Module 8A:
Creating a Sheet Metal Part & Flat Pattern Wrapping the 3D Space of a Polyhedron

In this *Module*, we will learn how to create a sheet metal part wrapping a polyhedron based on an octagonal shape. Some 3D modeling programs have tools for the creation and modification of polyhedrons; for example, 3D Studio MAX owned by Discreet, a subsidiary of Autodesk, the developer of Inventor, provides the **Hedra Object** tool that can instantly create polyhedrons and polyhedral stars and modify them by changing the **P** and **Q** values in the **Hedra Object** tool's dialog window (*Figure 8A-1A* and *Figure 8A-1B*); in addition, 3D Studio MAX files can be exported as **AutoCAD DWG** and/or **DXF** format files and opened in AutoCAD program as wireframe-based surface models (*Figure 8A-1B*).

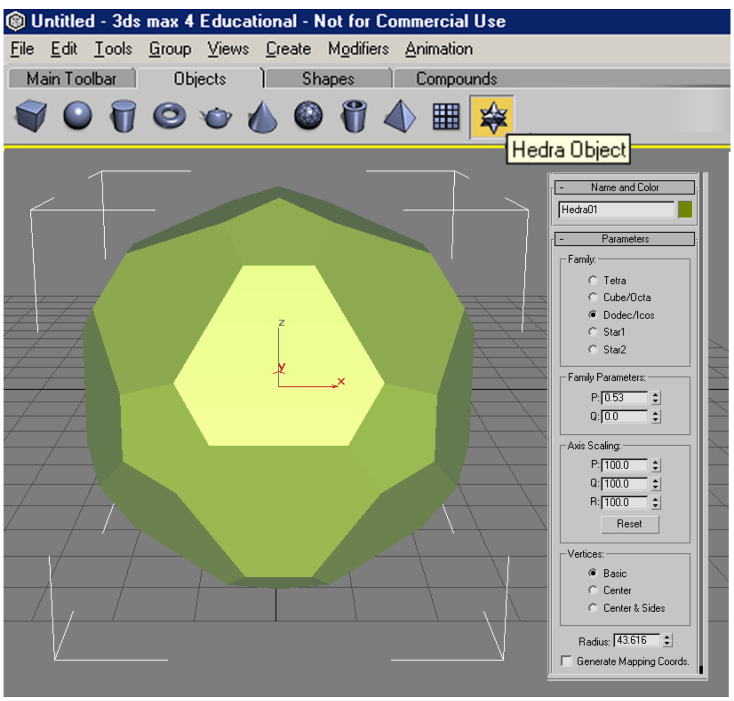


*Figure 8A-1A: The **Hedra Object** tool in 3ds MAX.*

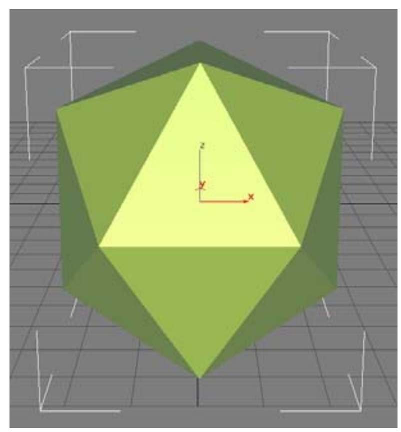


*Figure 8A-1B: Modification of **Hedra Object** model by changing the **P** and/or **Q** values.*

In this *Module*, we will learn how to create a 3D solid model of a polyhedron based on an octagonal shape, and then sheet metal parts that are used to wrap the 3D space of this polyhedron.

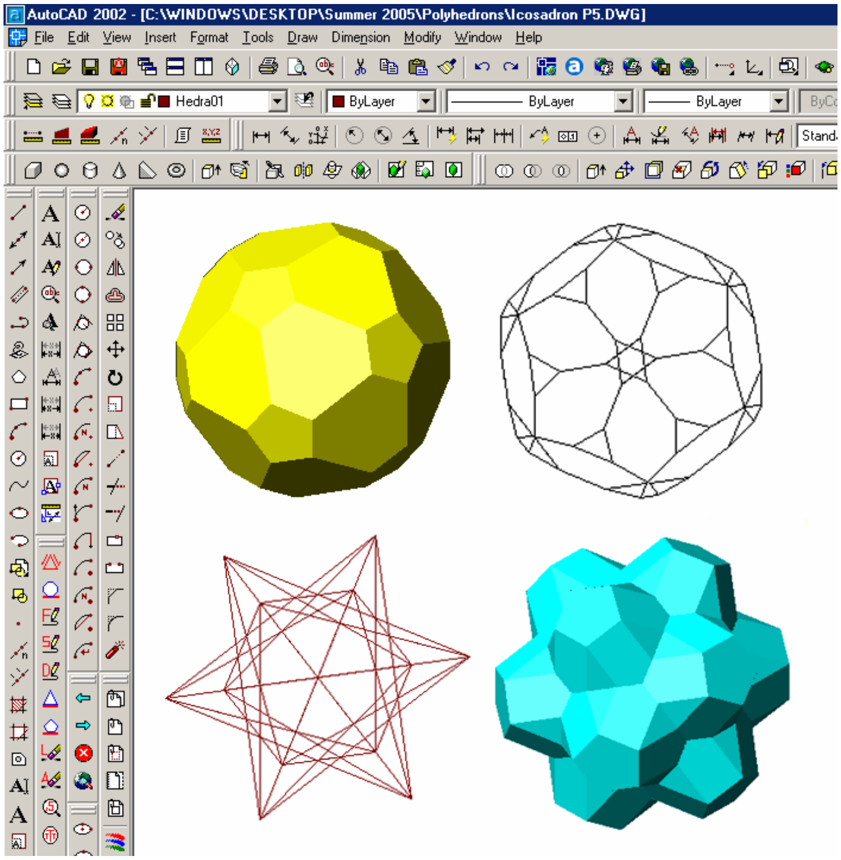


Figure 8A-1C: Exporting 3D Studio Max files into AutoCAD (top) as surface models (bottom).

Section 1: Creating The Derived Part of The Octagon-Based Polyhedron

Step 1: Creating an octagon-based prism extruded from one of the three principal Planes

We will first create a 36-inch deep prism based on an octagonal profile with a 36-inch cross-flat length. Launch Inventor, start a new **Sheet Metal (in).ipt** file under the **English** tab. "*Sketch1*" is created by default in the **Model** panel' **XY Plane** (the one parallel to your computer's screen); click the **Return** button to exit the Sketch mode and delete the default *sketch1* feature from the **Model** panel, with the **Delete** key on the keyboard. Select the **YZ Plane** in the **Model** panel and click the **Sketch** button to start a new sketch; rename it *YZ Plane Hex Extrude Sketch* in the **Model** panel; use the **Project Geometry** tool to project the **Center Point** onto the sketch for a snap point; use the **Polygon** and **General Dimension** tools to draw a 8-sided 36-inch octagon snapped-centered at the projected **Center Point** (*Figure 8A-2A*); click the **Return** button to exit the *YZ Plane Hex Extrude Sketch*. Save the file as *Tut-Octagonal Polyhedral Body.ipt* in a new folder named *Tut-Octagonal Polyhedral*. Save at each step throughout the entire project. Next, use the **Extrude** tool with **Join** as **Type**, **Distance** and 36 inch for **Extents** and the octagon just drawn in the *YZ Plane Hex Extrude Sketch* as **Profile** to create the prism, and rename the **Extrude** feature *YZ Plane Hex Extrusion* in the **Model** panel.

