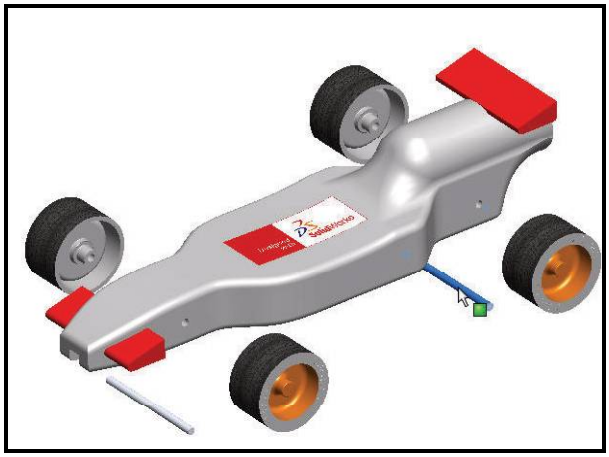
Lesson 2
Designing the Race Car

When you complete this lesson, you will be able to:

- Describe important factors to the performance of a CO_2-powered `Race Car`
- Create the `Race Car` assembly from an existing model using the following Feature and Sketch tools: Extruded Boss/Base, Extruded Cut, Fillet, Line, Sketch Fillet, Smart Dimension, Mate, Explode, and Rotate Component
- Insert components into a new assembly
- Apply Standard mates between components in the `Race Car` assembly
- Create an Exploded configuration of the `Race Car` assembly
- Apply the `Mass Properties` tool
- Apply the `Measure` tool
- Open Parts from the `Race Car` assembly
- Confirm the required `Race Car` dimensions for Type-R with the Rules and Regulations of the F1 in Schools™ Design Project contest

Important Design Considerations



Within the framework of the *F1 in Schools™ Design Project* contest specifications, there are a few factors to keep in mind when it comes to building a winning car. These are:

- **Friction**
  Energy used to overcome friction is energy that isn't being used to accelerate your `Race Car`. Sources of friction include:
  - Wheels and axles: if the wheels do not spin freely, the `Race Car` will be slow.
  - Misaligned axles: if the axle holes are not drilled perpendicular to the centerline of the car, the car will have a tendency to turn to the left or right. This will cost you speed and the contest!
  - Misaligned screw eyes: if the screw eyes are not positioned and aligned properly, the guideline can drag on them, the car body, or the wheels. This can slow the car dramatically.
  - Bumps or imperfections in the rolling surface of the wheel. The more perfectly round and smooth the wheels are, the better they will roll.
- **Mass**
  There is a finite amount of thrust produced by a CO_2 cartridge. It stands to reason that a car with less mass will accelerate quicker and travel down the track faster. Reducing the mass of your car is one way to build a faster car. Keep in mind that the contest specifications stipulates a minimum mass of 55grams for the vehicle.
- **Aerodynamics**
  The air exerts a resistance, or drag, as the car tries to move through it. To minimize drag, your car should have a smooth, streamlined shape.

Note: Check in the back of this lesson for a summary of the required design requirements for your `Race Car` assembly. Visit www.f1inschools.co.uk for updated design requirements and specifications.

About Balsa

Balsa trees grow naturally in the humid rain forests of Central and South America. Its natural range extends south from Guatemala, through Central America, to the north and west coast of South America as far as Bolivia. However, the small country of Ecuador on the western coast of South America, is the world's primary source of balsa for model building.

Balsa needs a warm climate with plenty of rainfall and good drainage. For that reason, the best stands of balsa usually appear on the high ground between tropical rivers. Ecuador has the ideal geography and climate for growing balsa trees.

Balsa wood imported into North America is plantation grown. Don't worry about destroying the rain forests by using balsa – it grows incredibly fast. In 6 to 10 years the tree is ready for harvesting, having reached a height of 18 to 28 meters (60 to 90 feet) and a diameter of about 115 centimeters (45 inches). If left to continue growing, the new wood on the outside layers becomes very hard and the tree begins to rot in the center. Unharvested, a balsa tree may grow to a diameter of 180 centimeters (6 feet) or more, but very little usable lumber can be obtained from a tree of this size.

Use balsa wood with a clear conscience. The rain forests aren't being destroyed to harvest it.

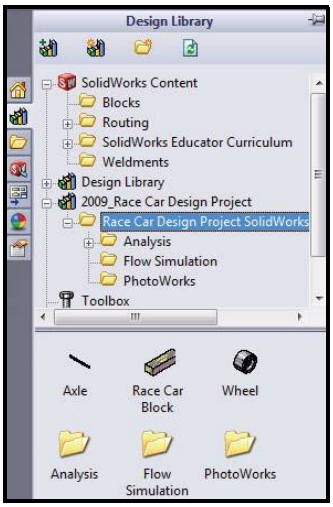
Start SolidWorks and open an existing part

1 **Start the SolidWorks application.**
Click **All Programs, SolidWorks, SolidWorks** from the Start menu. The SolidWorks graphics area is displayed.

2 **Open the Design Library.**
Click the **Design Library** tab from the Task Pane.

3 Open the Race Car Block.

Click the **Race Car Design Project SolidWorks** folder located in the Design Library.



