-8F: The new Model panel listing.

Section 5: Creating A Derived Part File For A Square-Based Regular Right-Axis Pyramid

Step 1: Creating a triangular-based prism

Launch Inventor, start a new **Sheet Metal (in).ipt** file under **English** tab. Turn **Visibility** on for **XZ** and **XY** and **YZ Planes**, plus the **Center Point** from the **Model** panel. "*Sketch1*" is created by default in the **Model** panel's **XY Plane** (the one parallel to your computer's screen). Go to **View→Isometric** for better visualization in 3D space; and click the **Look At** tool button to return to orthographic view and start drawing the cross-section of a regular right prism, which shall be cut into a pyramid in the next step. From the **Sketch** panel, click-select the **Project Geometry** tool to project the **Center Point** onto the sketch first; then select the **Polygon** tool with **Inscribed** option to draw a triangle (*Figure 4A-9A*); use the **Horizontal** constraint tool to constraint the base line of the triangle to horizontal position (*Figure 4A-9B*); use the **General Dimension** tool to apply a 36-inch dimension to the base line. Click the **Return** button to exit the **Sketch** mode. Rename the sketch "*Pyramid*" in the **Model** panel. Save the file as *Tut-Right Regular Square Pyramid.ipt*, inside the *Tut-Pyramid* folder.

Next, use the **Extrude** tool with 36-inch for **Distance** and **Midplane** for **Direction**, complete the 3D prism feature (*Figure 4A-9C*). Rename the **Extrude** feature "*Triangular Prism*" in the **Model** panel.

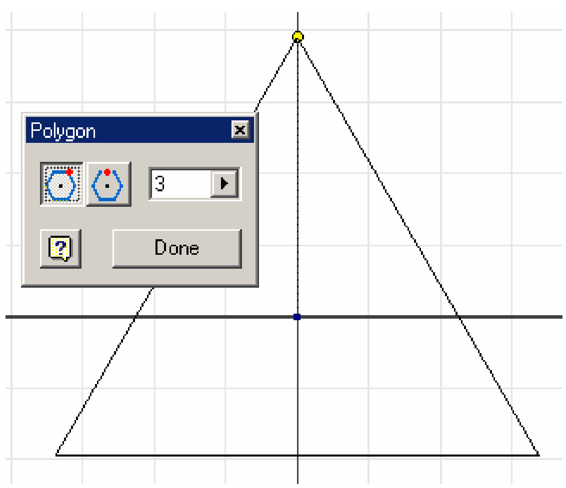


Figure 4A-9A: Starting the profile sketch for a regular right prism

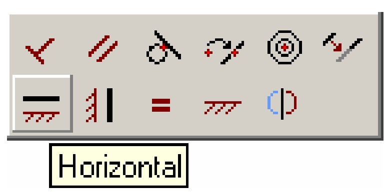


Figure 4A-9B: The Horizontal constraint tool.

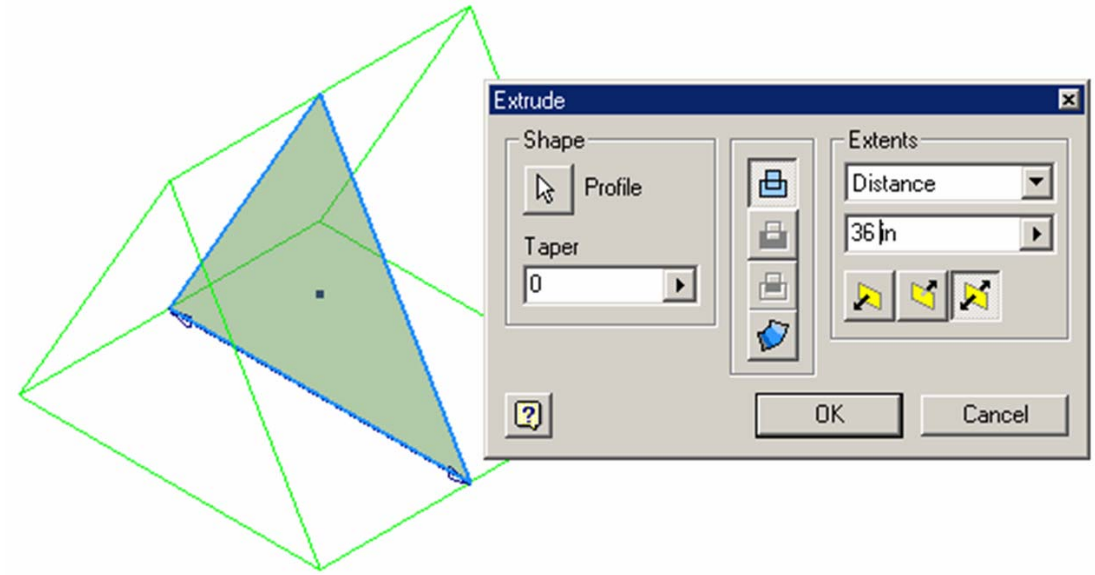


Figure 4A-9C: The Extrude tool.

Step 2: Cut the triangular-based prism into a rectangular-based pyramid

Next, click-select the **YZ Plane** (*Figure 4A-9D*), the **Sketch** and **Look At** tool buttons and start a new sketch to draw the cut-off profile transforming the triangular prism into a square-based pyramid; click-select the **Project Geometry** tool and project the **Center Point** and the base line of the triangular prism onto the new sketch (*Figure 4A-9E*); click-select the **Polygon** tool, choose the **Circumscribe** option and type 3 in the number of sides text field for a triangle; click on the projected **Center Point**, move the cursor to the mid point of the projected base line, and click when the green snap indicator appears (*Figure 4A-9F*) to complete the triangle; next, click-select the **Circle center Point** tool to draw a circle starting at the projected **Center Point** with a convenient radius that allows the circle to enclose the entire prism (*Figure 4A-9G*); next, click the **Return** button to exit the sketch, and rename the sketch as "*Cut*" in the **Model** panel.

Next, select the **Extrude** tool with **Cut** as **Type**, **All** as **Extents** and **MidPlane** as **Direction** (*Figure 4A-9H*), and the space between the triangle and the circle as **Profile**, cut the prism into a square-based regular right pyramid (*Figure 4A-9I*); rename the **Extrude** feature as "*Pyramidal Cut*" in the **Model** panel. Save the file. Also, go to **File→Save A Copy As** menu to save another copy of the file under the name of *Tut-Oblique Square Pyramid*, and another copy as *Tut-Twice Oblique Square Pyramid.ipt*, in the same folder, for further learning in later Sections of this Module. Close the file.

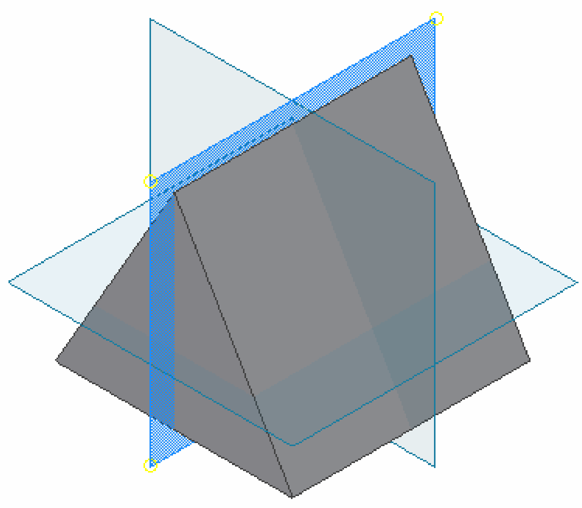


Figure 4A-9D: Start a cut-off profile sketch.

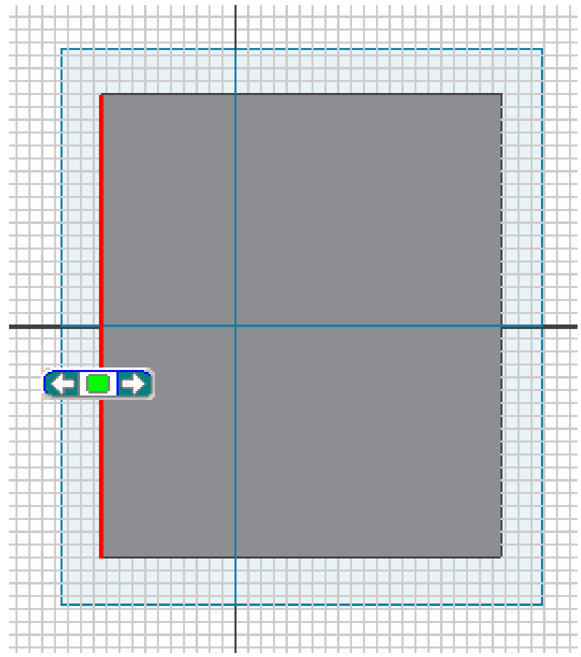


Figure 4A-9E: Project the base line onto the new sketch

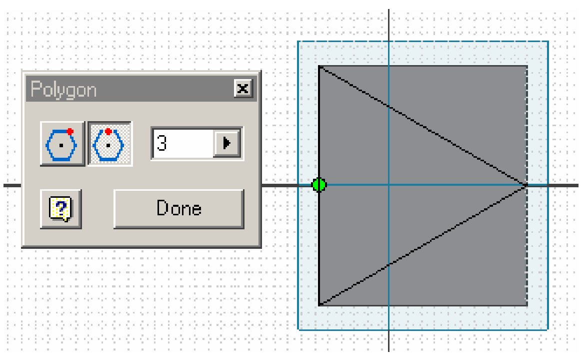


Figure 4A-9F: Draw the triangle.

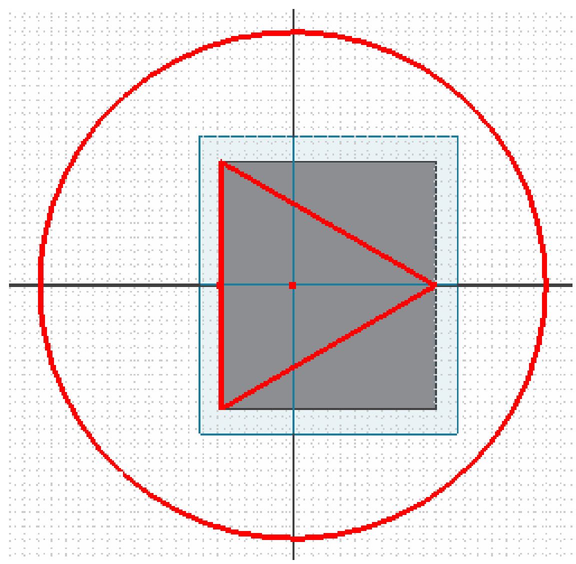


Figure 4A-9G: The cut-off profile.

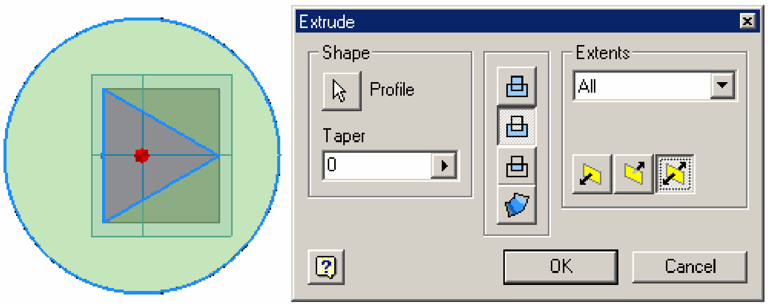


Figure 4A-9H: Cut the prism into a pyramid.

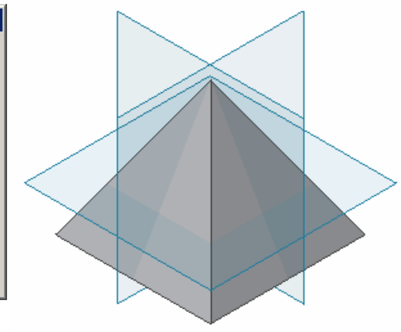


Figure 4A-9I: The complete regular square-base pyramid.

We have created a 3D model of a square-based regular right-axis pyramid with a sharp vertex at the top. Due to the characteristics of sheet metal material and the way cut metal sheets are bent, no sheet metal part wrapping this pyramidal space can actually create this sharp pointed vertex; instead, a corner relief is needed (*Figure 4A-9J*); therefore, the actual space the sheet metal part wraps is a frustum of a pyramid, although in the assembly process, extra material can be welded on the vertex and sanded into a sharp corner, but this is not our concern here. Thus, in order to allow the sheet metal part to be created correctly and in a workable way, we will cut a tiny depth of the vertex tip in the derived part, with a cutoff profile sketch drawn on a plane perpendicular to the right axis of the square-based pyramid. The step-by-step procedures are explained in the next paragraphs.