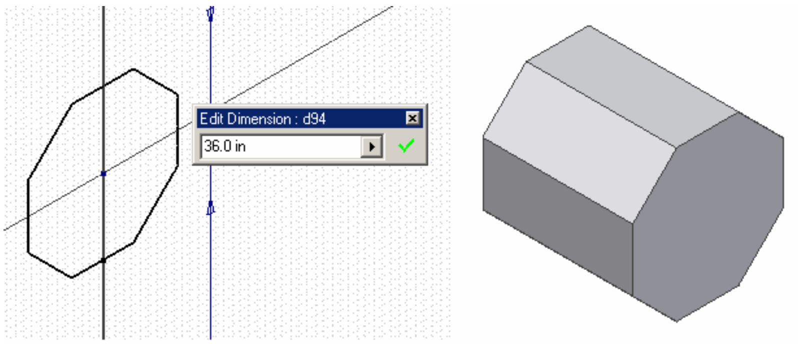


Figure 8A-2A: The YZ Plane Hex Extrusion.

Step 2: Cutting the octagonal prism into an octagonal shape from the second principal Plane

Next, cut the prism into an octagon-shape body from the **XY Plane**. Select the **XY Plane** from the **Model** panel and click the **Sketch** button to start a new sketch; and rename it *XY Plane Hex Cut Sketch* in the **Model** panel; use the **Project Geometry** tool to project the **Center Point**; use the **Polygon** and **General Dimension** tools to draw a 8-sided 36-inch octagon snapped-centered at the projected **Center Point**; use the **Circle Center Point** tool to draw a large circle outside of the octagon, of any convenient size which can enclose the entire 3D model; click the **Return** button to exit the *XY Plane Hex Cut Sketch*. Next, use the **Extrude** tool with **Cut** as **Type**, **All** for **Extents**, **Midplane** for **Direction** and the area between the octagon and the circle in the *XY Plane Hex Cut Sketch* as **Profile** to cut the prism; and rename the **Extrude** feature *XY Plane Hex Cut* in the **Model** panel (*Figure 8A-2B*).

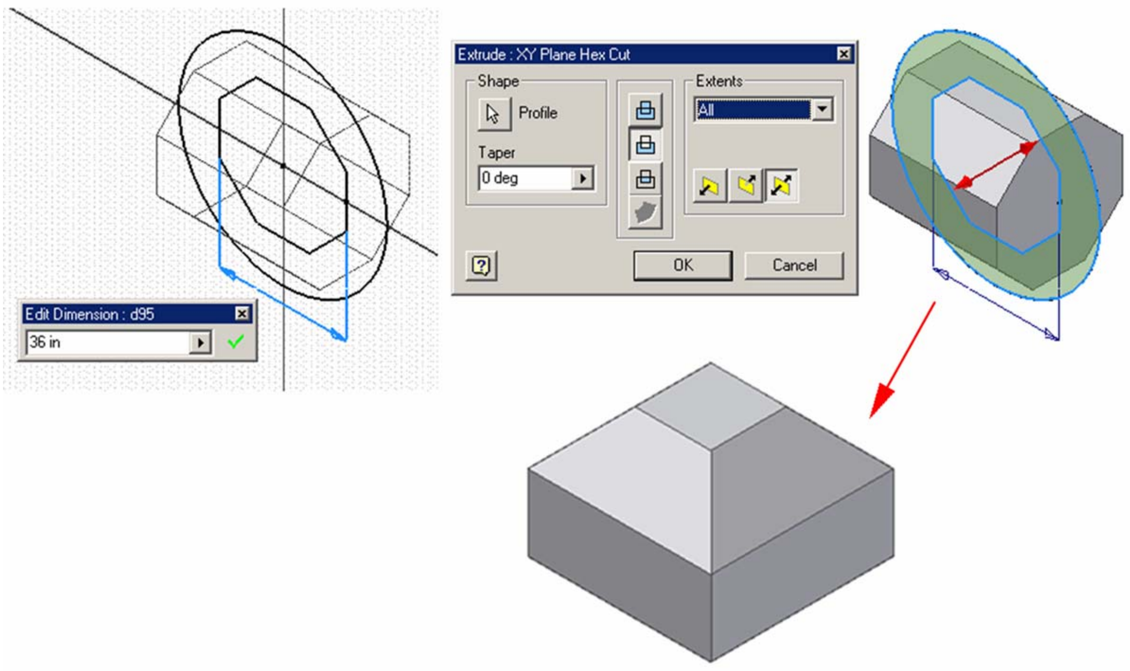


*Figure 8A-2B: The XY Plane Hex Cut Sketch (left), the XY Plane Hex Cut **Extrude** feature (middle); and the resulted 3D model (right).*

Step 3: Cutting the octagonal prism into an octagonal shape from the third principal Plane

Next, cut the prism into an octagon-shape body from the **XZ Plane**. Select the **XZ Plane** from the **Model** panel; click the **Sketch** button to start a new sketch; and rename it *XZ Plane Hex Cut Sketch* in the **Model** panel; use the **Project Geometry** tool to project the **Center Point**; use the **Polygon** and **General Dimension** tools to draw a 8-sided 36-inch octagon snapped-centered at the projected **Center Point**; use the **Circle Center Point** tool to draw a large circle outside of the octagon, of any convenient size that can enclose the entire 3D model created so far; click the **Return** button to exit the *XZ Plane Hex Cut Sketch*. Next, use the **Extrude** tool with **Cut** as **Type**, **All** for **Extents**, **Midplane** for **Direction** and the area between the octagon and the circle in the *XZ Plane Hex Cut Sketch* as Profile to cut the prism; and rename the **Extrude** feature *XZ Plane Hex Cut* in the **Model** panel (*Figure 8A-2C*). The 3D model of the octagon-based polyhedron is completed and ready to be used as a **Derived Part** for its **Work Surface** in an Inventor sheet metal file. The features of the octagon-based polyhedron are listed in the **Model** panel (*Figure 8A-2D*). Save the close the file.