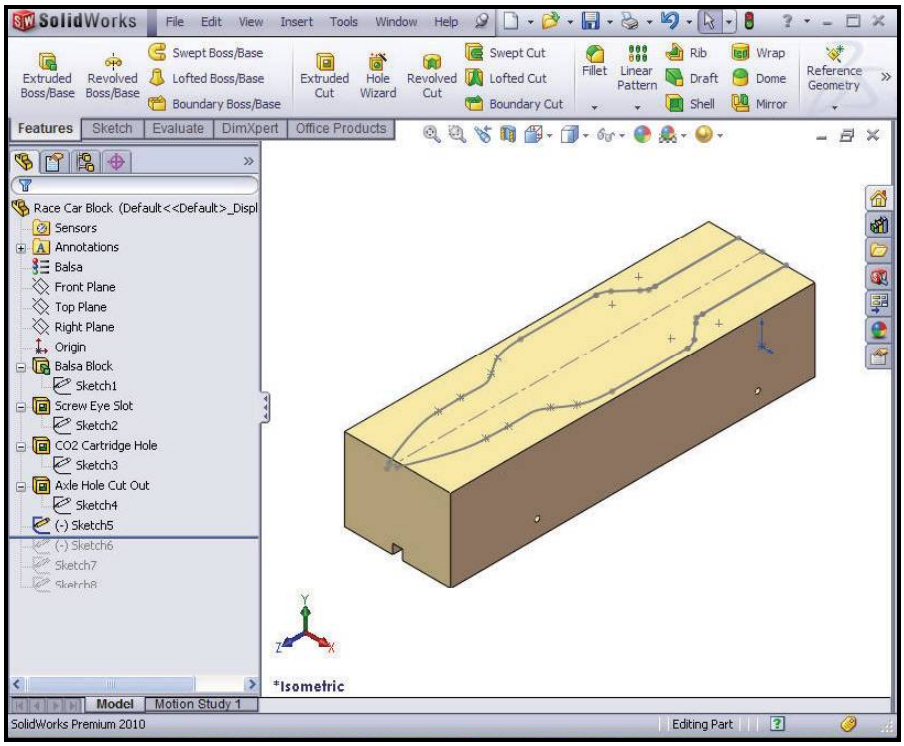
The contents of the folder is displayed in the lower portion of the Design Library window.

Drag and drop the part named **Race Car Block** into the SolidWorks graphics area. View the model and the FeatureManager design tree.

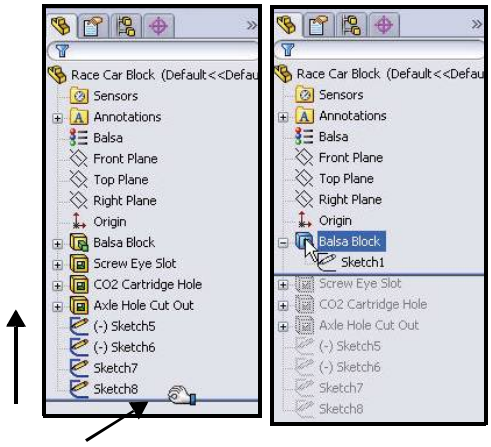
Note: This may take 1-5 seconds.

The FeatureManager design tree located on the left side of the SolidWorks window provides an outline view of the active model. This makes it easy to see how the model was constructed.

The FeatureManager design tree and the graphics area are dynamically linked. You can select features, sketches, drawing views, and construction geometry in either pane.



4 Review the created features and sketches in the model.

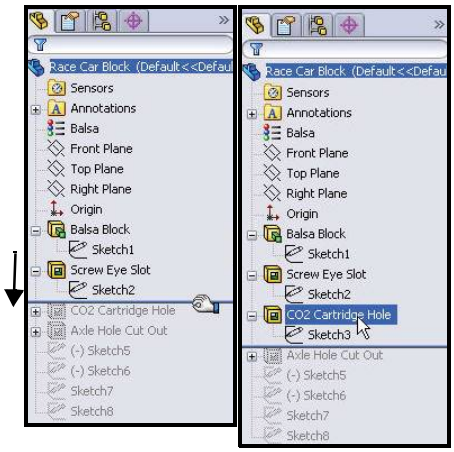


Drag the **rollback bar** upwards to a position before the `Balsa Block` feature.

The `Balsa Block` feature is displayed.

Double-click the `Balsa Block` feature in the FeatureManager. The feature is displayed in blue in the graphics area and Sketch1 is displayed. View the dimensions. If needed, press the z key to fit the model to the graphics area.

Note: The `Balsa Block` is 223mm x 50mm x 65mm. If you plan to use a fixture to machine your car, you must make sure that your design is no longer that 210mm. Most fixtures have a nose plate that holds the front of the balsa block and if your design is too long, it can/will end up breaking the endmill or possible damaging the fixture.



Drag the **rollback bar** downwards to a position before the `Screw Eye Slot` feature.

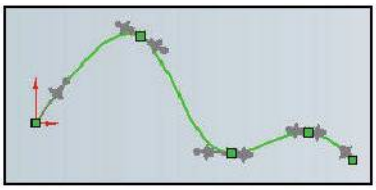
View the features in the graphics area.

Double-click the `Screw Eye Slot` feature in the FeatureManager. The feature is displayed in blue and `Sketch2` is displayed.

Drag the **rollback bar** downwards to a position before the `CO2 Cartidge Hole` feature. View the features in the graphics area.

Double-click the `CO2 Cartidge Hole` feature in the FeatureManager. The feature is displayed in blue and `Sketch3` is displayed.

Drag the **rollback bar** downwards to a position before the `Axle Hole Cut Out` feature. View the features in the graphics area.



Double-click the `Axle Hole Cut Out` feature in the FeatureManager. The feature is displayed in blue and Sketch4 is displayed.