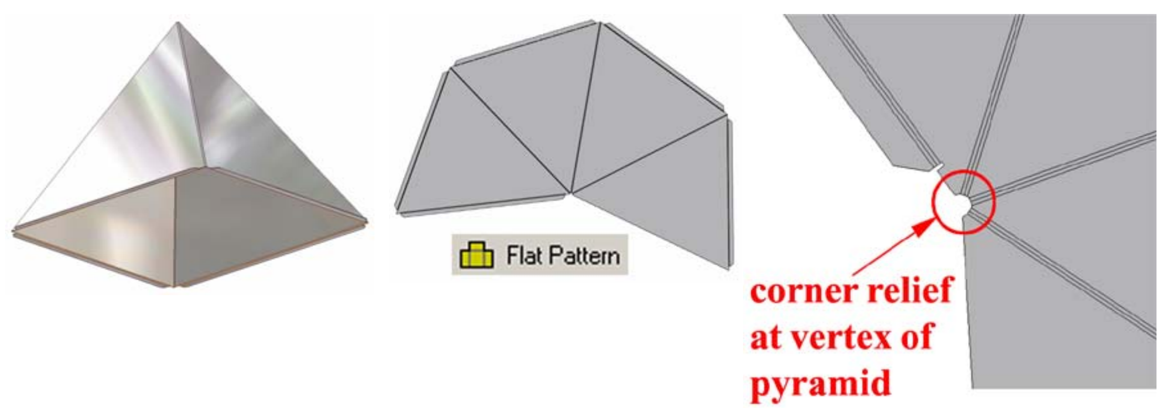


Figure 4A-9J: The sheet metal part wrapping the square-based regular right-axis pyramidal space. The folded part (left); the entire flat pattern (middle); and the vertex area with corner relief (right).

Step 3: Cut off the vertex tip of the rectangular-based pyramid

Click-select the **Work Point** tool; move the cursor closer to the vertex point; click once at the appearance of the yellow outlined circular point indicator; a light yellowish point appears on the vertex point (*Figure 4A-9K*), and the feature appears in the **Model** panel under the name of *Work Point1*, with a solid blue dot as its symbol (*Figure 4A-9L*); rename it **Vertex Work Point**. Next, select the **Work Plane** tool; click-select the *Vertex Work Point* (*Figure 4A-1M*), and then the **XZ Plane** (*Figure 4A-9M*), either on the screen or in the **Model** panel; the new work plane is created; it is perpendicular to the right axis of the pyramid, which coincides with the **Y Axis** of the Inventor's digital space and passes through the vertex point (*Figure 4A-9N*); rename it *Vertex Cutoff Work Plane* in the **Model** panel.

Next, select this *Vertex Cutoff Work Plane* and start a new sketch; draw a circle of any convenient radius approximately centered at the vertex point (*Figure 4A-9P*); rename the sketch *Vertex Cut* in the **Model** panel; click the **Return** button to exit the **Sketch** mode.

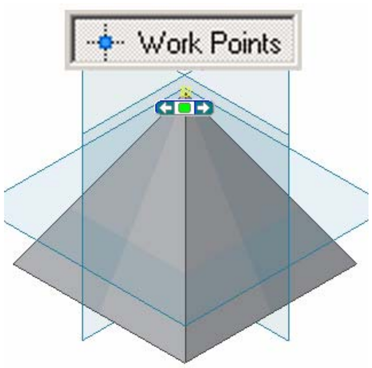


Figure 4A-9K: The Work Point tool.

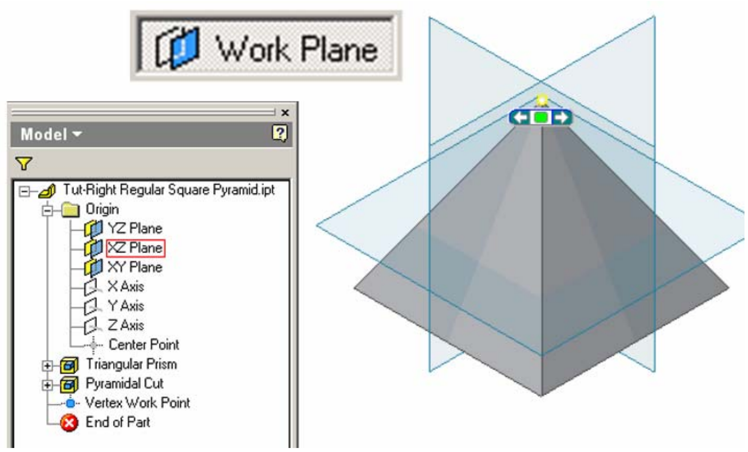


Figure 4A-9L: Picking the Vertex Work Point.

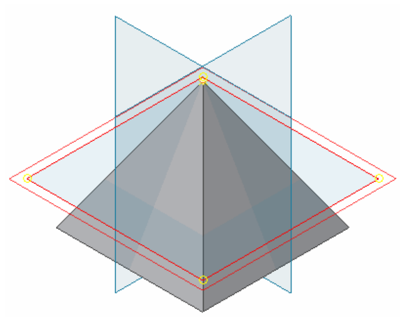


Figure 4A-9M: Picking the XZ Plane.

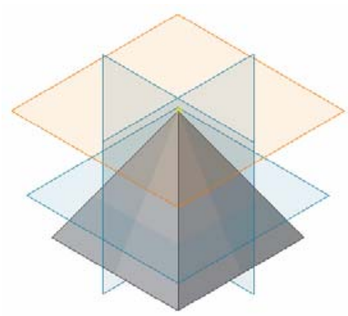


Figure 4A-9N: The Vertex Cutoff Work Plane.

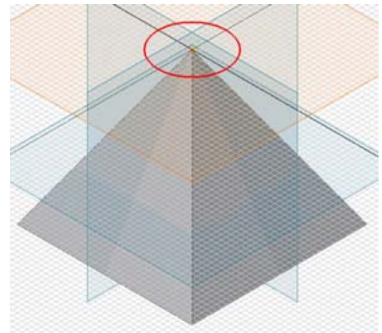


Figure 4A-9P: The Vertex Cut sketch.

Next, use the **Extrude** toot, with **Cut** as **Type**, **Distance** typed as 0.24 (inch) for **Extents**, and a downward **Direction** (*Figure 4A-9Q*), cut the vertex tip off with the *Vertex Cut* sketch profile (*Figure 4A-9R*); rename the **Extrude** feature *Vertex Cut* in the **Model** panel. The value of Distance here is double the intended thickness of the sheet metal material (0.12 inch); this value should be adjusted if needed due to several factors including the dihedral angles between the lateral sheet metal panels if the sheet metal part is a whole piece. Such adjustment can be done from the inside the sheet metal file, as shall be explained in Module 5B. If the pyramidal space is instead wrapped by four separate triangular-shaped sheet metal parts, then corner relieves are not needed and the sheet metal parts can extend all the way to the vertex point. If the part is of small size with a flat pattern that can fit into a single metal sheet, then one-piece design is suitable; if it is of large size which single-piece flat pattern cannot fit into a single metal sheet, then multiple-piece design is a more suitable option.

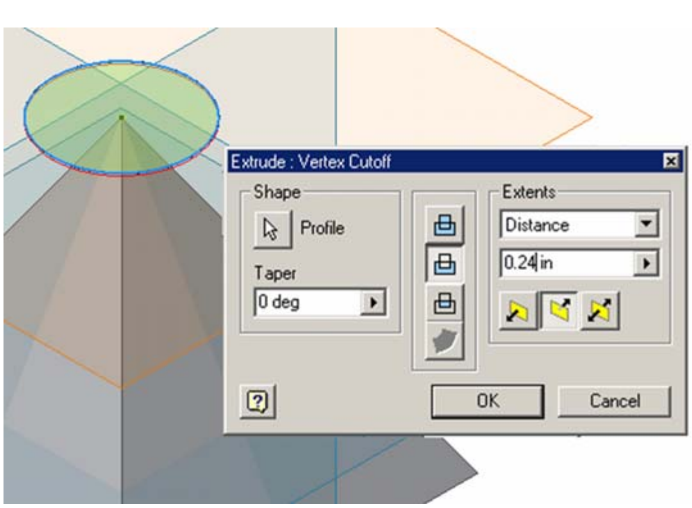


Figure 4A-9Q: The Extrude options.

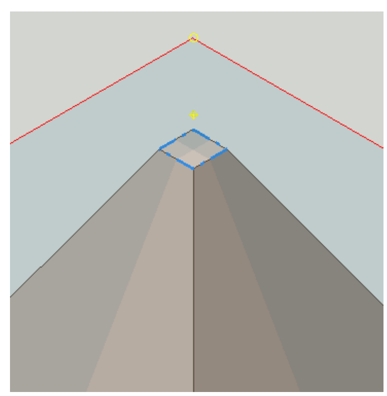


Figure 4A-9R: The vertex cutoff.

Section 6:
Creating A Derived Part File For A Regular Square-Based Pyramid With An Axis Oblique In One Direction

In this Section 7 and 7 of the Module, we will learn how to change an existing feature by changing its sketch profile.

Open the *Tut-Oblique Square Pyramid*, from the same folder. From the **Model** panel, select the "*Cut*" sketch and right-click for the shortcut menu and choose **Edit Sketch** (*Figure 4A-10A*); select the **Wireframe Display** mode from the **Command Bar** (*Figure 4A-10B*) for better visualization. Select the two angled lines of the triangle profile and press the **Delete** key on the keyboard to delete them. Select the **Project Geometry** tool to project the lower-right corner point onto the new sketch for a snap point (*Figure 4A-10C*), then right-click for the shortcut menu and choose **Done** to exit the tool; select the **Line** tool to draw an angled edge line connecting this projected point and the top endpoint of the vertical base line; and draw another angled edge line starting from the projected point and extending out of the vertical base line, at any convenient angle (*Figure 4A-10D*). Use the **Trim** tool to trim off the segments of the lines outside of the new triangle and use the **General Dimension** tool to apply a 24-inch dimension to the vertical base line (*Figure 4A-10E*); right-click for the shortcut menu and choose **Done** to exit the tool (*Figure 4A-10F*); click the **Return** or the **Update** button to exit the sketch mode and update the 3D model. The 3d model of the original right-axis square-based pyramid is changed into a square-based triangular pyramid with an axis oblique in one direction. Go to **View→Isometric** menu to view the new model (*Figure 4A-10G*). In the **Model** panel, rename the "*Pyramidal Cut*" as "*Oblique Cut*" (*Figure 4A-10H*). Save and close the file.

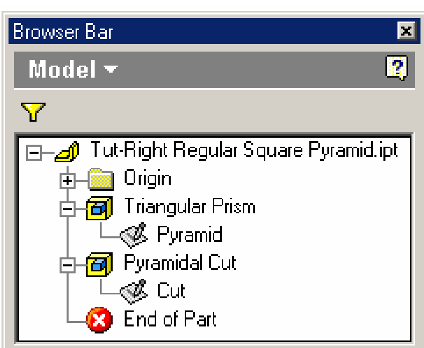


Figure 4A-10A: The Model panel.

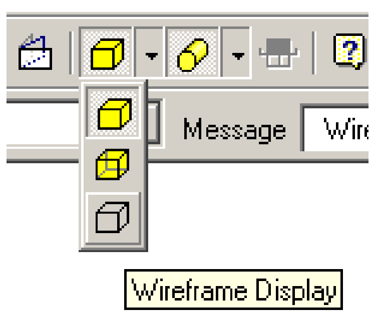


Figure 4A-10B: Wireframe Display mode.

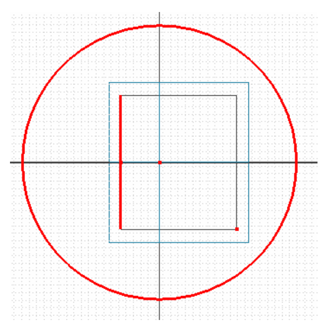


Figure 4A-10C: Delete the angled edge lines and project the lower-right corner point.