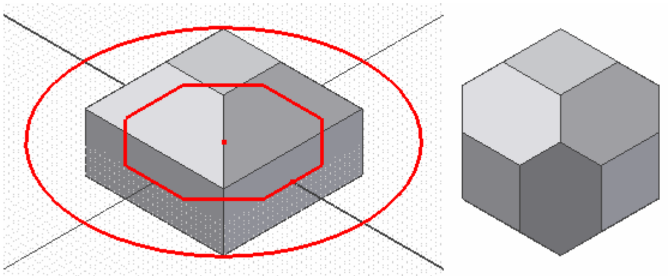


*Figure 8A-2C: The XY Plane Hex Cut Sketch (left), the XY Plane Hex Cut **Extrude** feature (middle); and the resulted 3D model (right).*

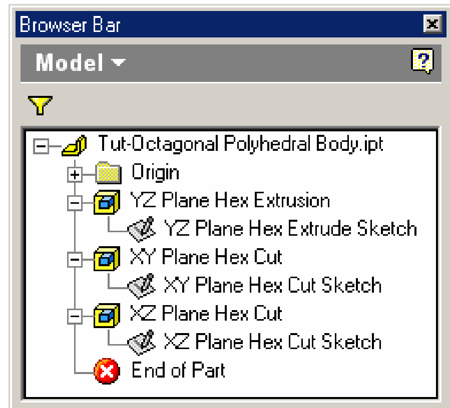


*Figure 8A-2D: The features listed in the **Model** panel.*

Section 2:
Creating The Sheet Metal Parts Wrapping The 3D Space of The Octagon-Based Polyhedron

There are two ways to design this sheet metal project, one is to design it as a single-piece sheet metal part through 4 sets of adjacent **Face** features with **Bends**, in ordered steps (in each step, one set of adjacent **Face** features are created with automatic generation of **Bend** features; and for the 4th set, the profile sketches need to be adjusted so as to allow a 0.001-inch gap along the gray stripes, as shown in *Figure 8A-3A*, for the Inventor program to generate the **Face** and its **Bend** feature); the other way is to create 4 pieces of partial sheet metal parts in three separate files (as shown in *Figure 8A-3B*, the top and bottom pieces being identical), and to assemble all pieces in an assembly file afterwards. The second option is more practical due to availability of material sizes and is chosen for this project.

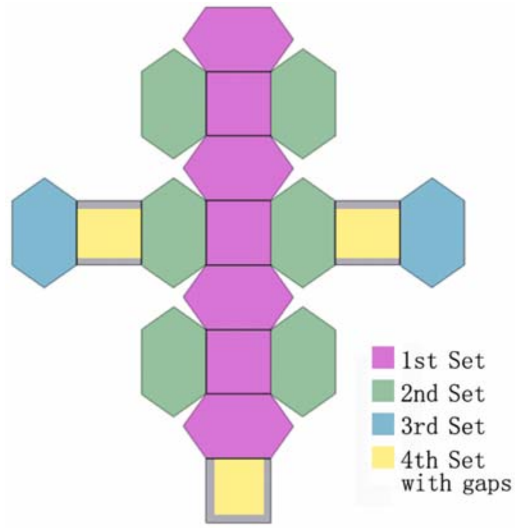


*Figure 8A-3A: The creation of a single-piece sheet metal part through 4 ordered steps with 4 sets of adjacent **Face** features with **Bends**.*

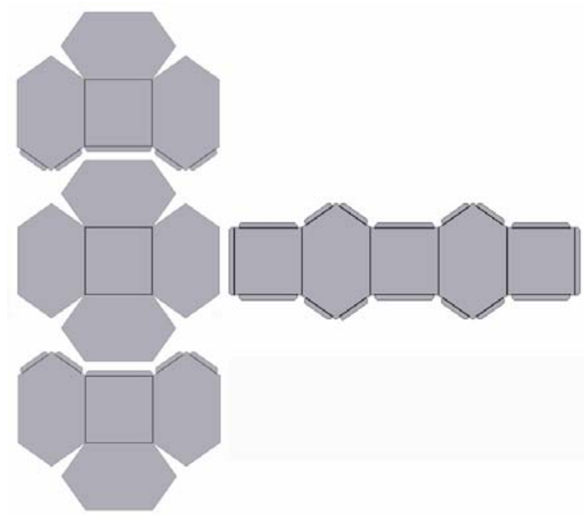
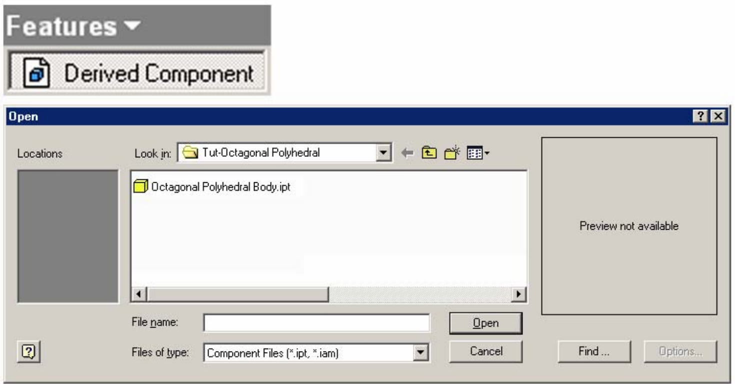


Figure 8A-3B: A more practical design of creating four pieces in three separate files and of assembling them into one file afterwards.

Step 1: Creating the 5-Face partial sheet metal part

Start a new **Sheet Metal (in).ipt** file under the **English** tab. "*Sketch1*" is created by default on the **Model** panel's **XY Plane** (the one parallel to your computer's screen); click the **Return** button to exit and delete the default *sketch1* feature from the **Model** panel, with the **Delete** key on the keyboard. Select the **Derived Component** tool from the **Features** panel; in the **Open** dialog window that opens up, select the *Tut-Octagonal Polyhedral Body.ipt* file from the *Tut-Octagonal Polyhedral* folder; click the **Open** button; in the **Derived Part** window opens; select the **Body As Work Surface** option and click the **OK** button to place the octagonal polyhedron's 3D **Work Surface** model into the file (*Figure 8A-3C*). Save the file as *Octagonal Polyhedral Body Face Sheet Metal 5 Piece.ipt* in a new folder named *Tut-Octagonal Polyhedral*. Save at each step throughout the entire project.



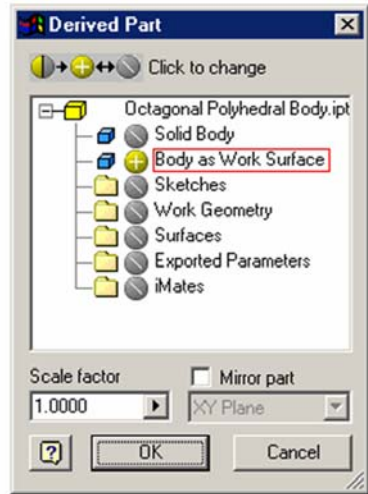
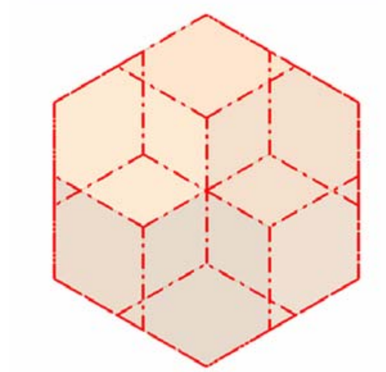


*Figure 8A-3C: The **Derived Component** tool (left) and **Derived Part** window (right).*



Next, create the sheet metal **Face** features extruding outwards from the **Work Surface** of the **Derived Part**, by first selecting each work surface for a new sketch and projecting the edges onto the sketch with the **Project Geometry** tool; and then by using the **Face** tool to create one **Face** feature, and then the adjacent one with automatic generation of **Bend** features.