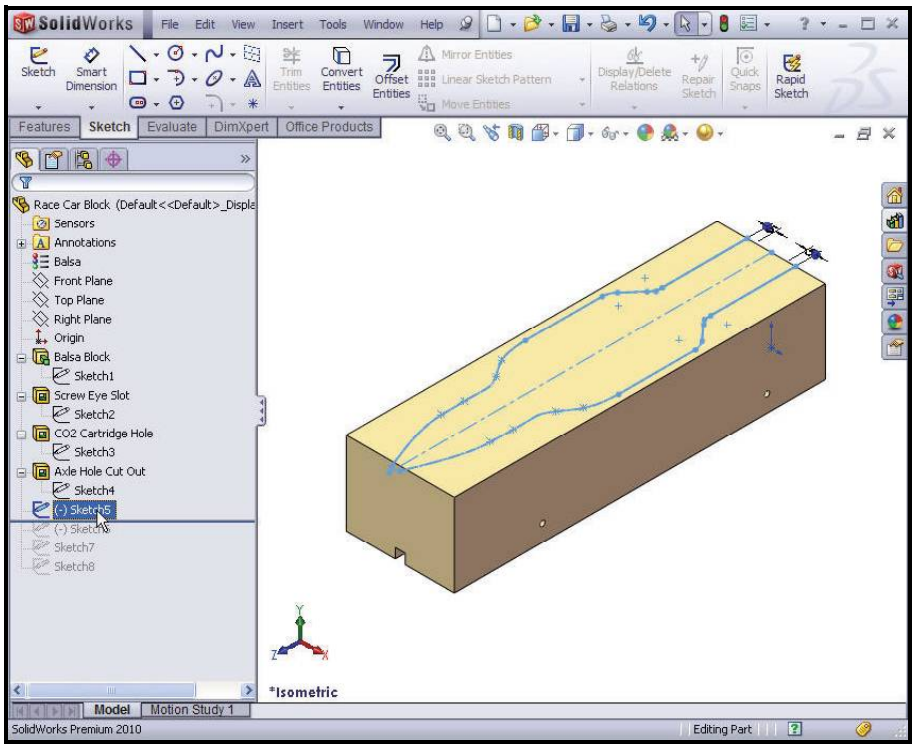
Drag the **rollback bar** downwards to a position before `(-)Sketch5`.

Click `(-)Sketch5` from the FeatureManager. View `(-)Sketch5` in the graphics area.

`(-)Sketch5` is the sketch of a Spline. Splines are used to sketch curves that have continuously changing shape. Splines are defined by a series of points between which the SolidWorks software uses equations to interpolate the curve geometry.

Splines are very useful for modeling free-form shapes, “body of the Race Car” that are smooth.

Note: `(-)Sketch5` is not fully defined, because a spline is free-form and will vary by the designer.

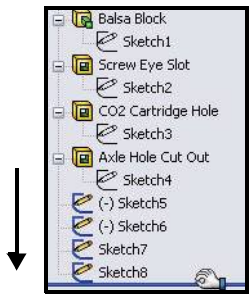


Drag the **rollback bar** downwards to a position below `Sketch8`.

Click `Sketch8` from the FeatureManager.

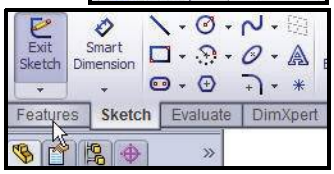
View `Sketch8` in the graphics area.

Click **inside** the graphics area.



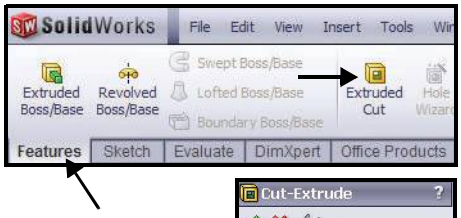
Extruded Cut Feature

An Extruded Cut feature removes material from a part or an assembly. Remove material for the `Race Car Body`.



1 Create the first Extruded Cut Feature.
Right-click `(-)Sketch5` from the FeatureManager.

Click **Edit Sketch** from the Context toolbar. The Sketch toolbar is displayed in the CommandManager.



Click the **Features** tab from the CommandManager. The Features toolbar is displayed.

Click the **Extruded Cut** tool from the Features toolbar. The `Cut-Extrude` PropertyManager is displayed.

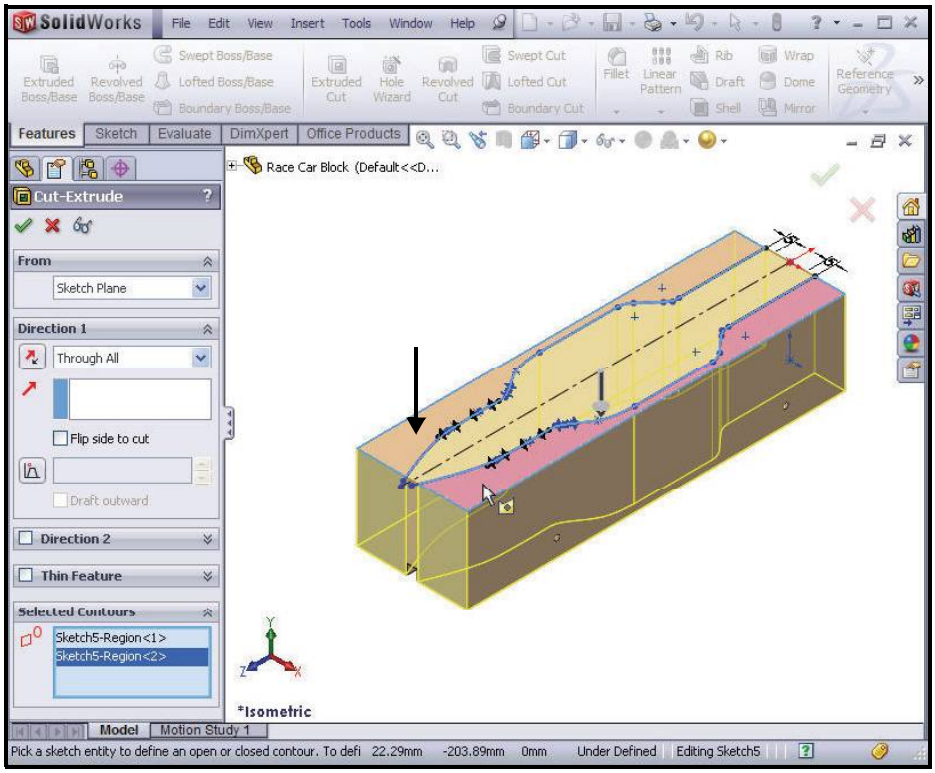
Select **Through All** for the `End Condition` in Direction 1.

Click the **two surfaces** as illustrated in the graphic area. `Sketch5-Region<1>` and `Sketch5-Region<2>` are displayed in the `Selected Contours` dialog box.

Click **OK** from the `Cut-Extrude` PropertyManager.

`Cut-Extrude1` is displayed in the FeatureManager.