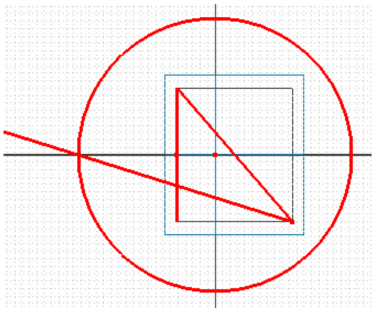


Figure 4A-10D: Draw two new edge lines.

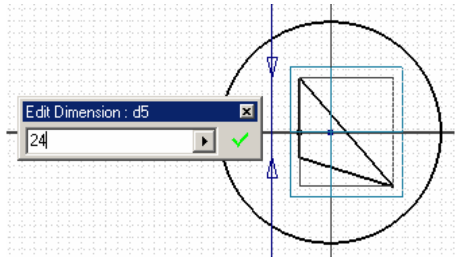


Figure 4A-10E: Apply a dimension.

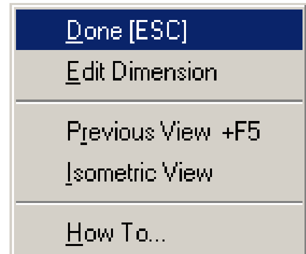


Figure 4A-10F: The shortcut menu.

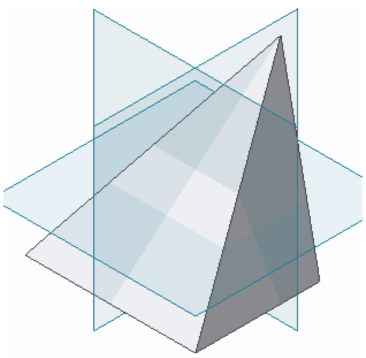


Figure 4A-10G: The square-based triangular pyramid with an axis oblique in one direction.

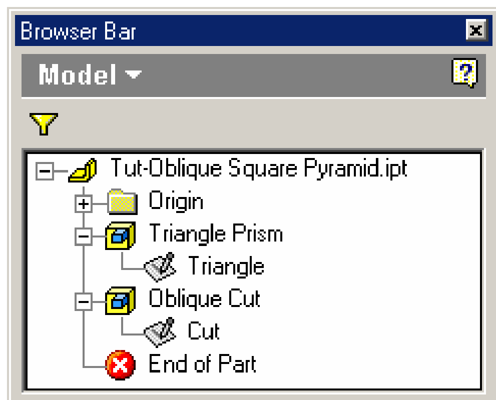


Figure 4A-10H: The Model panel.

Section 7:
Creating A Derived Part File For A Rectangle-Based Pyramid With An Axis Oblique In Two Directions

Open the *Tut-Twice Oblique Square Pyramid.ipt* file. In the **Model** panel, rename the "*Triangular Prism*" **Extrude** feature as "*Oblique Triangle Prism*," and the "*Pyramid*" Sketch feature as "*Oblique Triangle*;" rename the "*Pyramid Cut*" **Extrude** feature as "*Twice Oblique Cut*" and its dependent "*Cut*" Sketch as "*Twice Oblique*" (*Figure 4A-11A*) In the Model panel, select the "*Oblique Triangle*," right-click for the shortcut menu and select **Edit Sketch** option (*Figure 4A-11B*). The screen switches to sketch mode; click-select the **Line** tool; from the top vertex of the triangle, draw a horizontal construction line to restraint the height; next, click-select the horizontal construction line as well as the two inclined edge lines of the original equilateral triangle, and go to the

Command Bar to change the **Style** of these lines to **Construction** (in Inventor, **Construction** lines in the **Sketch** features do not participate in the creation of 3D solid features; these three construction lines can be deleted with the **Delete** key on the keyboard before the completion of **Edit Sketch** operation is desired); next, use the **Line** tool to draw an inclined line from the right endpoint of the base line extending beyond the top horizontal construction line; apply an angular dimension of 115º to the angle between this inclined line and the horizontal base line (*Figure 4A-11C*); click-select the **Trim** tool and trim off the portion of this inclined line against the top horizontal construction line; next, use the **Line** tool to draw another inclined line connecting the top endpoint of the first inclined line and the left endpoint of the horizontal base line, using green snap indicators for accuracy while drawing lines. The profile of an oblique triangle with the same height as the original equilateral triangle is completed. Click the **Return** or the **Update** button in the **Command Bar**. The 3D model of a prism with an oblique triangular base appears (*Figure 4A-11D*). Save the file.

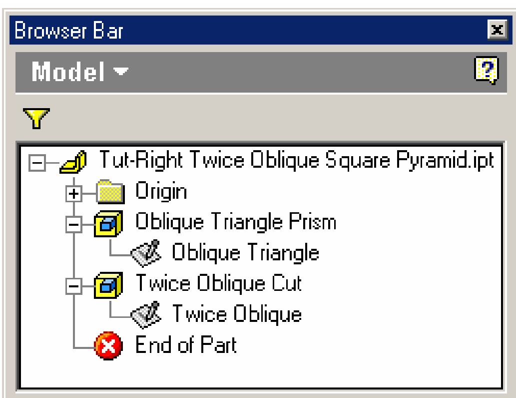


Figure 4A-11A: The new Model panel

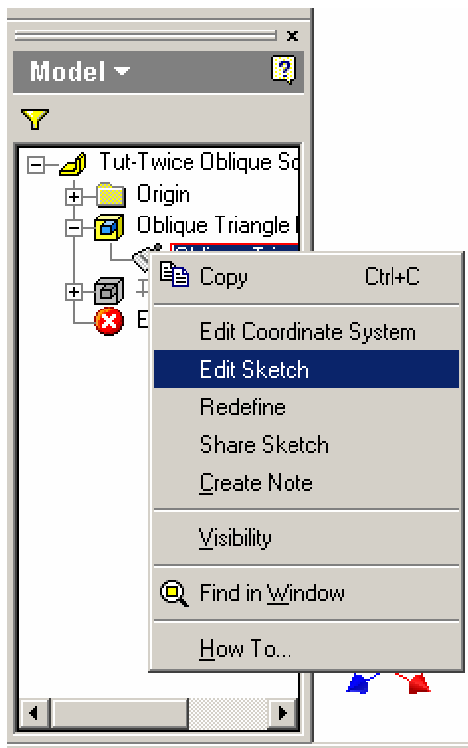


Figure 4A-11B: Edit Sketch.

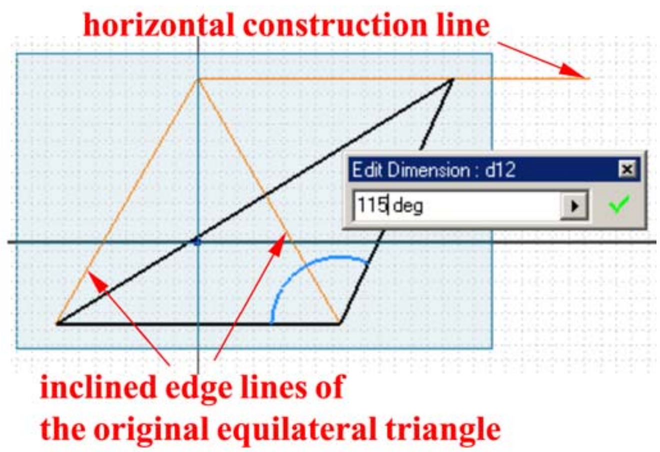


Figure 4A-11C: The new "Oblique Triangle" sketch.

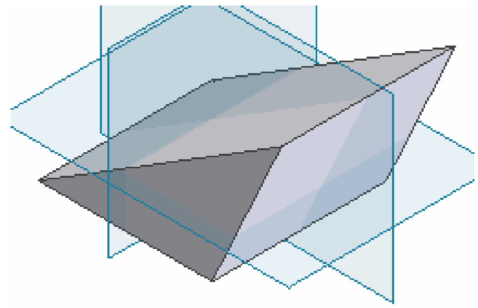


Figure 4A-11D: The oblique triangular prism.

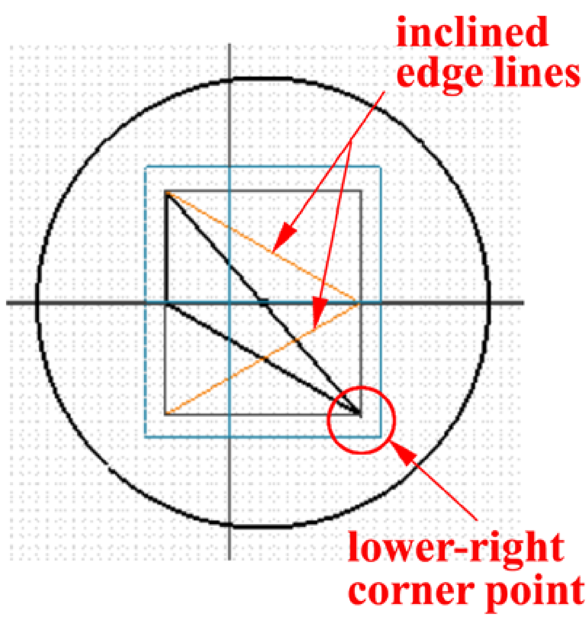


Figure 4A-11E: The oblique triangle.

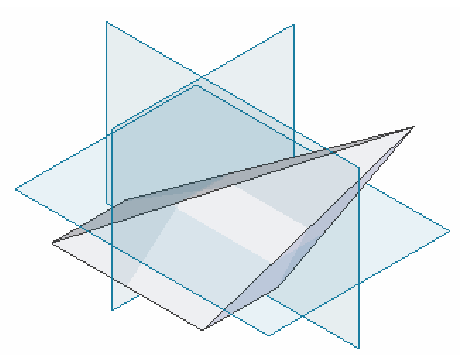


Figure 4A-11F: The twice oblique square-based pyramid.

The next step is to cut the oblique triangular prism into an oblique square-based pyramid. Select the "*Twice Oblique*" Sketch feature from the **Model** panel; right-click for the shortcut menu and select the **Edit Sketch** option; the screen switches to the **Sketch** mode; go to the **Command Bar** to change the **Display** mode to **Wireframe Display** for better viewing of the 3D model's geometry; click-select the **Look At** tool button from the

Command Bar and then the "*Twice Oblique*" **Sketch** feature from the **Model** panel to switch to the normal view of the sketch; delete both inclined side edge lines of the triangle in the original sketch; next, use the **Project Geometry** tool to project the lower-right corner point of the prism onto the sketch for a snap point; and from this point, use the **Line** tool to draw two inclined lines to the top endpoint and midpoint of the vertical edge line of the original equilateral triangle profile; an oblique triangle is formed; next, use the **trim** tool to trim off the lower segment of the vertical edge line that is beyond the oblique triangle (*Figure 4A-11E*). Click the **Return** button. The oblique prism is transformed into a square-based pyramid with an axis twice oblique in two directions (*Figure 4A-11F*).

To see that this square-based pyramid has an axis that is oblique in two directions, click-select the **Rotate** tool, right-click for the shortcut menu and choose the **Common View [SPACE]** option (*Figure 4A-11G*); the **Common View** cubic symbol appears; click the green arrow along any edge, the arrow turns red (*Figure 4A-11H*) and the common orthographic view replaces the isometric view (*Figure 4A-3I*); continue clicking the green arrow on the edges until the top view is seen (*Figure 4A-11I*), this top view shows that the vertex of the pyramid is located off the center of the square base, in two directions, indicating that the axis of the pyramid is oblique in two directions, or away from the Y-Axis along both X-Axis and Z-Axis. To exit the Rotate tool, right-click and choose **Done** in the shortcut menu (*Figure 4A-11J*). Save the file.

If desired, you may open the *Tut-Oblique Square Pyramid*, and *Tut-Right Regular Square Pyramid.ipt* files inside the same *Tut-Pyramid* folder, and perform similar step to make a comparison. In the case of the right square-based pyramid, in the *Tut-Right Regular Square Pyramid.ipt* file, the vertex of the pyramid is right at the center of the square base, indicating that the axis of the pyramid is straight right up (*Figure 4A-1K*). In the case of the square-based pyramid with an axis oblique in one direction, in the *Tut-Oblique Square Pyramid* file (*Figure 4A-11L*), the vertex of the pyramid is located off the center of the square base, in one direction, indicating that the axis of the pyramid is oblique in one direction, or away from the Y-Axis along the Z-Axis.