Select the adjacent work surfaces of the **Derived Part**'s 3D model, click the Sketch button to start new sketches, and use the **Project Geometry** tool to create relevant **Sketch** features one after another, as shown in *Figure 8A-3D*. Notice that four edges (shown in thick black stripes in *Figure 8A-3E*) of the sketch profiles for two **Face** features (shown in white in *Figure 8A-3E*) need to be adjusted so as to allow a 0.001-inch gap along the gray stripes, for the Inventor program to generate the **Face** and its **Bend** feature. This task can be accomplished by using the **Offset**, **General Dimension**, **Extend** and **Trim** tools, as explained in previous *Modules*. Next, use the **Face** tool to create the central square-shaped piece first, and all hexagonal pieces with automatic generation of Bend features afterwards (*Figure 8A-3F* and *Figure 8A-3G*), outwards from the **Work**

Surfaces of the **Derived Part'**s 3D model. Rename all **Sketch** and **Face** features with specific names, as shown in *Figure 8A-3K*.

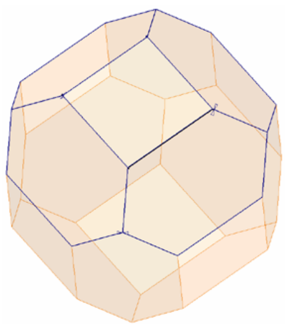


Figure 8A-3D: The face profile sketches.

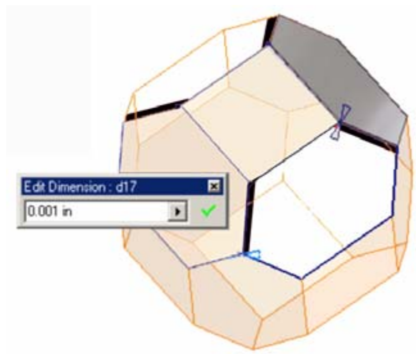


Figure 8A-3E: Adjustment to two face sketches.

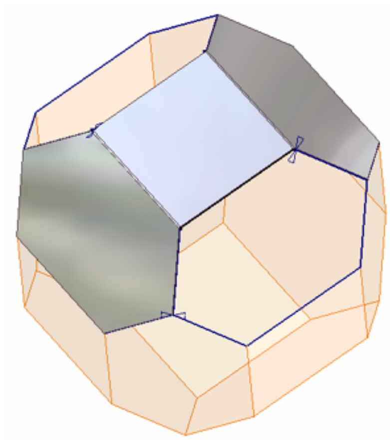


*Figure 8A-3F: Creating the first three **Face** features.*

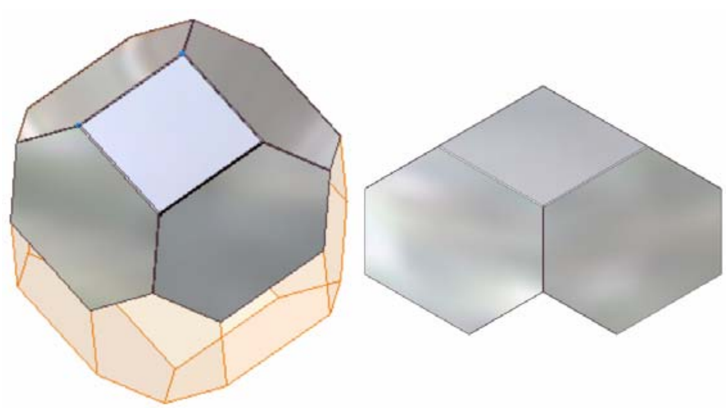


Figure 8A-3G: The completed part.

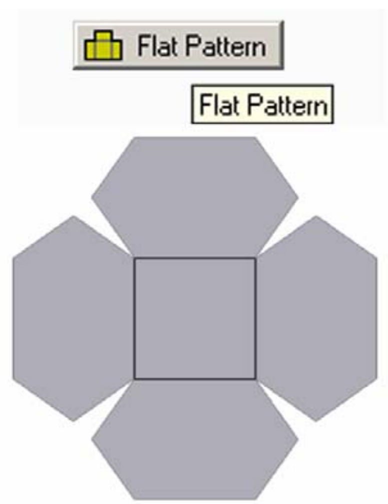


*Figure 8A-3H: The **Flat Pattern** view.*

Next, select the outer surface of square Central Face and click the **Flat Pattern** tool button in the **Sheet Metal** panel to create the **Flat Pattern** view (*Figure 8A-3H*). Notice that by using the **Zoom Window** tool to zoom in the corner area of the sheet metal part, you might see some irregular cutoff made by Inventor during the creation of the **Face** features' **Bends**; we can add "patches" to fill up these imperfect corners, by first using the **Project Geometry**, **Line**, **Extend**, and **Trim** tools to create a patch sketch on the outer surfaces of the Face features concerned (*Figure 8A-3I*); and then by creating a patching **Face** features (*Figure 8A-3J*). Save and close the file.

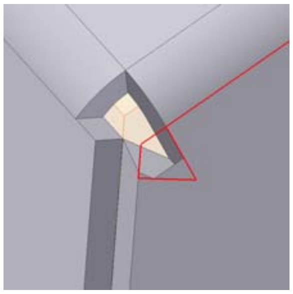


Figure 8A-3I: The patch sketch.

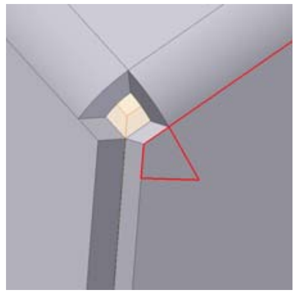


*Figure 8A-3J: The patching **Face** feature.*

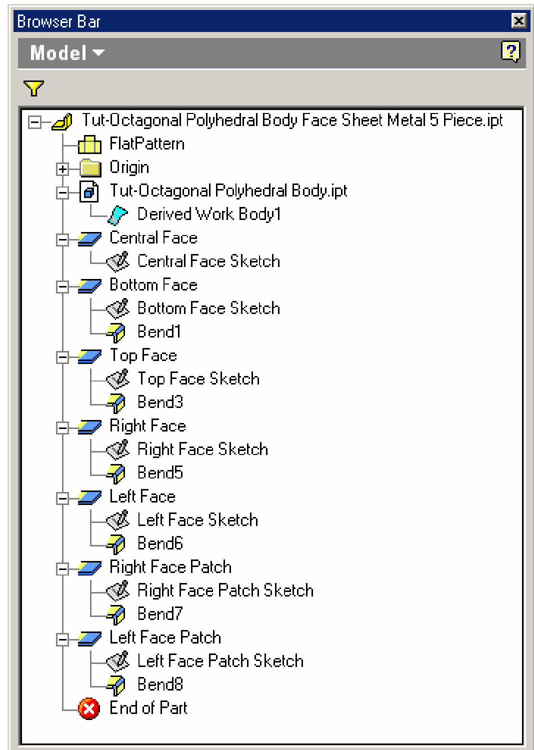
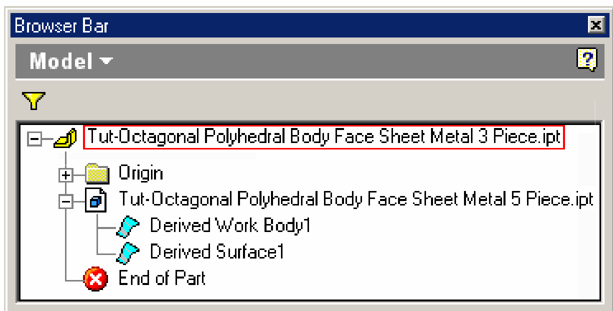