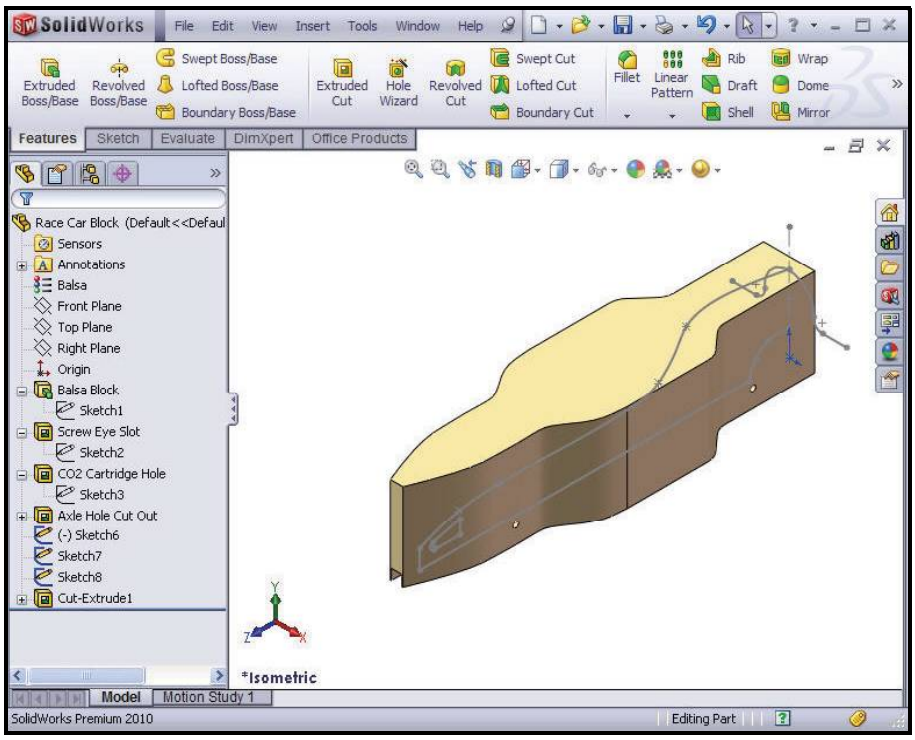
Click **inside** the graphics area. View the results.



Note: **Pin** the Menu bar toolbar and the Menu bar menu to obtain access to both menus in this book.

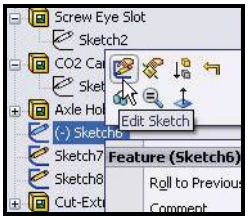
2 Save the model.

Click **Save** from the Menu bar toolbar.



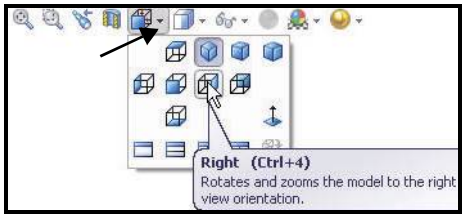
3 Create the second Extruded Cut Feature.

Right-click `(-)Sketch6` from the FeatureManager.



Click **Edit Sketch** from the Context toolbar. The Sketch toolbar is displayed in the CommandManager.

Click **Right** view from the Heads-up View toolbar. The Right view is displayed.



Press the **z** key to Zoom out. Press the **Z** key to Zoom in. Press the **f** key to fit the model to Graphics area.

Click the **Features** tab from the CommandManager. The Features toolbar is displayed.

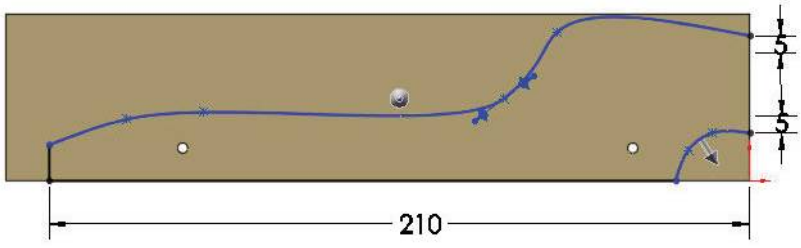
Click the **Extruded Cut** tool. The `Cut-Extrude` PropertyManager is displayed.

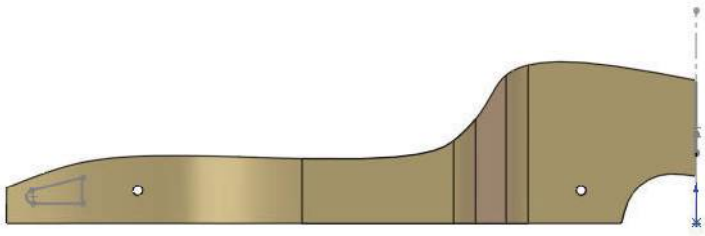
Note: `Through All` is selected for `End Condition` in Direction 1 and Direction 2.

Check the **Flip side to cut** box. View the direction of the extrude.

Click **OK** from the `Cut-Extrude` PropertyManager. `Cut-Extrude2` is displayed.

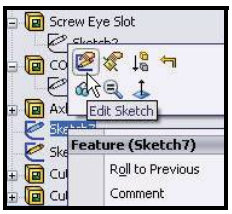
Click **Save** from the Menu bar toolbar.





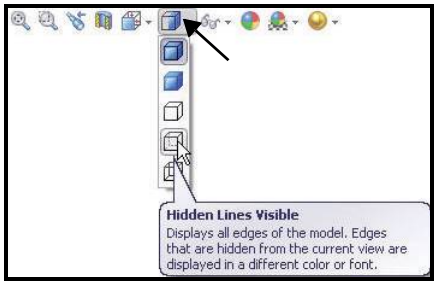
4 Create the third Extruded Cut Feature.
Create the hole for the CO_2 cartridge.

Right-click `Sketch7` from the FeatureManager.



Click **Edit Sketch** from the Context toolbar. The Sketch toolbar is displayed in the CommandManager.