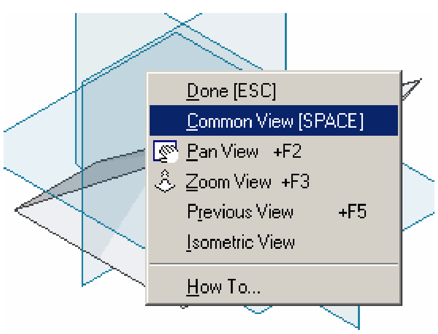


Figure 4A-11G: The Rotate tool with Common View [SPACE] option.

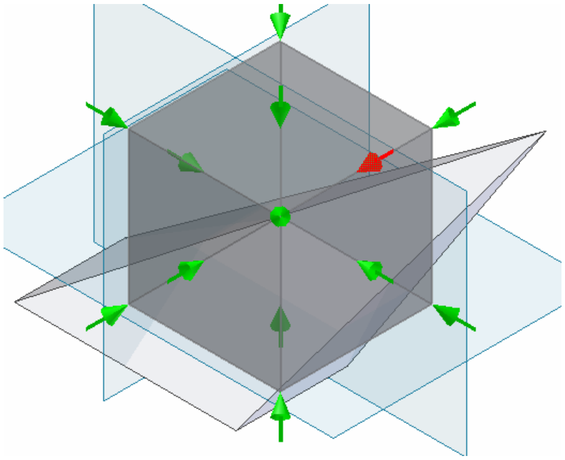


Figure 4A-11H: Switch to orthographic view.

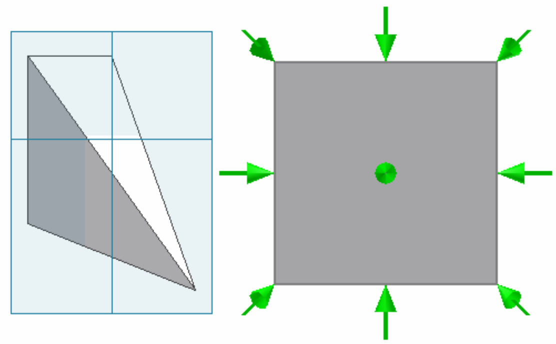


Figure 4A-11I: The top view of the square-based pyramid with an axis oblique in two directions.

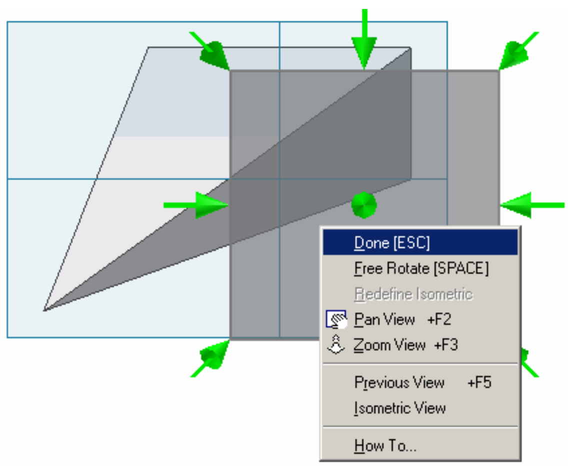


Figure 4A-11J: Exit the Rotate tool.

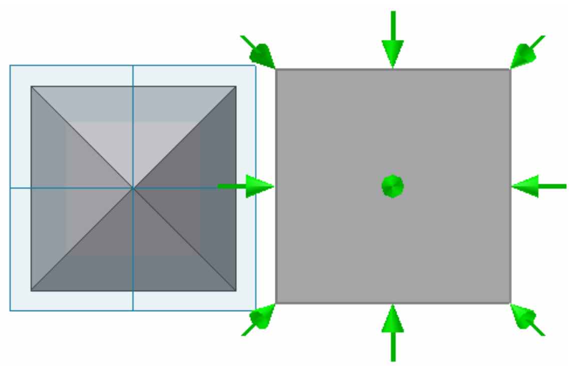


Figure 4A-11K: Right square-based pyramid.

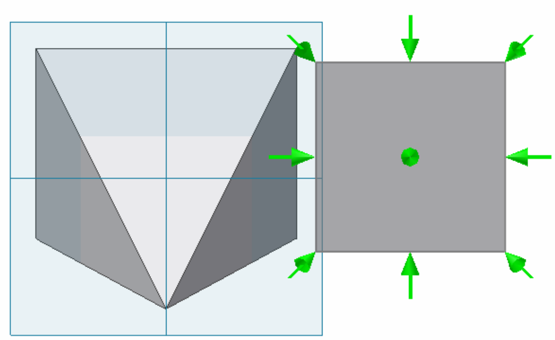
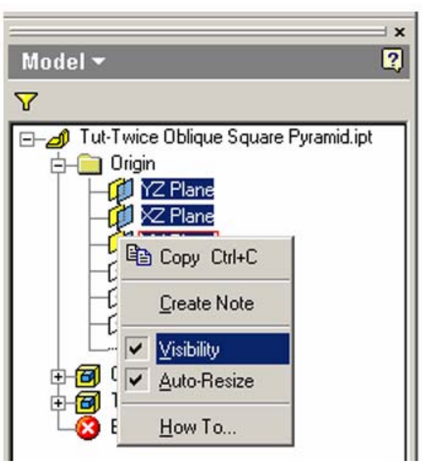
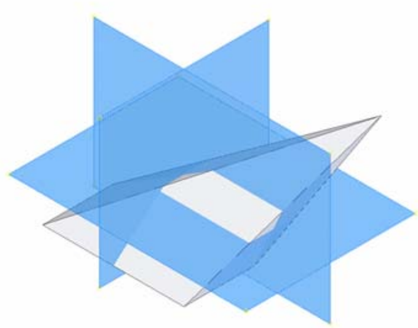


Figure 4A-11L: The top view of the square-based pyramid with an axis oblique in one direction.

Next, we will cut off the vertex tip of the oblique pyramid with a depth along the oblique axis of the pyramid, so as to provide a “corner relief” for the single-piece sheet-metal part, as explained in the previous Section 5 of this Module. In the case of a pyramid with an axis oblique in two directions, the axis is neither coincident nor parallel with any of the **X**, **Y**, and **Z Axis** of the Inventor’s digital space; and the plane used to draw the cutoff profile sketch for the vertex tip is not perpendicular to any of the existing **YZ**, **XZ**, and **XY Planes**; therefore, hold the **Shift** key and click-select the **YZ**, **XZ**, and **XY Planes** in the **Model** panel, and then right-click for the shortcut menu and uncheck **Visibility** (*Figure 4A-11M*), so as to avoid visual confusion by features that are not essential to the task. In order to create the work plane for the cutoff profile sketch, the oblique axis must be first established. The oblique axis passes through the vertex and the center point of the base. Therefore, we need to establish these two points first. The procedures to complete this task are explained as follows. Select the base surface of the oblique pyramid and click-select the **Sketch** button from the **Command Bar** to start a new **Sketch**; use the **Project Geometry** tool to project the four edge lines and use the **Line** tool to draw two diagonal construction lines; then use the **Point, Hole Center** tool to draw a point at the intersection of the two diagonal construction lines (which appears as a cross, as shown in *Figure 4A-11P*), all with the help of green snap indicators (*Figure 4A-11N*); rename the sketch *Base Center Point Construction* in the **Model** panel; click the **Return** button to exit the **Sketch** mode. Next, create two work points; select the **Work Point** tool; move the cursor closer to the vertex point and at the appearance of the yellow snap indicator, click once to create a work point and rename it *Vertex Work Point* in the **Model** panel (*Figure 4A-11Q*); then move the cursor closer to the point drawn at the intersection of the two diagonal lines on the base, click once to create a work point when the “cross” point symbol turns red, and rename it *Base Center Work Point* in the **Model** panel (*Figure 4A-11R*). Use the **Rotate** tool to access the vertex point of the pyramid if necessary.





igure 4A-11M: urning Visibility off or all three Planes.

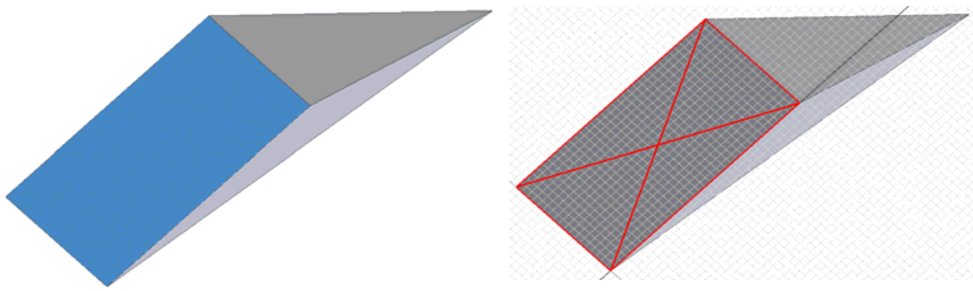


Figure 4A-11N: Selecting the base surface (left); projecting the edge lines and drawing diagonal construction lines.

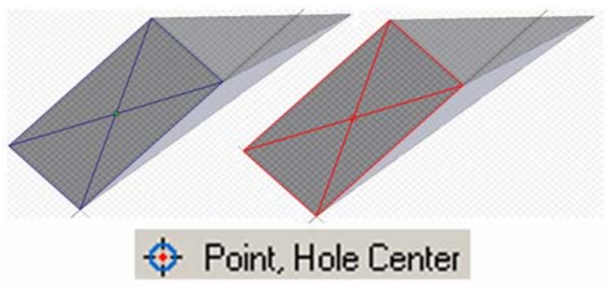


Figure 4A-11P: picking the point of intersection (left) and creating the Base Center Work Point (right).

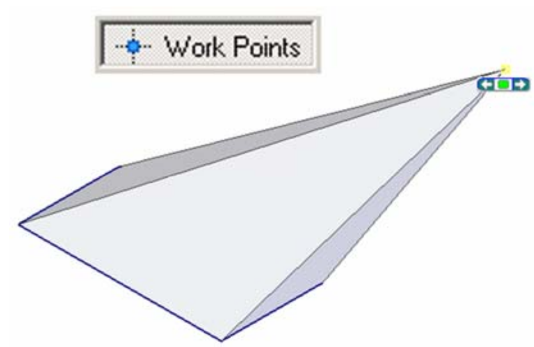


Figure 4A-11Q: Creating the Vertex Work Point.

Next, create the work axis passing through the two work points just created. Select the **Work Axis** tool; click-select the *Vertex Work Point* and the *Base Center Work Point* features in the **Model** panel or on the screen; the orange work axis appears on the screen; rename the new *Work Axis1* feature *Oblique Work Axis* in the **Model** panel (*Figure 4A-11S*). Next, create a new work plane that contains both the *Oblique Work Axis* and the **Y Axis,** on which a centerline oblique axis can be drawn. Select the **Work Plane** tool and click on the **Y-Axis** and *Oblique Work Axis* features in the **Model** pane. A new work plane appears (*Figure 4A-11T*); rename the new work plane *Oblique Axis Work Plane* in the **Model** panel.

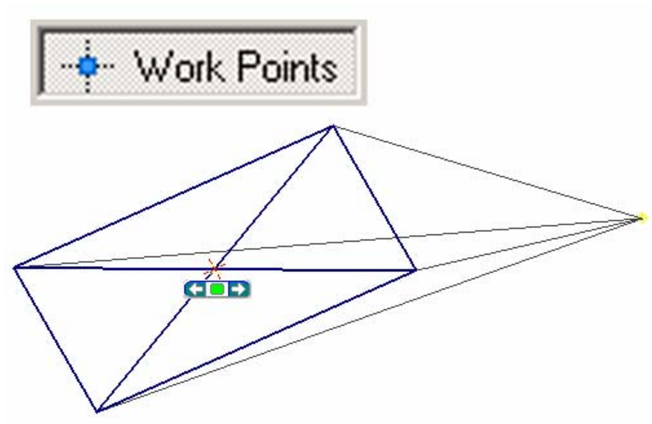


Figure 4A-11R: The Base Center Work Point (red cross).