*Figure 8A-3K: The features listed in the **Model** panel.*

Step 2: Creating the 4-face partial sheet metal part

Start a new **Sheet Metal (in).ipt** file under the **English** tab. "*Sketch1*" is created by default in the **Model** panel's **XY Plane** (the one parallel to your computer's screen); click the **Return** button to exit the *Sketch1*, and delete the default sketch1 feature from the **Model** panel with the **Delete** key on the keyboard. Select the **Derived Component** tool from the **Features** panel; in the **Open** window that opens up, select the *Tut-Octagonal Polyhedral Body Face Sheet Metal 5 Piece.ipt* file from the *Tut-Octagonal Polyhedral* folder; click the **Open** button; the **Derived Part** window opens; select the **Body As Work Surface** option and click the **OK** button to place the 5-piece partial sheet metal part's 3D **Work Surface** model into the file. Notice that the surfaces of the octagon-based polyhedral model that are already covered by the 5-piece partial sheet metal part are of a darker orange shade. In addition, notice that, as shown in the **Model** panel (*Figure 8A-4A*), there are actually 2 Work Surfaces in the *Octagonal Polyhedral*

Body Face Sheet Metal 5 Piece.ipt Placed Part (the *Derived Work Body1* that belongs to the 5-piece sheet metal part, and the *Derived Surface1* that belongs to the 3D model of the octagon-base polyhedron in the *Tut-Octagonal Polyhedral Body.ipt* file). Save the file as *Tut-Octagonal Polyhedral Body Face Sheet Metal 4 Piece.ipt* in a same *Tut-Octagonal Polyhedral* folder. Save often at each step throughout the entire project.



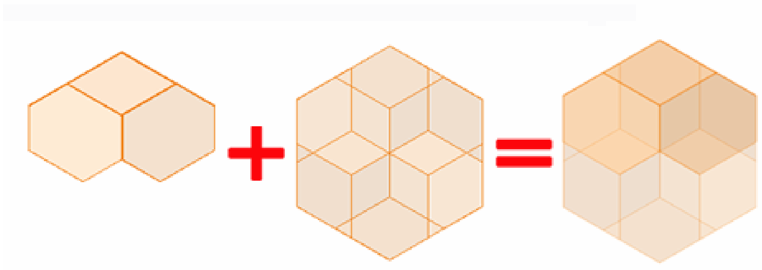


*Figure 8A-4A: The **Work Surfaces** of the **Placed Part** from the Tut-Octagonal Polyhedral Body Face Sheet Metal 5 Piece.ipt file.*

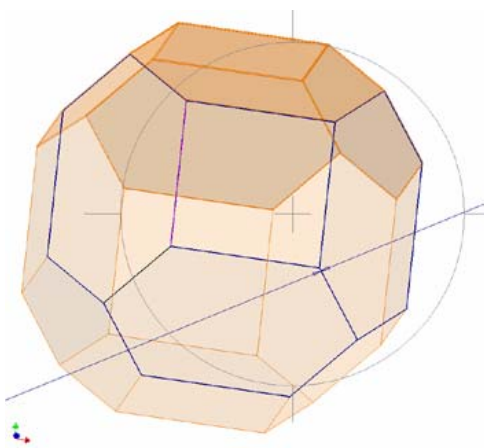


Figure 8A-4B: The face sketches.

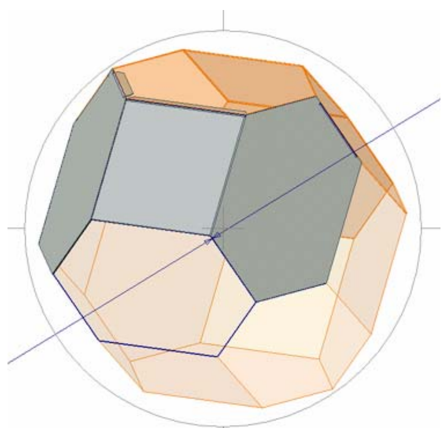


*Figure 8A-4C: The first 3 **Face** features.*

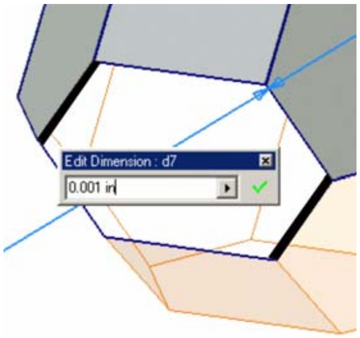


Figure 8A-4D: Adjusting the 4th face sketch.

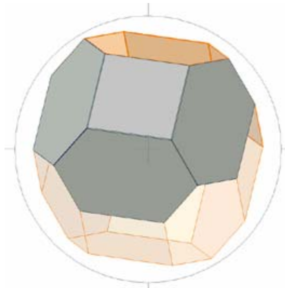


*Figure 8A-4E: All **Face** features created.*

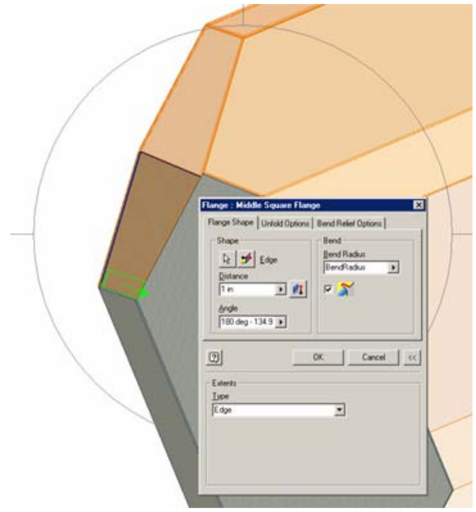


*Figure 8A-4F: Adding the **Flange** feature (**Edge-Type**) to the square **Face** feature.*

Next, create face profile sketches on relevant work surfaces (*Figure 8A-4B*); create the first 3 **Face** features (*Figure 8A-4C*); make adjustments to the bottom face sketch (shown in white) to allow 0.001-inch gaps between the relevant edges of the face (shown as thick black lines in *Figure 8A-4D*) and the edges of the neighboring **Face** features; use the **Face** tool again to create the last **Face** feature. Next, use the **Flange** tool to add a **Flange** feature to the square-shaped **Face** with **Edge** as **Type** in the **Extent** section (*Figure 8A-4G*), and four **Flange** features with 1.00-inch end corner **Offset1** and **Offset2** as **Type** in the **Extent** section (*Figure 8A-4H*), all with the inner edge of the **Face** features selected as the **Edge** in the **Shape** section, and the **Edge** direction all pointing inwardly towards the interior of the polyhedron; the **Distance** is set to 1.00-inch for all **Flange** features and the **Angle** can be measured "on-the-fly" or by first deleting the default value in the text field, then clicking the rightward-pointing triangle at the right end of the **Angle** text field for a shortcut menu and choosing the **Measure Angle** option, and click-selecting the surface of the polyhedron and then the relevant sheet metal Face feature's surface (sometimes you need to type 180- at the start of the measured angle's value, as explained in previous *Modules*). Next, add 0.5-inch **Corner Chamfers** to the ends of all **Flange** features (*Figure 8A-4I*). The 2nd partial sheet metal part is completed. Click-select the outer surface of the square-shaped Face feature and click the **Flat Pattern** tool button to create the **Flat Pattern** view (*Figure 8A-4J*). Rename all **Sketch**, **Face**, **Flange** and **Corner Chamfer** features with specific names at each step of their creation. The features of the part are listed in the **Model** panel (*Figure 8A-4K*). Save and close the file.