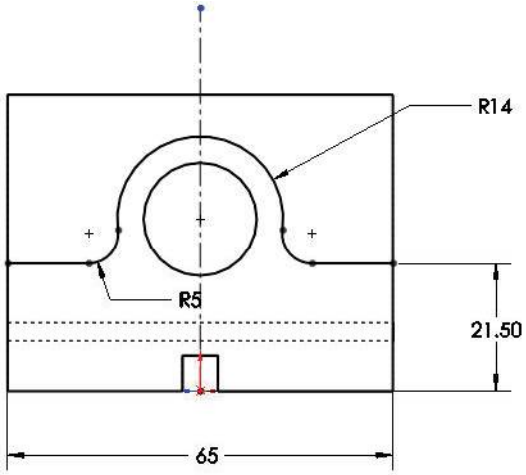
Click **Back** view from the Heads-up View toolbar.



Click **Hidden Lines Visible** from the Heads-up View toolbar.

View the dimensions of the sketch.

Note: `Sketch7` is the sketch for the CO_2 cartridge hole.



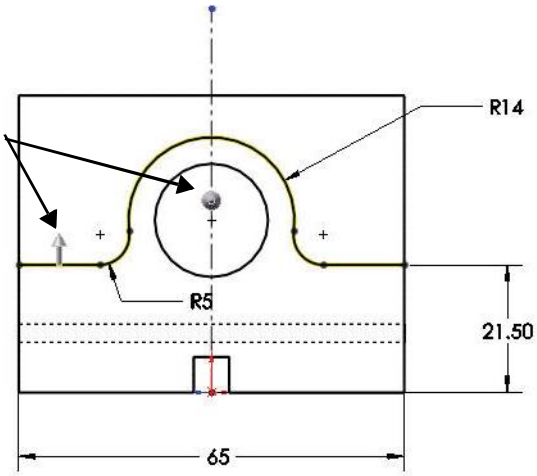
Click the **Features** tab from the CommandManager. The Features toolbar is displayed.

Click the **Extruded Cut** tool. The `Cut-Extrude` PropertyManager is displayed.

Click **Through All** for `End Condition` in Direction 1 and Direction 2.

Check the **Flip side to cut** box.

Note: View the direction of the extrude feature arrows.

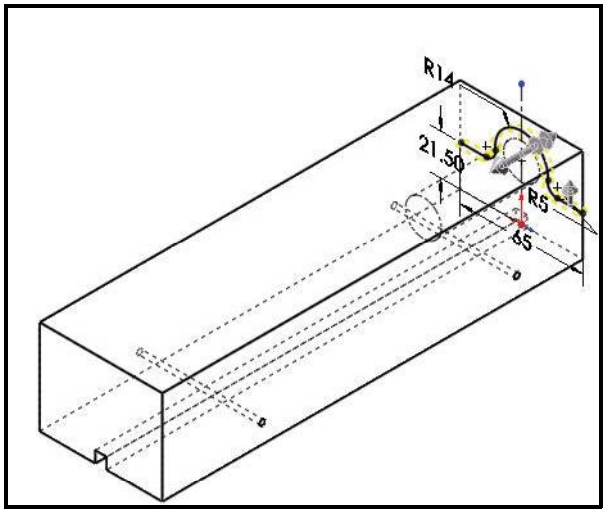


Click **Isometric** view from the Heads-up View toolbar.

Click **OK** from the `Cut-Extrude` PropertyManager. View the Extruded Cut feature. `Cut-Extrude3` is displayed.

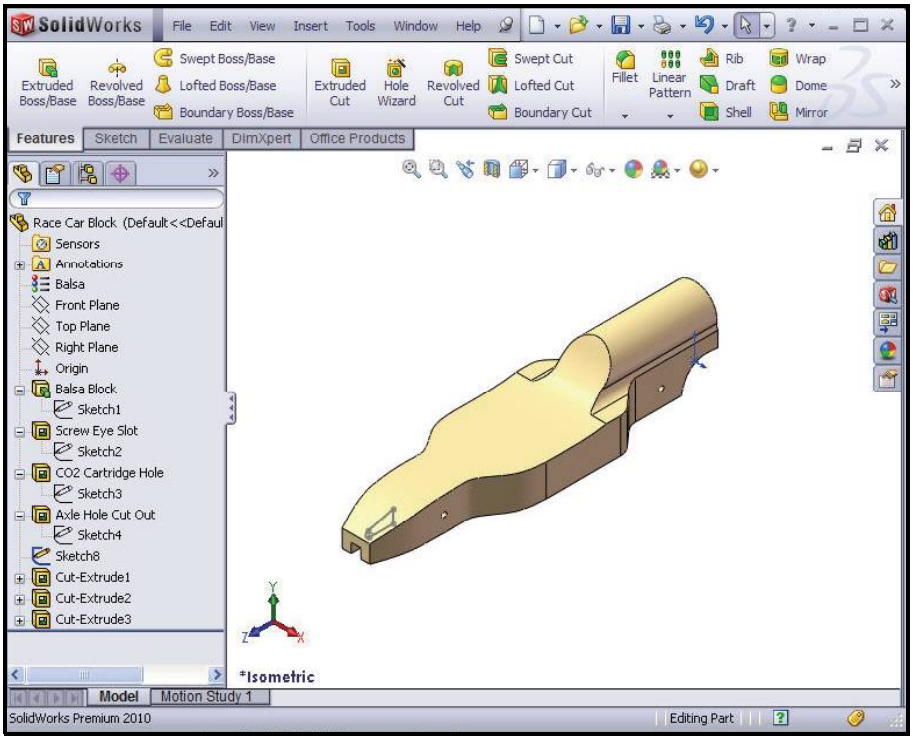
Click **inside** the graphics area.

Click **Shaded With Edges** from the Heads-up View toolbar.

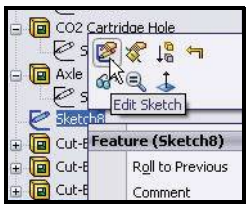


5 Save the model.

Click **Save**.