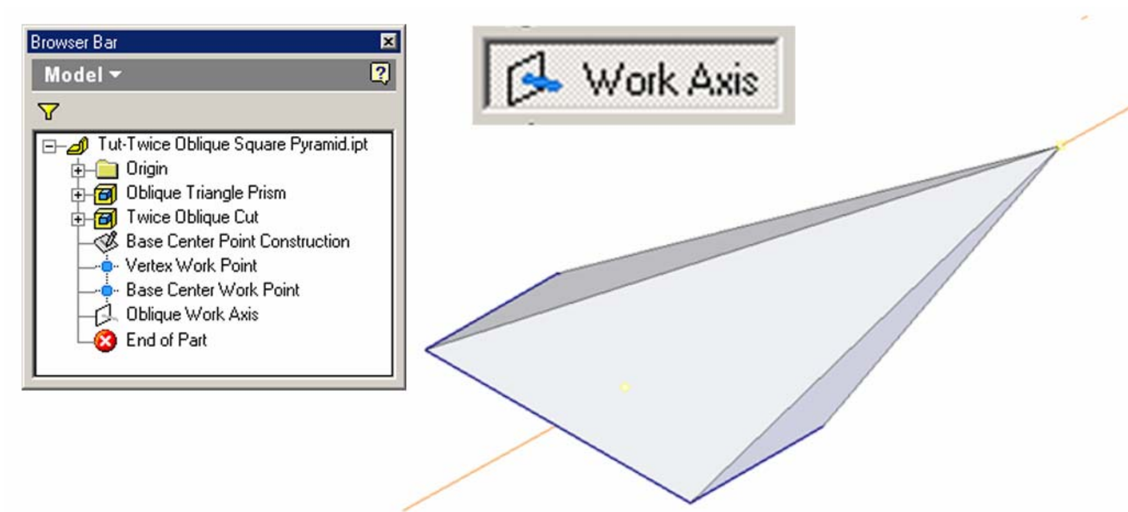
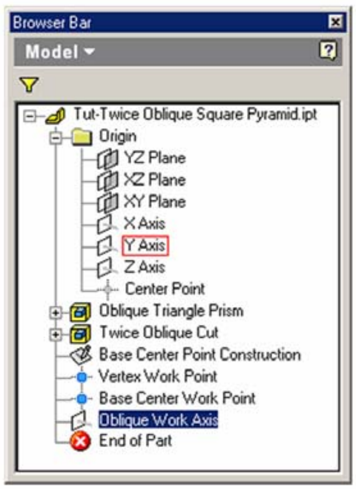


Figure 4A-11S: The Oblique Work Axis through the Vertex Work Point and the Base Center Work Point.

Next, select the *Oblique Axis Work Plane* and click the **Sketch** button to start a new sketch; since the oblique axis will be hidden inside the 3D pyramid, go to the **Command Bar** to the display mode to **Wireframe Display** for better visibility; use the **Line** tool to draw a line snapping to the *Vertex Work Point* and the *Base Center Work Point*; and go to the **Command Bar** to change the **Style** of this line to **Centerline** for better visualization (*Figure 4A-11U*); rename the new sketch *Oblique Axis Centerline* in the **Model** panel.



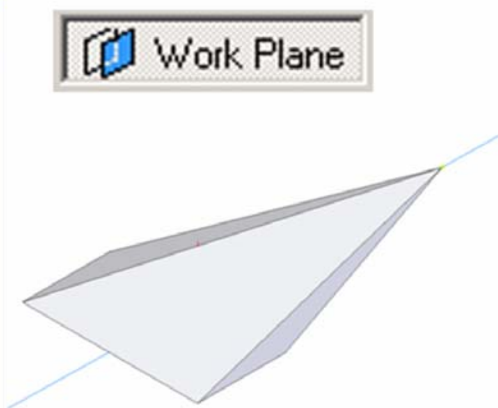
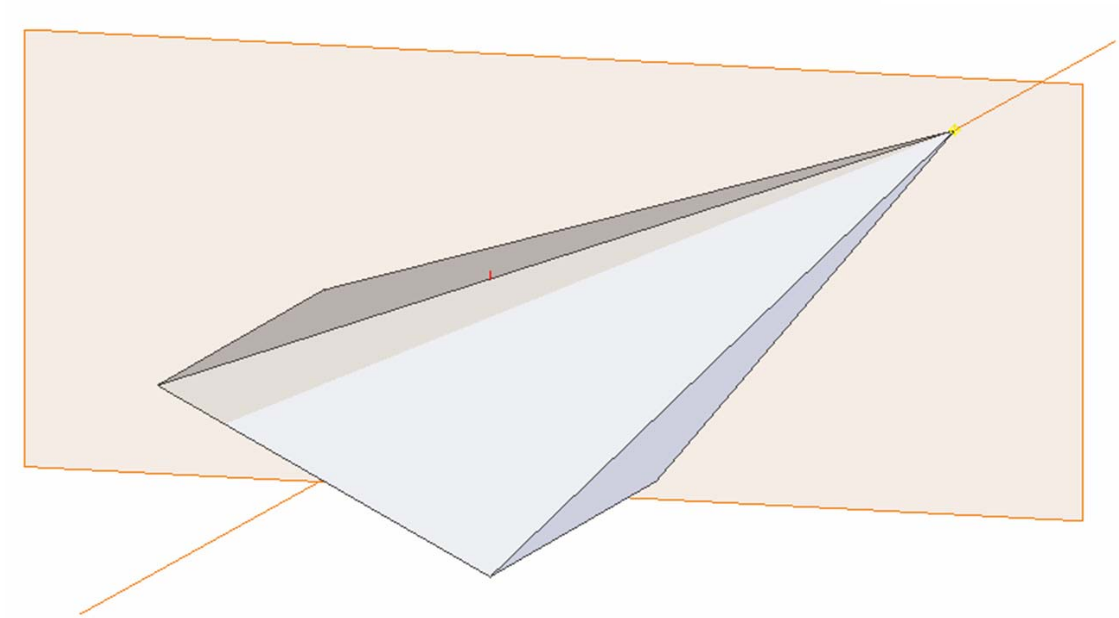


Figure 4A-11T: Creating the Oblique Axis Work Plane; selecting the Y Axis and Oblique Work Axis in the Model panel (left); the Oblique Axis Work Plane created (bottom).



Next, create a work plane perpendicular to the *Oblique Axis Centerline*. Select the **Work Plane** tool again; move the cursor closer to the *Vertex Work Point* and click once; then move the cursor closer to the centerline oblique axis just drawn and click once when it turns red (*Figure 4A-11V*); the new work plane appears on the screen; rename the new work plane feature *Perpendicular to Oblique Axis Work Plane* in the **Model** panel.

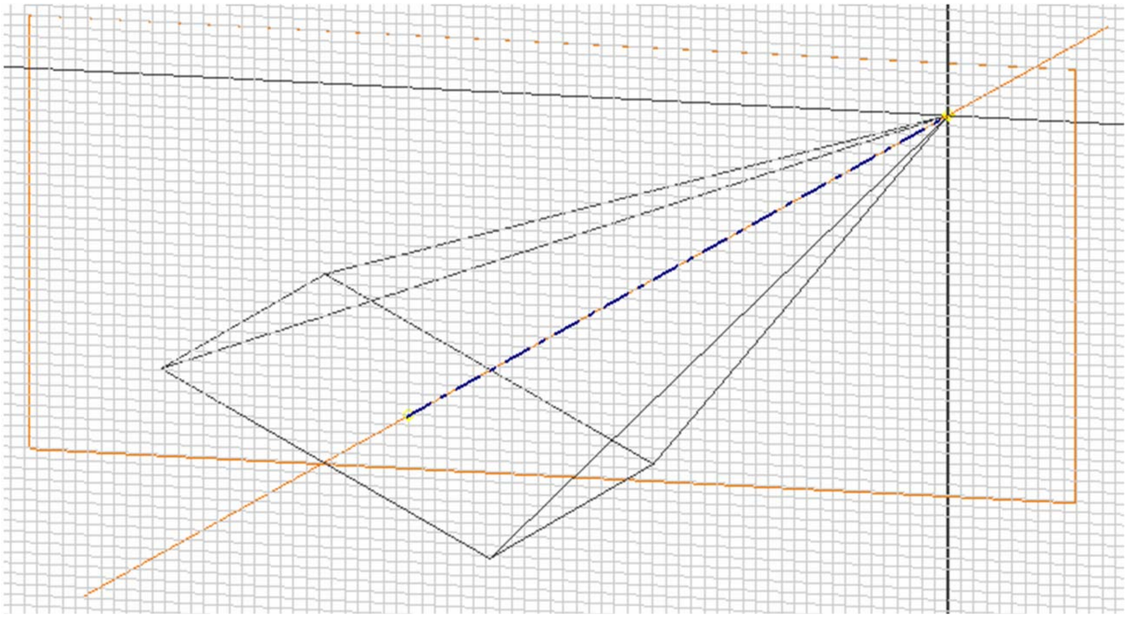


Figure 4A-11U: The Oblique Axis Centerline sketch drawn on the Oblique Axis Work Plane.

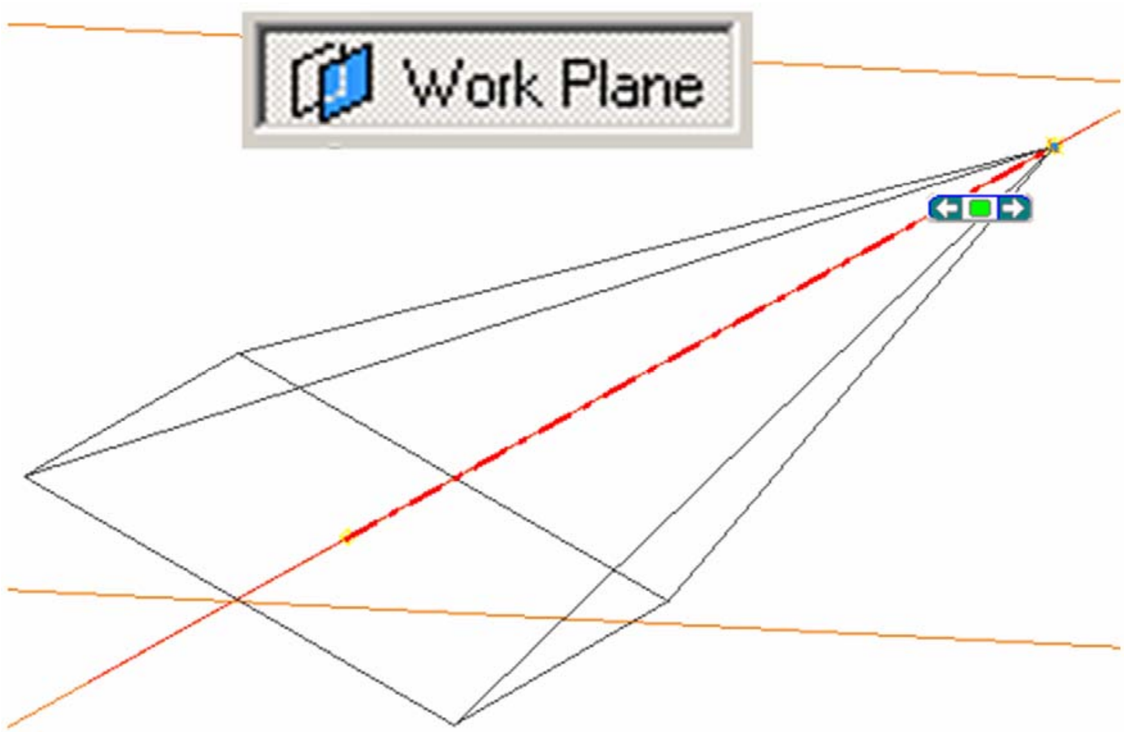


Figure 4A-11V: Creating the Perpendicular to Oblique Axis Work Plane.

Next, use the **Rotate** tool to rotate the 3D model and view the perpendicular relationship between the *Perpendicular to Oblique Axis Work Plane* and the *Oblique Work Axis*; they appear to be perpendicular. Next, click-select the *Perpendicular to Oblique Axis Work Plane*, and then click the **Look At** tool button; the orthographic view appears on which centerline oblique axis "disappears" (it turns into a point, or PV, which stands for "point view" in descriptive geometry terminology); this proves that both features are perpendicular to each other (*Figure 4A-11W*). Next, select the *Perpendicular to Oblique Axis Work Plane*, and click the **Sketch** button to start a new sketch; use the **Circle Center Point** tool to draw a circle with any convenient size and centered at the vertex (*Figure 4A-11X*); rename the sketch *Vertex Cut* in the **Model** panel.