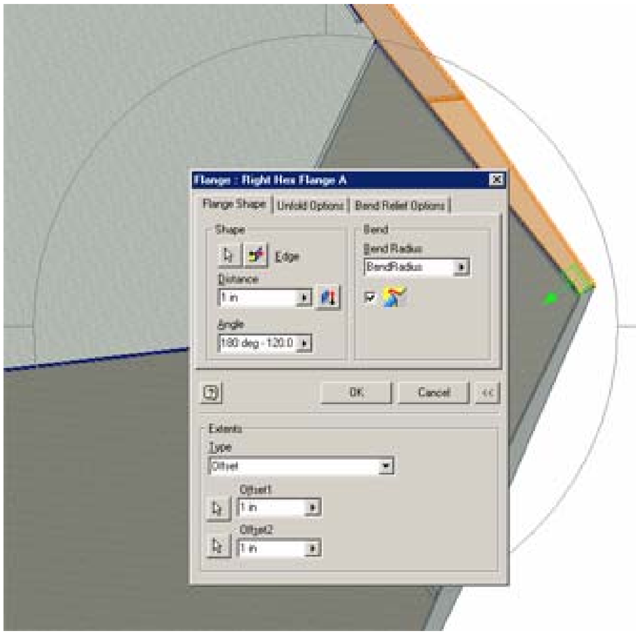


*Figure 8A-4G: Adding the 1.0-inch **Offset**-type **Flange** to the hexagonal **Face** feature.*

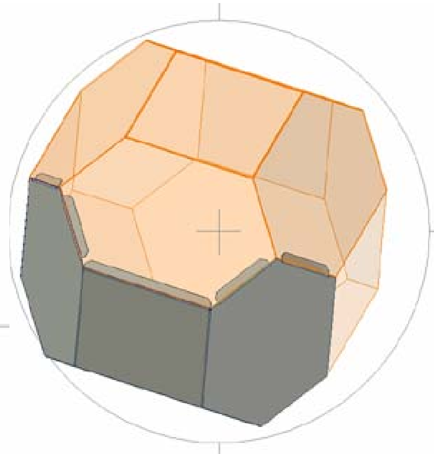


*Figure 8A-4H: All **Flange** features added.*

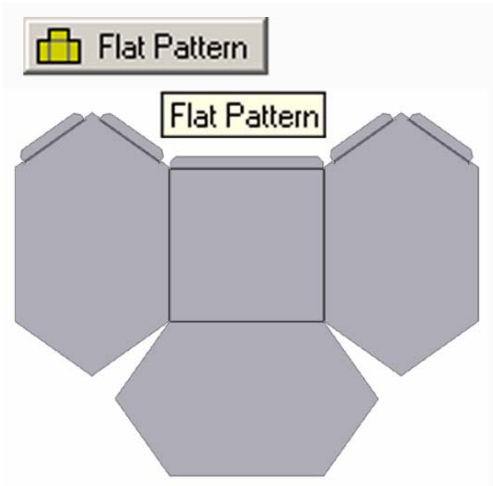


*Figure 8A-4J: The **Flat Pattern** view.*

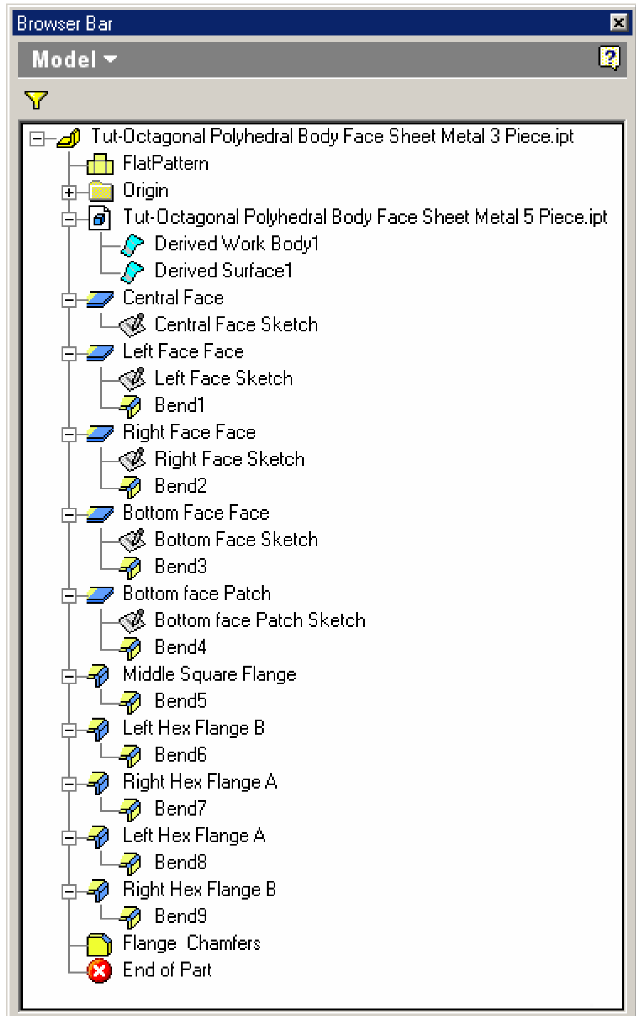


*Figure 8A-4K: The features listed in the **Model** panel.*

Step 2: Creating the 5-face in one stripe partial sheet metal part

Start a new **Sheet Metal (in).ipt** file under the **English** tab. "*Sketch1*" is created by default in the **Model** panel's **XY Plane** (the one parallel to your computer's screen); click the **Return** button to exit and delete the default *sketch1* feature from the **Model** panel with the **Delete** key on the keyboard. Select the *Derived Component* tool from the **Features** panel; in the **Open** window that opens up, select the *Tut-Octagonal Polyhedral Body Face Sheet Metal 4 Piece.ipt* file from the *Tut-Octagonal Polyhedral* folder; click the **Open** button; the **Derived Part** window opens; select the **Body As Work Surface** option and click the **OK** button to place the 4-piece partial sheet metal part's 3D **Work**

Surface model into the file (*Figure 8A-5A*). Notice that the surfaces of the octagon-based polyhedral model already covered by the 5-piece and 4-piece partial sheet metal parts are of a darker orange shade. Save the file as *Octagonal Polyhedral Body Face Sheet Metal 1 Stripe.ipt* in the same *Tut-Octagonal Polyhedral* folder. Save often at each step throughout the entire project.