Create the Front Wing



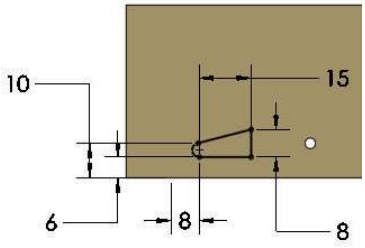
1 Create a MidPlane Extruded Boss Feature.
Right-click `Sketch8` from the FeatureManager. `Sketch8` is the sketch for the front wing of the car.

Click **Edit Sketch** from the Context toolbar. The Sketch toolbar is displayed in the CommandManager.

Click **Right** view from the Heads-up View toolbar.

Click the **z** key to fit the model in the graphics area.

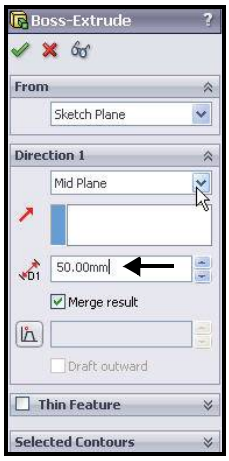
View the sketch dimensions.



2 Create an Extruded Boss Feature.
An Extruded Boss feature adds material to the model.

Click the **Features** tab from the CommandManager. The Features toolbar is displayed.

Click **Extruded Boss/Base** from the Features toolbar. The `Boss-Extrude` PropertyManager is displayed.



Select **Mid Plane** for `End Condition` in Direction 1.

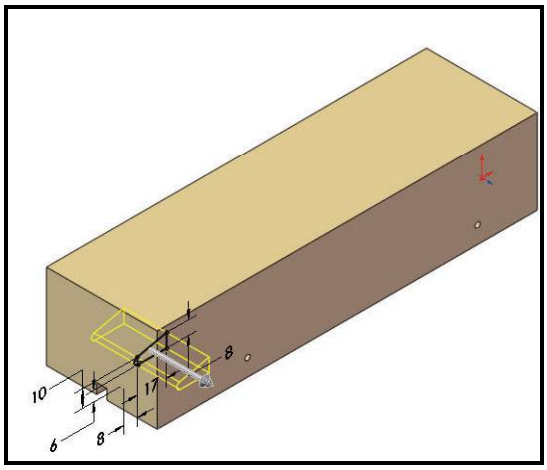
Enter **50.00**mm for `Depth`.

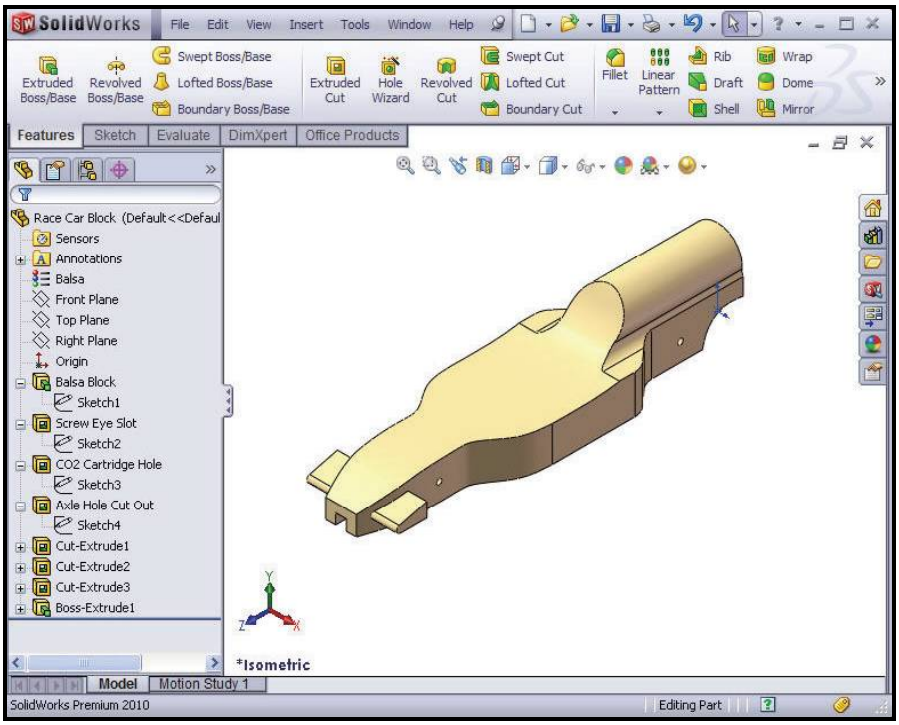
Click **Isometric** view from the Heads-up View toolbar. View the Extruded Boss feature.

Click **OK** from the `Boss-Extrude` PropertyManager. `Boss-Extrude1` is displayed.

Click **inside** the graphics area.

Note: Use your **middle mouse button** to rotate the model in the graphics area. View the created features.





3 Save the model.

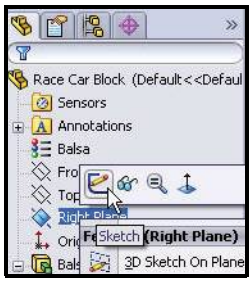
Click **Save** from the Menu bar toolbar.

Create the Rear Wing

1 Create a Sketch.

Click **Hidden Lines Removed** from the Heads-up View toolbar.

Right-click **Right Plane** from the FeatureManager.



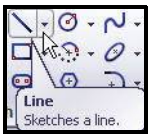
Click **Sketch** from the Context toolbar. The Sketch toolbar is displayed. Right Plane is your Sketch plane.

Click **Right** view from the Heads-up View toolbar.

Press the **z** key to fit the model to the graphics area.

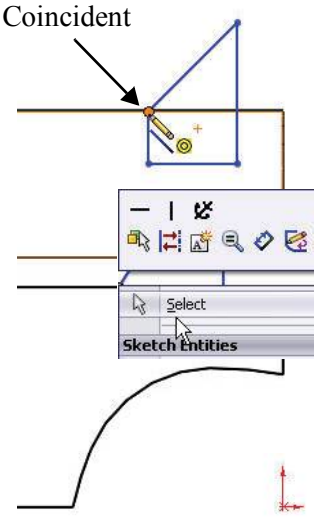
Click the **Zoom to Area** tool from the Heads-up View toolbar.