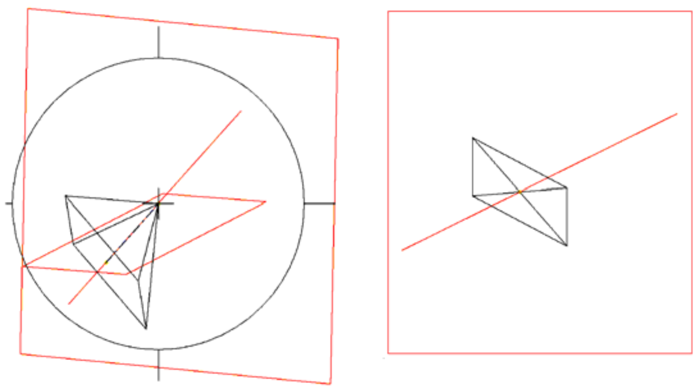


Figure 4A-11W: Investigating the perpendicular relationship between the centerline oblique axis and the Perpendicular to Oblique Axis Work Plane, with the Rotate (left) and Look At (right) tools.

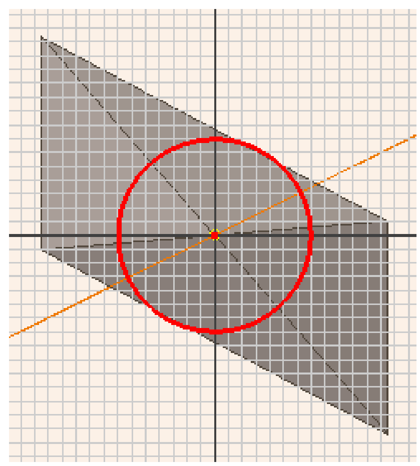
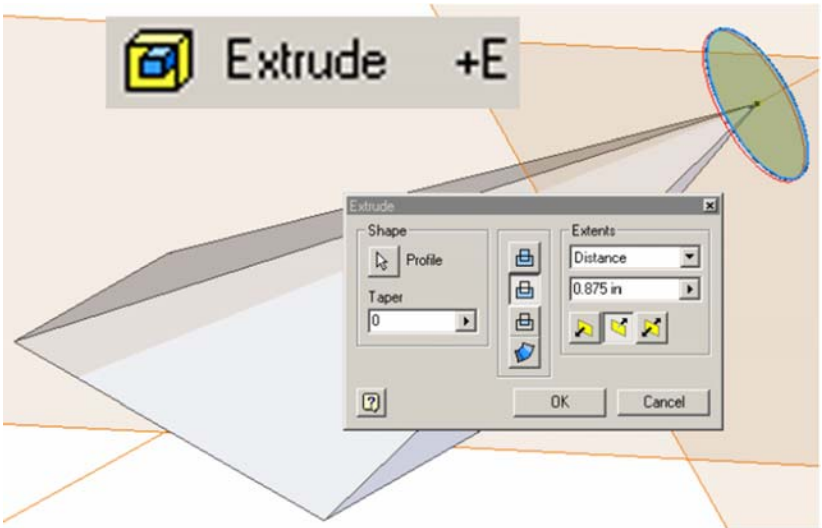


Figure 4A-11X: The Vertex Cut sketch.

Next, use the **Extrude** tool with **Cut** as **Type**; type 0.875 (inch) as **Distance** for **Extents**, and a downward **Direction** to cut off the vertex top of the pyramid; and rename the new **Extrude** feature *Vertex Cutoff* in the **Model** panel (*Figure 4A-11Y*). The sheet metal part latter designed wrapping this oblique pyramidal space is shown on *Figure 4A-11Z* and.



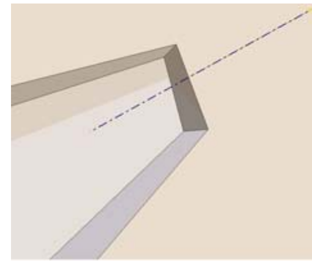
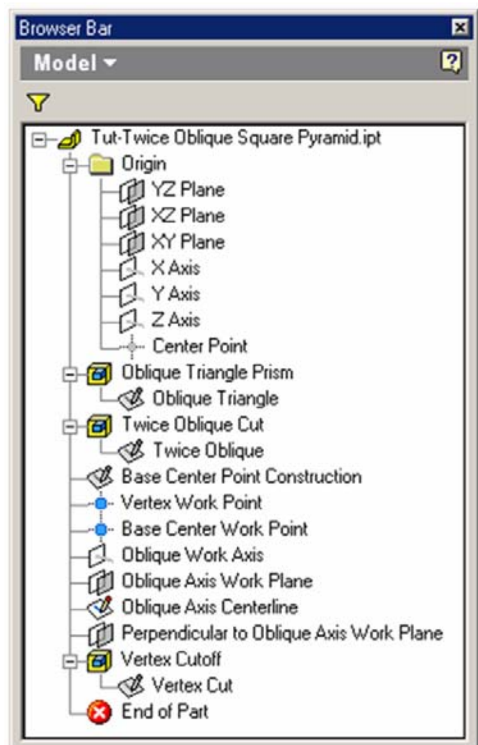


Figure 4A-11Y: The Extrude tool settings (left); the cutoff vertex (right); and the features listed in the Model panel (bottom right).



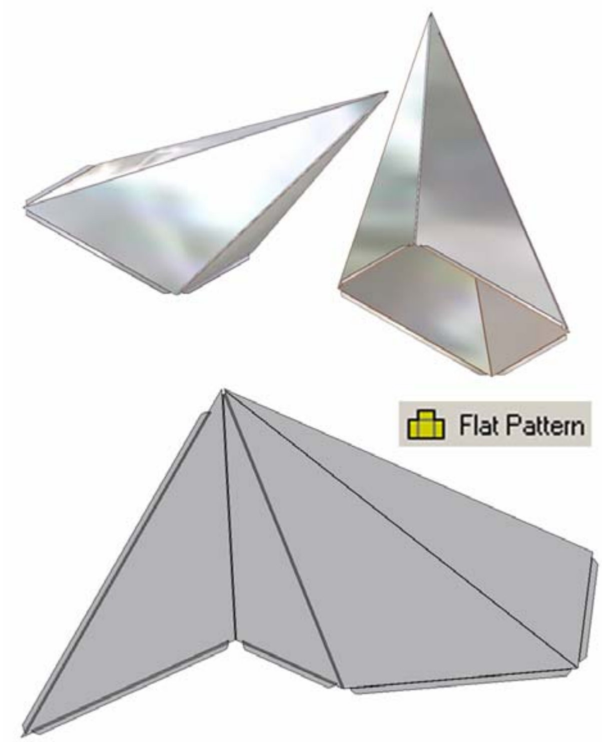


Figure 4A-11Z: The sheet metal part. 3D Folded model (top); 2D flat pattern (bottom).

Section 8: Creating A Derived Part File For An Oblique Pyramid With A Triangular or Other Polygonal Base Other Than A Square or A Rectangle, With A Vertex At One Corner of The Top Surface

Open the *Tut-Oblique Triangular-Base Pyramid.ipt* file from the same *Tut-Piramid* folder. Click-select the **Work Plane** tool; move the cursor closer to the left and right endpoints of the frontal base edge line, and the rear corner of the top surface, and click once at each point when the outline yellow circle snap indicator appear; a new work plane appears (*Figure 4A-12A*); rename it in the **Model** panel "*Cutoff Surface Work Plane*." Next, select this plane and click the **Sketch** button to start a new sketch; use the **Circle Center Point** tool to draw a circle large enough to enclose the whole prism (Figure 4A-12B); click the **Return** button to exit the sketch mode and rename the new sketch "*Cutoff*" in the **Model** panel. Next, use the **Extrude** tool with **Cut** as **Type**, **All** as **Extents** and outwards from the prism as **Direction**, and the circle as **Profile** (*Figure 4A-12C*), cut the prism into an oblique triangle-based pyramid (*Figure 4A-12D*); rename the **Extrude** feature "*Surface Cutoff*" in the **Model** panel (*Figure 4A-12F*).

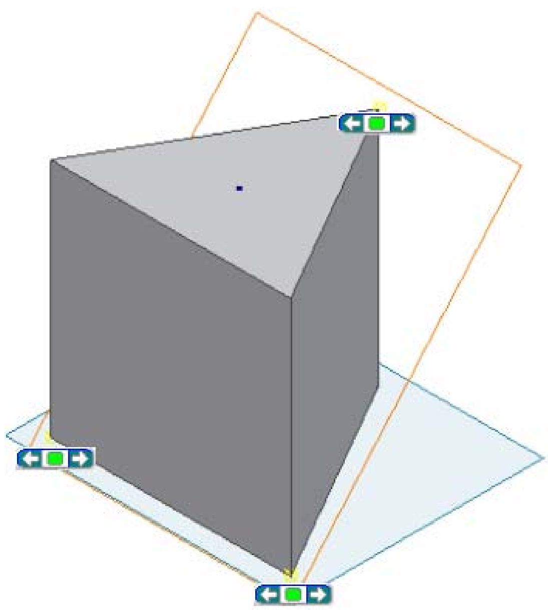


Figure 4A-12A: Creating the "Cutoff Surface Work Plane.

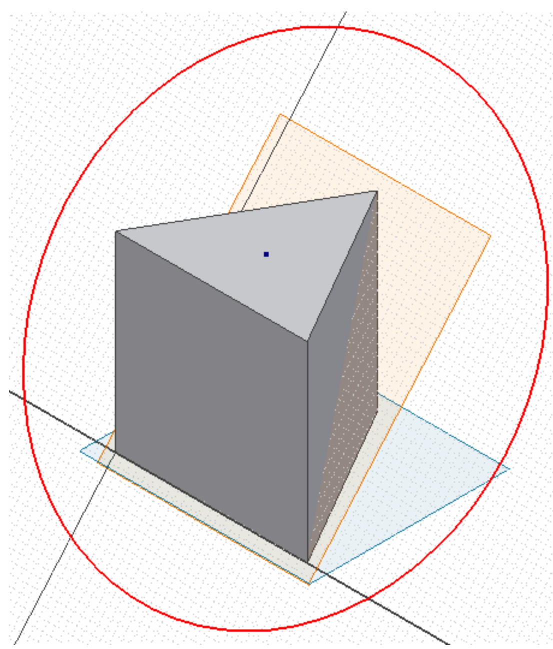


Figure 4A-12B: The "Cutoff" sketch.

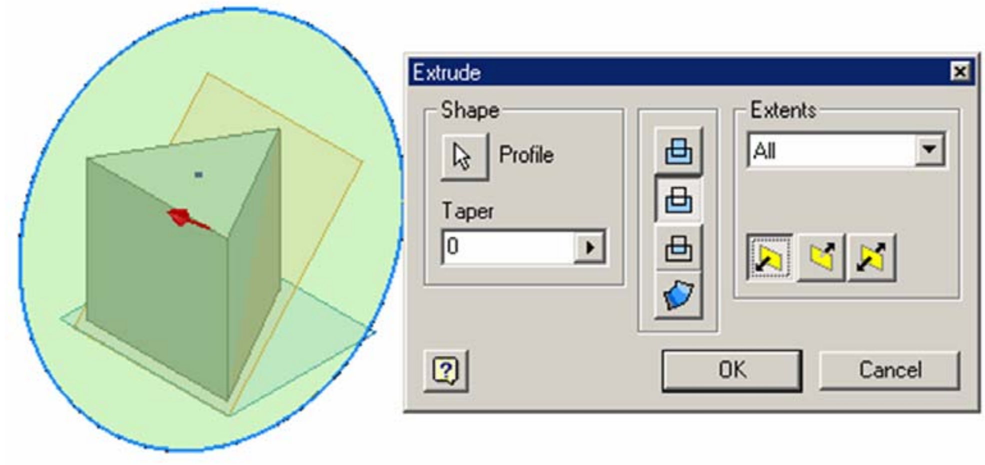


Figure 4A-12C: The Extrude tool.

Since the vertex is a corner point of the top surface and the base is triangular, no further cuts are needed. To view the geometric relationships of edge lines, surfaces and points in the 3D model, use the **Rotate** tool with **Common View [SPACE]** option to rotate the 3D model to the top view; it is obvious that the two angled edges of the top surface overlap their corresponding edges on the base surface; and that the vertical edge is shared by both top and base surfaces (*Figure 4A-12E*). The features of the 3D model are listed in the **Model** pane (Figure 4A-12F). Save the file.

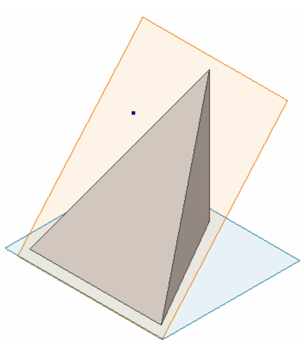


Figure 4A-12D: The complete pyramid.