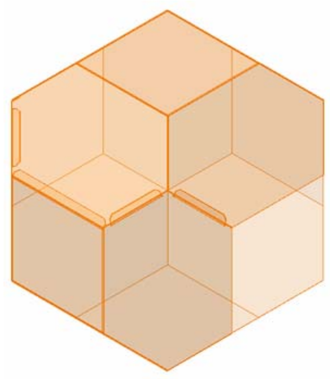


*Figure 8A-5A: The **Derived Part** from the Tut-Octagonal Polyhedral Body Face Sheet Metal 4 Piece.ipt file.*

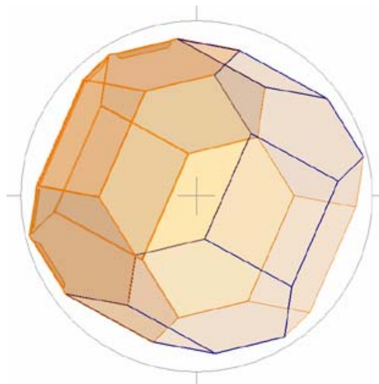


Figure 8A-5B: The relevant face sketches.

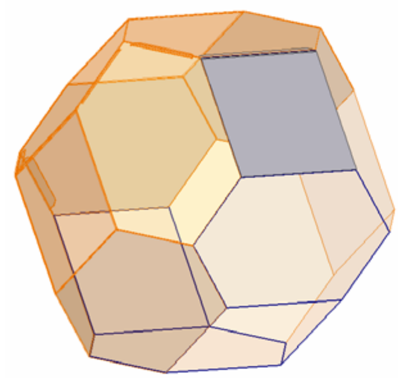


*Figure 8A-5C: Creating the first **Face** feature (the end piece).*

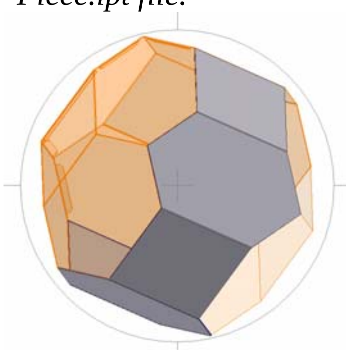


*Figure 8A-5D: All **Face** features completed.*

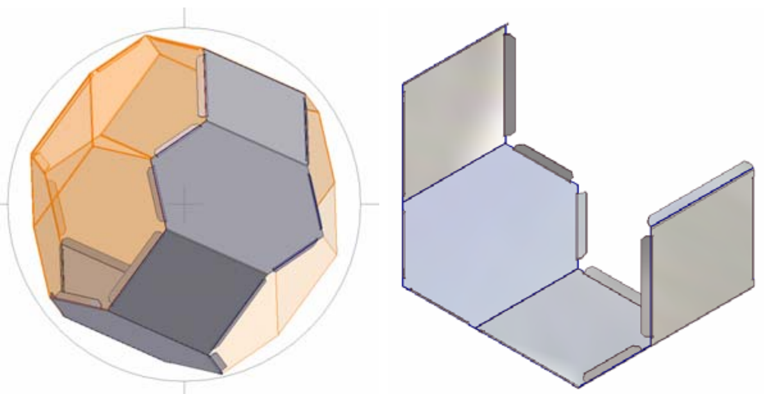
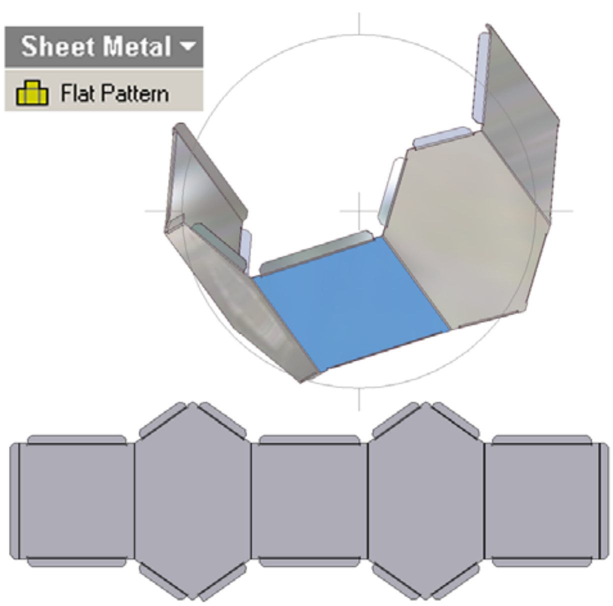


*Figure 8A-5E: **Flange** and **Corner features** added.*

Next, create face profile sketches on relevant work surfaces (*Figure 8A-5B*); create the first **Face** features on the end face sketch (*Figure 8A-5C*); and the subsequent **Face** features with automatic creation of **Bend** features, in a sequential order, from the 1st through the 5th **Face** features (*Figure 8A-5D*).

Next, use the **Flange** tool to add one **Flange** feature per each of the two square-shaped **Face** features at the end edge, with **Edge** as **Type** in the **Extent** section of the **Flange** tool's dialog window; next, add 10 additional **Flange** features with 1.00-inch end corner **Offset1** and **Offset2** as **Type** in the **Extent** section for all other edges of all **Face** features. All **Flange** features should have the inner edge of the **Face** features selected as the **Edge** in the **Shape** section, and the **Edge** direction all pointing inwardly towards the interior of the polyhedron; and the Distance of the Flange feature should be set to 1.00-inch and the **Angle** can be measured "on-the-fly" as explained in the previous section of this Module.

Next, add 0.5-inch **Corner Chamfers** to the ends of all **Flange** features (*Figure 8A-5E*). The 3rd partial sheet metal part is completed. Click-select the outer surface of the central square-shaped end **Face** feature and click the **Flat Pattern** tool button to create the **Flat Pattern** view (*Figure 8A-5F*). Rename all **Sketch**, **Face**, **Flange** and **Corner Chamfer** features with specific names at each step of their creation. The features of the part are listed in the **Model** panel (*Figure 8A-5G*). Save and close the file.



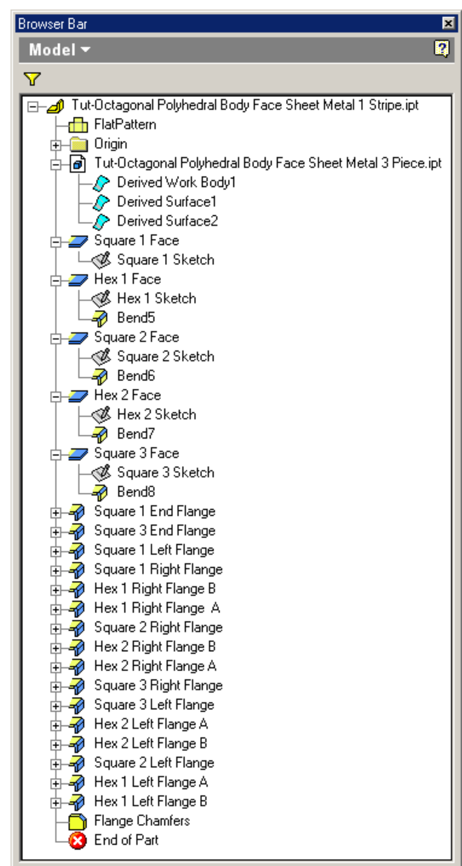


Figure 8A-5F: Selecting the central square-shaped Face feature for the Flat Pattern projection (left).