Zoom in on the back of the car as illustrated.



Click the **Zoom to Area** tool from the Heads-up View toolbar to deactivate.

Click the **Line** tool from the Sketch toolbar. The `Insert Line` PropertyManager is displayed.



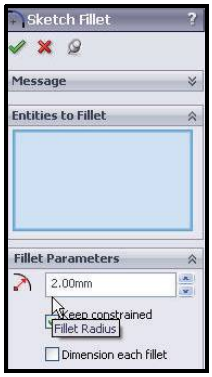
Sketch **four lines** as illustrated. The first point is Coincident with the top horizontal edge of the car.

2 Deselect the Line Sketch tool.

Right-click **Select** in the graphics area.

3 Apply the Sketch Fillet tool.

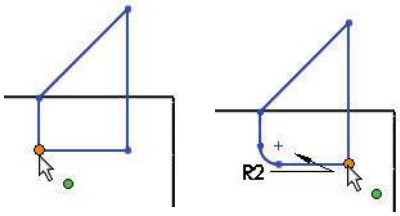
Click the **Sketch Fillet** tool from the Sketch toolbar. The `Sketch Fillet` PropertyManager is displayed.



Enter **2**mm for `Fillet Radius`.

Click the **left endpoint** of the horizontal line.

Click the **right endpoint** of the horizontal line.



Click **OK** from the `Sketch Fillet` PropertyManager.

Click **OK** from the `Sketch Fillet` PropertyManager.

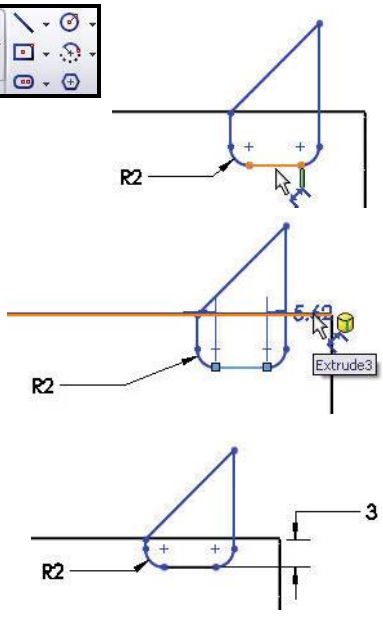
4 Dimension the Rear Wing.

Click the **Smart Dimension** tool from the Sketch toolbar. The Smart Dimension icon is displayed on the mouse pointer.

Click the **two** illustrated edges.

Click a **position** to the right.

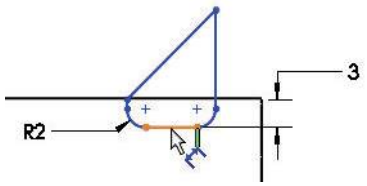
Enter the **3**mm dimension.

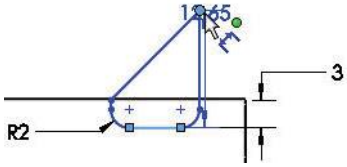


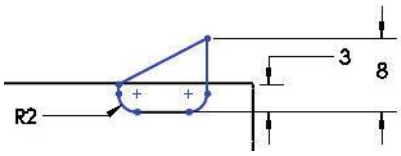
Click the illustrated **edge** and **point**.

Click a **position** to the right.

Enter the **8**mm dimension.



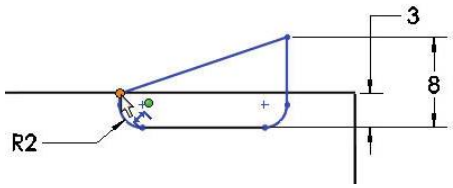


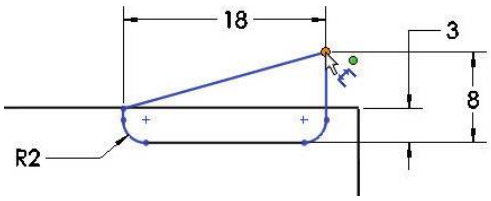


Click the illustrated **two points**.

Click a **position** above the model.

Enter the **18**mm dimension.



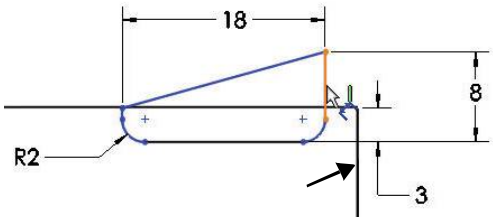


Click the illustrated **two edges**.

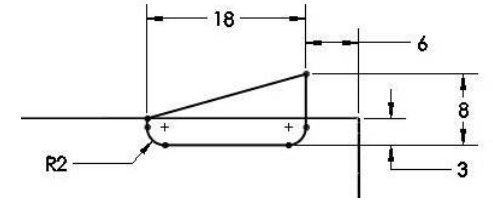
Enter the **6**mm dimension.

Click a **position** above and to the right.

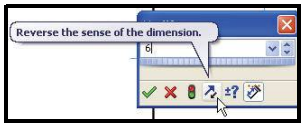
`Sketch9` is fully defined and is displayed in black.



Note: If needed, click the `Reverse the sense of dimension` icon in the Modify dialog box.



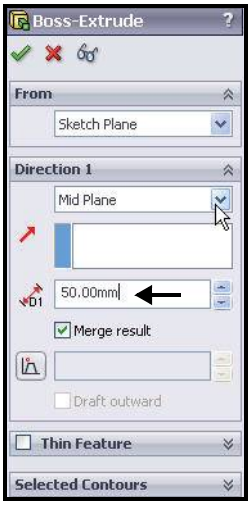
Click **OK** from the Dimension PropertyManager.



5 Create an Extruded Boss Feature.

Click the **Features** tab from the CommandManager. The Features toolbar is displayed.

Click the **Extruded Boss/Base** tool. The `Boss-Extrude` PropertyManager is displayed.