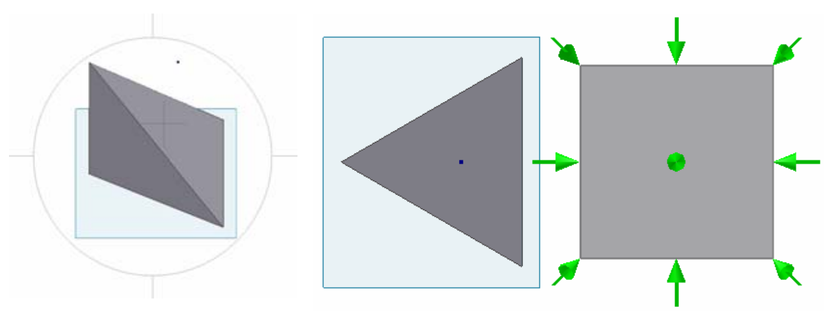


Figure 4A-12E: Rotating the 3D model to the top view. On the top view, two edges of the top surface overlap their corresponding edges of the base surface.

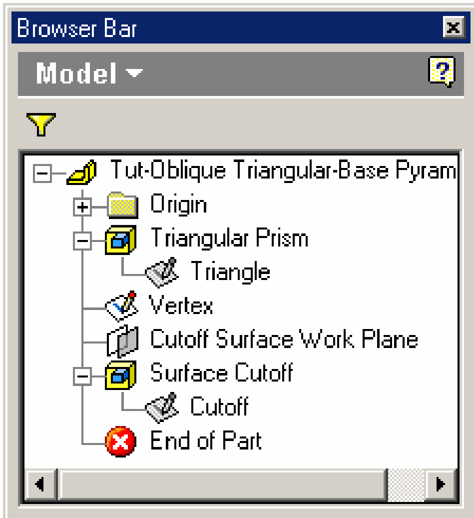


Figure 4A-12F:
The resulting Model panel.

Section 9:
Creating A Derived Part File For An Oblique Pyramid With A Triangular or Other Polygonal Base Except A Square Or A Rectangle, With A Vertex Is Outside of The Top Surface

To create an oblique pyramid with a polygonal base other than a square or a rectangle, with a vertex that is outside the top surface of the first extruded prism feature, the first feature of triangular-based prism must be created in such a way that the top surface is larger than the base surface, so that the vertex point can still be located within the 3D body (in other words, the first feature of triangular-based prism); this can be accomplished by creating the first feature of triangular-based prism **Extrude** feature as a tapered one, not as a regular “straight up” one.

Open the *Tut-Oblique Triangular-Base Pyramid Vertex Out.ipt* file from the same *Tut-Piramid* folder. Click-select the *Triangular Prism* feature from the **Model** panel; right-click for the shortcut menu and choose **Edit Features** option; in the **Extrude** tool dialog window that opens, type 45 (degrees) in the **Taper** text field (the taper angle needed is proportional to the distance between the vertex points of the oblique pyramid and the projected center point of the base on the plane that contains the vertex point and is parallel to the polygonal base of the pyramid; and trial-and-errors might be needed for determining the angle); a gray taper indicator appears, with an arrow pointing outward of the light green base surface profile, indicating that the top surface will be larger; click the **OK** button; the regular prism changed to a tapered prism with a much larger top surface

(*Figure 4A-13A*). Use the **Rotate** tool with **Free Rotate** option to rotate the model to a convenient position where both top and base edges can be seen (*Figure 4A-13B*).

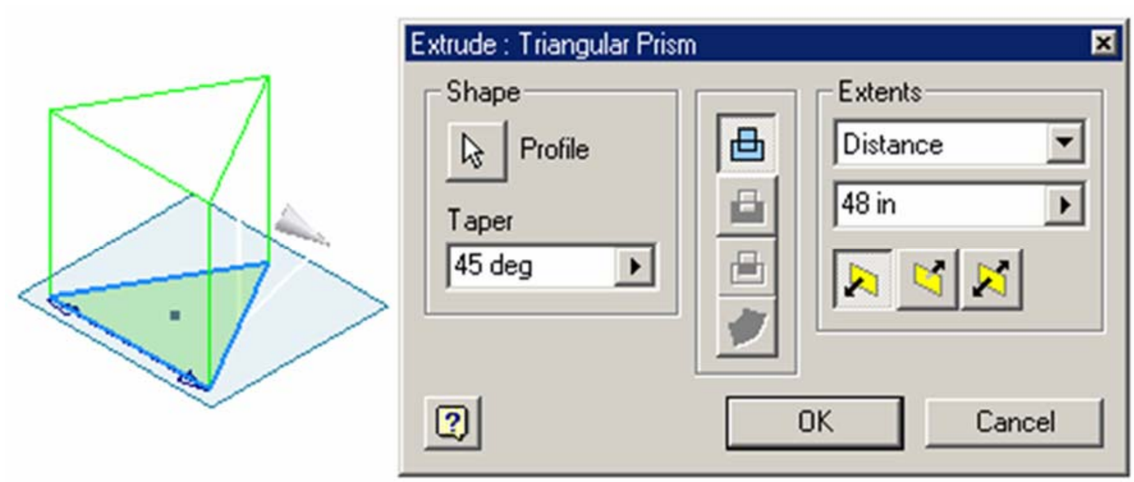
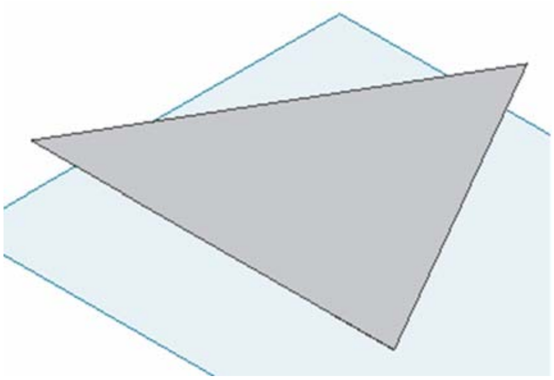


Figure 4A-13A: Change the regular prism into a tapered prism with a larger top surface.



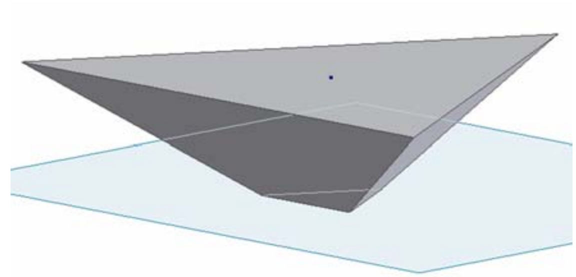


Figure 4A-13B: Rotating the 3D model to a convenient position.

Next, click-select the top surface of the tapered prism, click-select the **Sketch** tool to start a new sketch for the vertex point; rename the sketch "*Vertex*" in the **Model** panel; click the **Look At** button and then the "*Vertex*" Sketch feature in the **Model** panel to switch to the orthographic normal view; switch from **Shaded Display** to **Wireframe Display** from the **Command Bar**, so that the outlines of both the top and base surfaces can be seen; use the **Project Geometry** tool to project the **Center Point** onto the sketch; next, click-select the **Point, Hole Center** tool from the **Sketch** panel; click once inside the space between the edge lines of the larger top surface and of the smaller base surface (*Figure 4A-13C*); the vertex point appears as a cross; next, use the **General Dimension** tool to apply a 20 in (inches) horizontal linear dimension and a 30 in (inches) vertical linear dimension between the projected **Center Point** and the vertex point drawn with the **Point, Hole Center** tool; next, click the **Return** button to exit the **Sketch** mode.

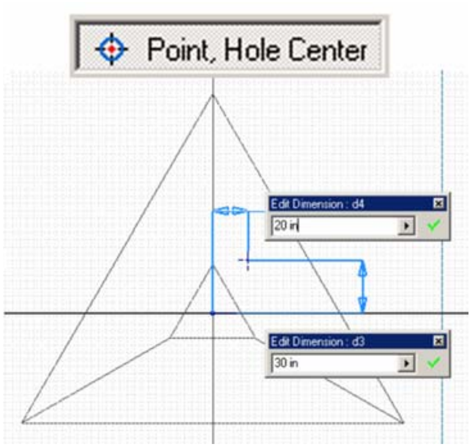


Figure 4A-13C: The Point, Hole Center tool and the Vertex sketch.

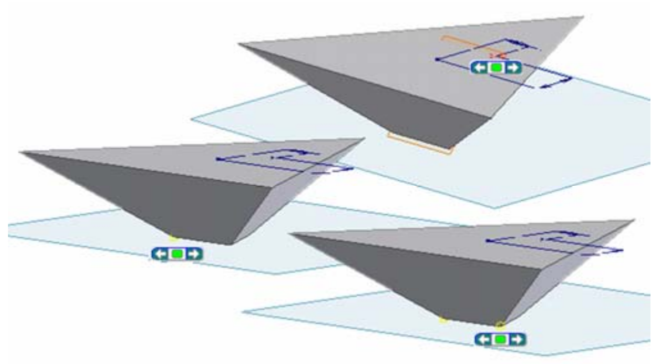


Figure 4A-13D: The Cutoff Work Plane.

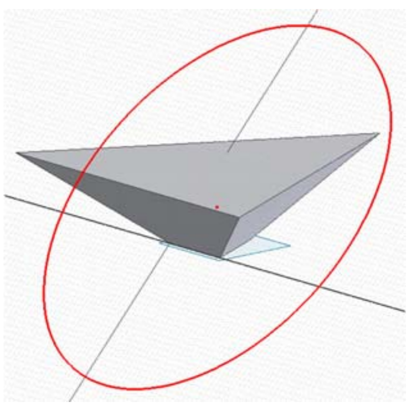


Figure 4A-13E: The "Cutoff 1" profile sketch.

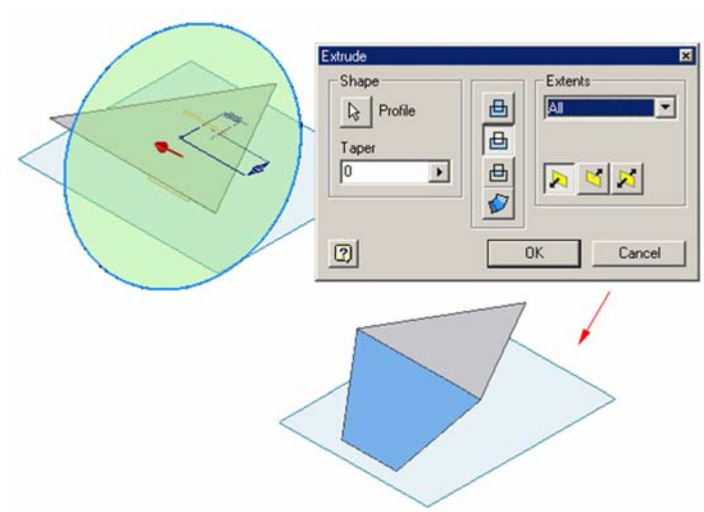


Figure 4A-13F: Cutting off one surface of the pyramid.

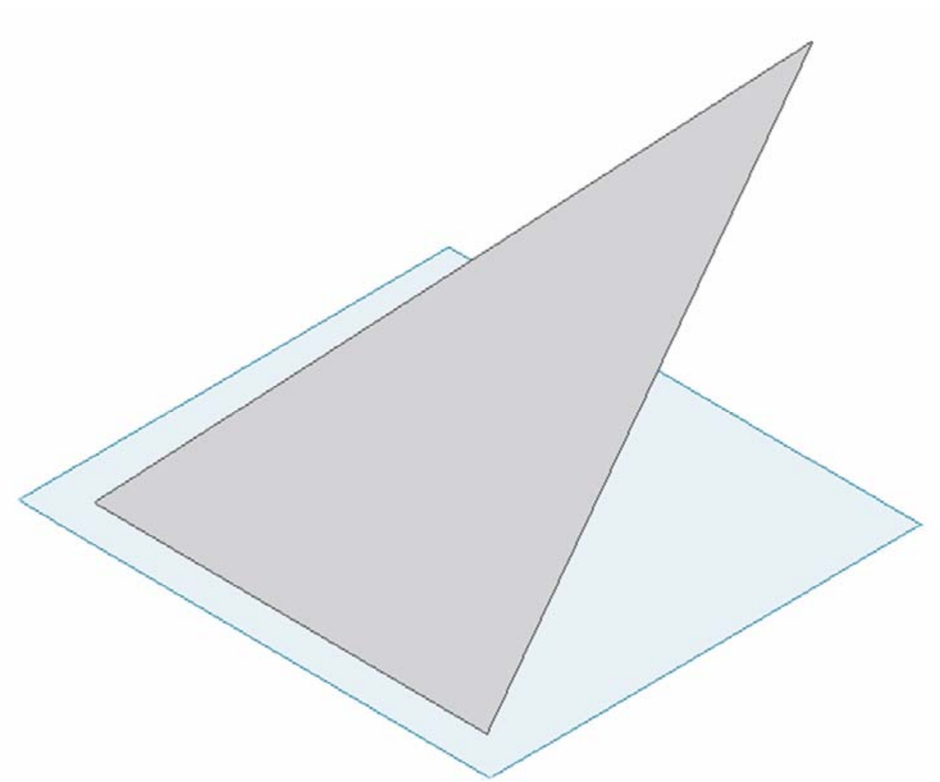


Figure 4A-13G: The completed oblique pyramid.