*Figure 8A-5G: The features listed in the **Model** panel (right).*

Section 3:
Create The Assembly File For All Partial Sheet Metal Parts Wrapping The 3D Space of The Octagon-Based Polyhedron

Start a new Inventor assembly (**.iam**) file under the **English** tab; save the file as *Octagonal Polyhedral Body Face Sheet Metal Assembly.iam* in the same *Tut-Octagonal Polyhedral* folder. Save often at each step throughout the entire project. Use the **Place Component** tool to place the 3D models of all *Tut-Octagonal Polyhedral Body Face Sheet Metal 1 Stripe.ipt*, *Tut-Octagonal Polyhedral Body Face Sheet Metal 4 Piece.ipt*, and *Tut-Octagonal Polyhedral Body Face Sheet Metal 5 Piece.ipt* files into the assembly file; and use the **Place Constraint** tool with **Mate** as **Type** and **Flush** as **Solution** to mate the **XY Plane**, **YZ Plane** and **XZ Plane** of each of these files with their corresponding **Planes** in the assembly file, which are listed in the **Origin** folder of the **Model** panel.

The 3 pieces are assembled; and the comprehensive coverage of the 3D space of the polyhedron still needs one piece of the *Tut-Octagonal Polyhedral Body Face Sheet Metal 4 Piece.ipt* file (*Figure 8A-6A*). Use the **Rotate** tool to examine this situation. In order to create the missing piece, use the **Place Component** tool again to place another copy of the *Tut-Octagonal Polyhedral Body Face Sheet Metal 4 Piece.ipt* file; notice that in the **Model** panel, the name of the new **Placed Part** reads *Tut-Octagonal Polyhedral Body Face Sheet Metal 4 Piece.ipt:2*, indicating that it is the 2nd instance of the **Placed Part** originating from the same part file. Next, use the **Place Constraint** tool with **Mate** as **Type** and **Mate** as **Solution** (*Figure 8A-6B*) to mate the **XZ Plane** of the 3D model of the 2nd **Placed Part** of the *Tut-Octagonal Polyhedral Body Face Sheet Metal 4 Piece.ipt* with the **XZ Plane** of the assembly file; next, click the **Flush** button to select it as **Solution** type in the **Place Constraint** dialog window, and mate the **XY Plane** of the *Tut-Octagonal Polyhedral Body Face Sheet Metal 4 Piece.ipt:2* model with the **XY Plane** of the assembly file. All 4 pieces are assembled (*Figure 8A-6C*). The features are listed in the **Model** panel (*Figure 8A-6D*).

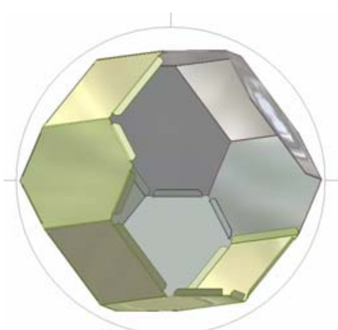


Figure 8A-6A: One piece missing.

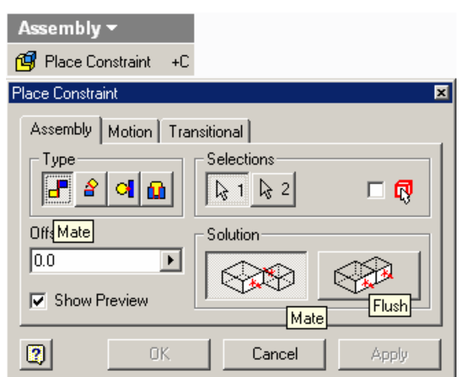


*Figure 8A-6B: The **Place Constraint** tool's dialog window.*

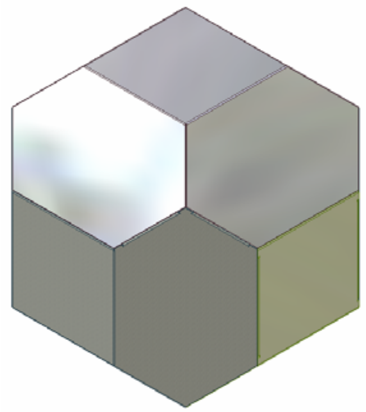


Figure 8A-6C: All 4 pieces assembled.

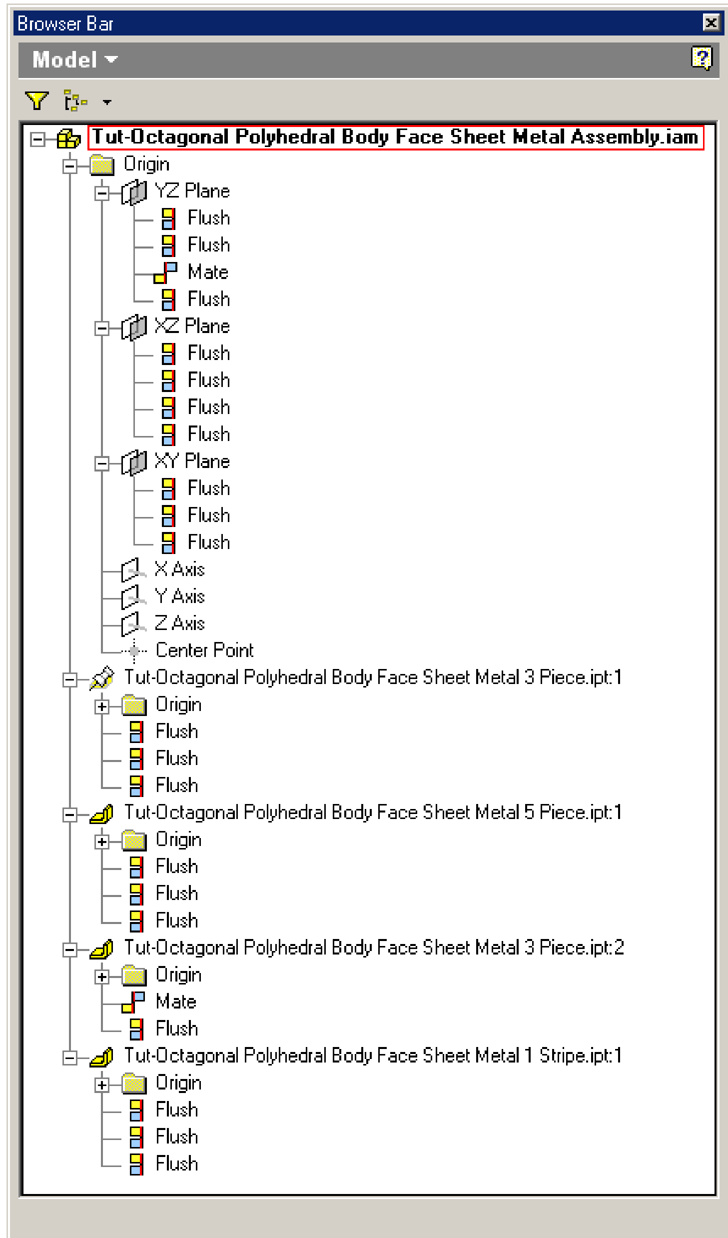


Figure 8A-6D: The features listed in the Model panel.

Congratulations! You learned in this *Module* how to create a 3D solid model of an octagon-based polyhedron; as well as sheet metal parts wrapping its 3D space; and you have completed all *Modules* of learning descriptive geometry with Autodesk Inventor contained in this *Hand-On Manual*. We will now proceed to the optional *Module 9*, the very last *Module*, which explores the way to create a 2D working drawing with a fully dimensioned and notated **Flat Pattern** view of a sheet metal part.