Next, click-select the **Work Plane** tool; move the cursor closer to the left and right endpoints of the frontal base edge line, click once at each of the two points when the outline yellow circle snap indicator appear; a new work plane appears; then move the cursor closer to the vertex point on the *Vertex* **Sketch**, and click once when the vertex point turns red (*Figure 4A-13D*); a new work plane is created; rename it in the **Model** panel "*Cutoff Work Plane 1*." Select this plane and click the **Sketch** button to start a new sketch; use the **Circle Center Point** tool to draw a circle large enough to enclose the whole prism (*Figure 4A-13E*); click the **Return** button to exit the sketch mode and rename the new sketch "*Cutoff 1*" in the **Model** panel. Next, use the **Extrude** tool with **Cut** as **Type**, **All** as **Extents**, outwards from the prism as **Direction**, and the circle as **Profile**, cut one surface of the pyramid out of the 3D body of the prism (*Figure 4A-13F*); rename the **Extrude** feature "*Surface Cutoff 1*" in the **Model** panel. Repeat the same procedures to cut off the remaining two surfaces and complete the oblique pyramid (*Figure 4A-13G*). Rename each **Work Plane**, **Sketch** and **Extrude** features as shown in *Figure 4A-13I*. Save the file.

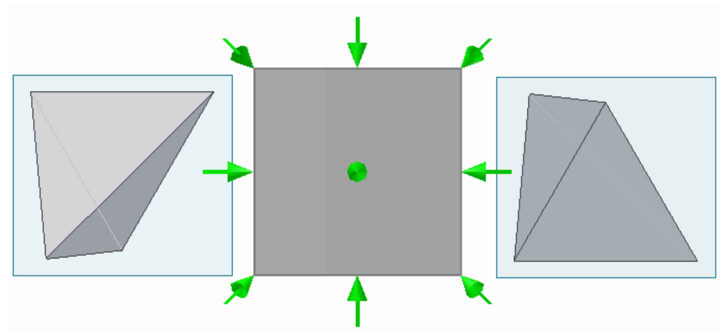


Figure 4A-13H: The top view (left) and the bottom view (right) of the completed oblique prism.

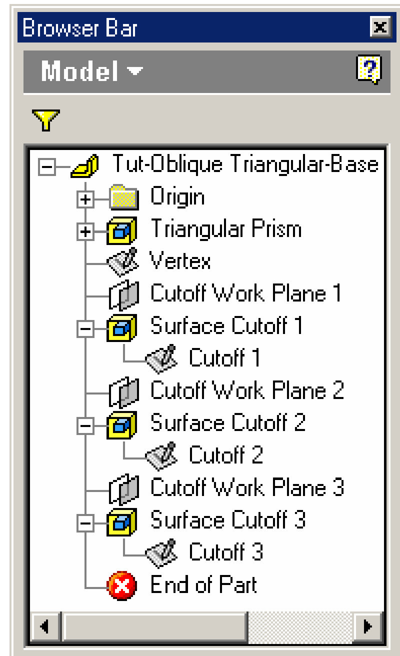


Figure 4A-13I: The Model panel features.

Next, analyze the spatial relationships of surfaces, edges and points by using the **Rotate** tool with **Common View [SPACE]** option to rotate the 3D model to the top and bottom views; the top view shows two foreshortened inclined lateral surfaces; and the bottom view shows one foreshortened inclined lateral surface and one true-shape base surface (*Figure 4A-10H*). Save and close the file.

Section 10:
Creating A Derived Part File For An Oblique Pyramid With A Triangular or Other Polygonal Base Other Than A Square or A Rectangle, With A Vertex Inside of The Top Surface

To create an oblique pyramid with a polygonal base other than a square or a rectangle, with a vertex that is inside the top surface of the first extruded prism feature, the vertex point should be created first on the top surface. Once this step is completed, a combination of **Work plane**, **Sketch** and **Extrude** (with **Cut** option) can be used to change the prism into an oblique pyramid, as explained in the previous Section 9 of this Module. An alternative method is to use the **Work Plane** and **Split** tools, as explained in Section 1 of this Module (page 4A-6).

Open the *Tut-Oblique Triangular-Base Pyramid Vertex In.ipt* file from the same *Tut-Piramid* folder. Click-select the top surface of the triangular prism (*Figure 4A-14A*); click the **Sketch** button to start a new sketch; rename it "*vertex*" in the **Model** panel; click the **Look At** button to switch the sketch to an orthographic (normal) view; use the **Project Geometry** tool to project the **Center Point** onto the *Vertex* sketch; use the **Point, Hole Center** tool to draw the vertex point above and to the right of the projected **Center Point**; use the **General Dimensions** tool to apply a 8-inch horizontal linear dimension and a 6-inch vertical dimension between the vertex point and the projected **Center Point** (*Figure 4A-14B*); click the **Return** button to exit the sketch mode.

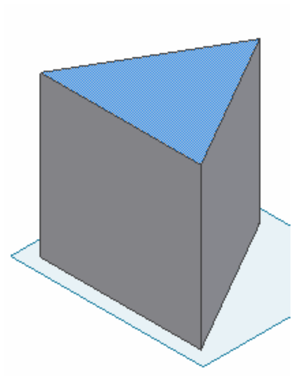


Figure 4A-14A: Selecting the top surface for a new sketch.

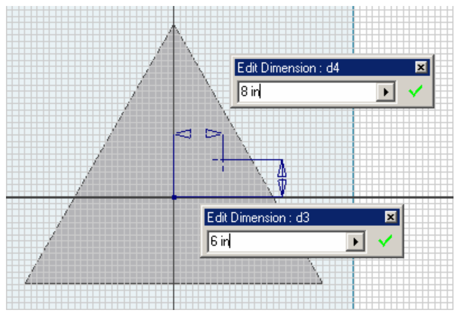


Figure 4A-14B: Drawing a vertex point and apply linear dimensions between the vertex and the Center Point.

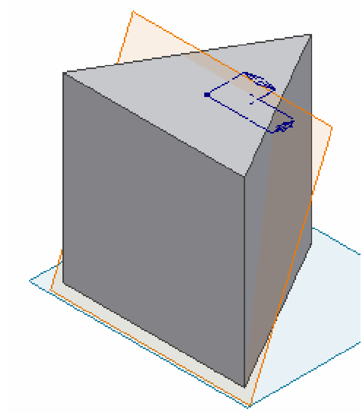


Figure 4A-14C: Creating the first 3-point cutoff work plane.

Next, click-select the **Work Plane** tool; move the cursor closer to the left and right endpoints of the frontal base edge line, click once at each of these two points when the outline yellow circle snap indicator appear; then move the cursor closer to the vertex point on the *Vertex* sketch, and click once when the vertex point turns red (*Figure 4A-14C*); a new **Work Plane** feature is created; rename it in the **Model** panel "*Cutoff Work Plane 1*." Select this plane and click the **Sketch** button to start a new sketch; use the **Circle Center Point** tool to draw a circle large enough to enclose the whole prism (*Figure 4A-14D*); click the **Return** button to exit the sketch mode and rename the new **Sketch** feature "*Cutoff 1*" in the **Model** panel. Next, use the **Extrude** tool with **Cut** as **Type**, **All** as **Extents**, outwards from the prism as **Direction**, and the circle as **Profile**, cut one surface of the pyramid out of the 3D body of the prism; rename the **Extrude** feature "*Surface Cutoff 1*" in the **Model** panel (*Figure 4A-14E*). Use the **Work Plane**, **Sketch**, and **Extrude** tools, repeat the same procedures to cut off the remaining two surfaces and complete the oblique pyramid (*Figure 4A-11F*).

Next, to see how the oblique axis' vertex affects the top view of the model, select the **Look At** button and click-select the *Vertex* **Sketch** feature in the **Model** panel (*Figure 4A-14G*); from the top view, it is obvious that the vertex pulls all edges of the pyramid with it. Rename all remaining **Work Plane**, **Sketch** and **Extrude** features as shown in the **Model** panel (*Figure 4A-14H*). Save and close the file.

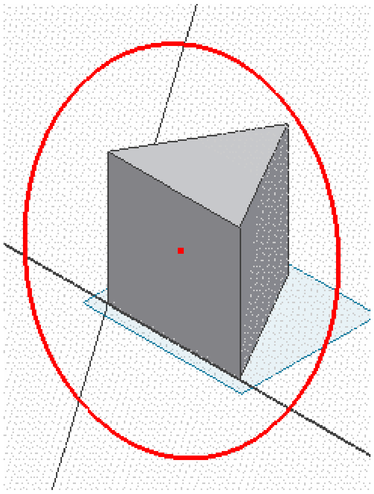


Figure 4A-14D: The cutoff sketch for an extrude cut.

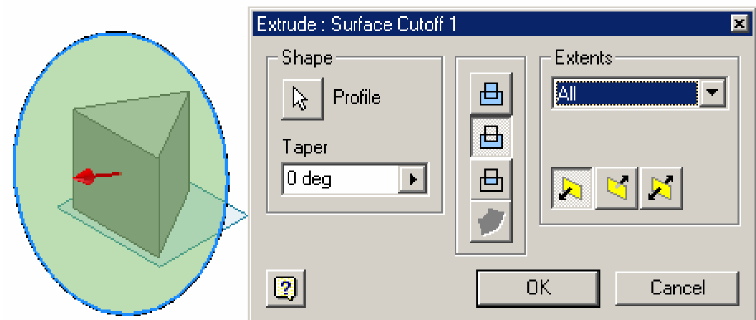


Figure 4A-14E: Using the Extrude tool.

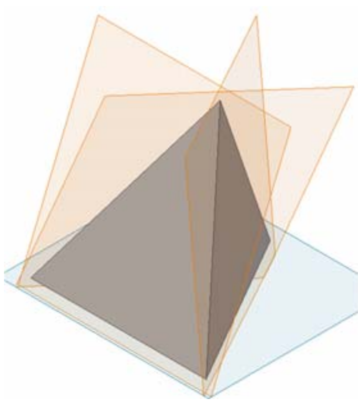


Figure 4A-14F: Completing the pyramid.

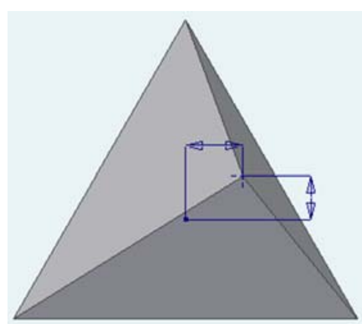


Figure 4A-14G: The top view

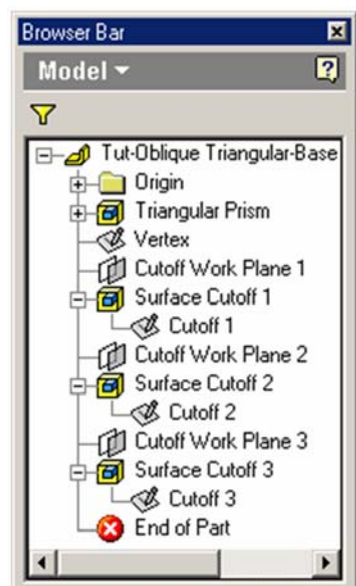


Figure 4A-14H: The Model panel features.

Congratulations! In this somehow lengthy Module with 10 Sections, you have learned the basic methods of creating the 3D models of most, if not all types of right and oblique pyramids, and observed the 3D spatial relationships of surfaces, edge lines and corner points of 3D models in Inventor’ s 3D digital space.