Click **Isometric** view from the Heads-up View toolbar.

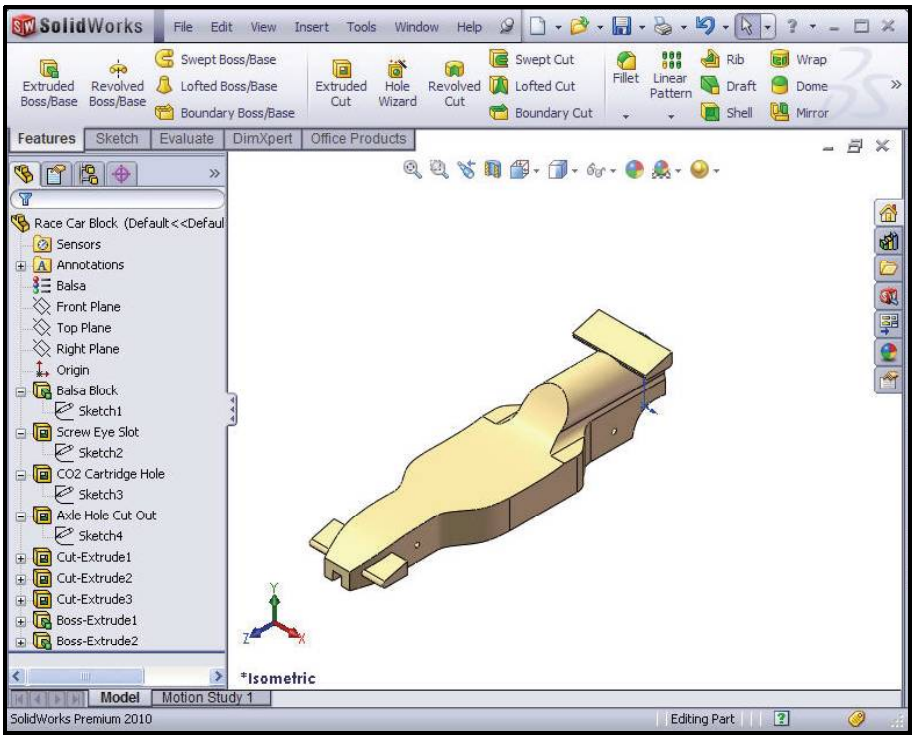
Select **Mid Plane** for the `End Condition` from the drop-down menu.

Enter **50**mm for `Depth`.

Click **OK** from the `Boss-Extrude` PropertyManager. `Boss-Extrude2` is displayed.

Click **Shaded With Edges** from the Heads-up View toolbar.

Click **inside** the graphics area. View the results.

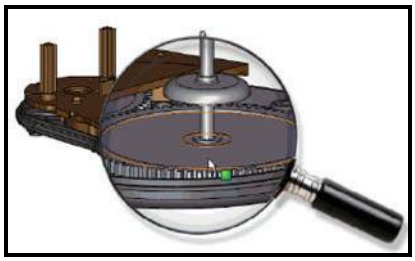


6 Save the model.

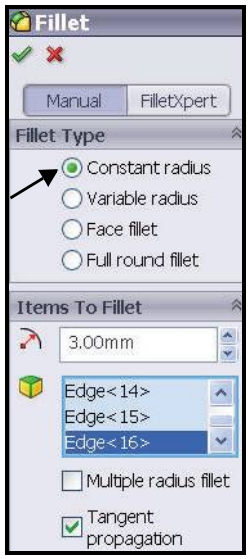
Click **Save** from the Menu bar toolbar.

Note: Press the **s** key to view the previous commands in the graphics area.

Note: Press the **g** key to activate the Magnifying glass tool. Use the Magnifying glass tool to inspect a model and make selections without changing the overall view of the model.



Insert Fillets



1 Insert a Fillet Feature.

Fillets creates a rounded internal or external face on the part. You can fillet all edges of a face, selected sets of faces, selected edges, or edge loops.

Click **Hidden Lines Removed** from the Heads-up View toolbar.

Click the **Fillet** tool from the Features toolbar. The `Fillet` PropertyManager is displayed.

Click the **Manual** tab in the `Fillet` PropertyManager. Click the `Constant radius` Fillet Type box.

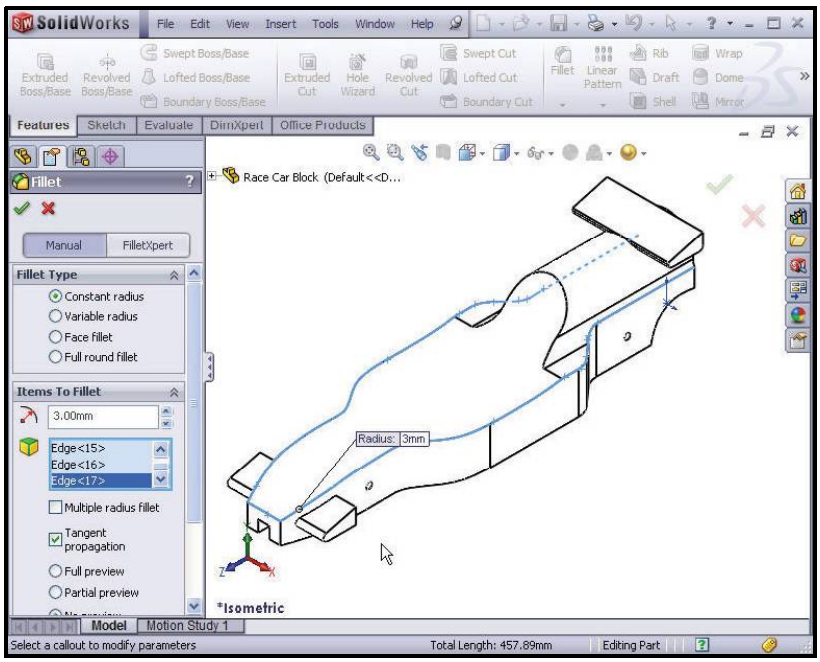
Enter **3**mm for `Radius`.

Click the **8 edges** on the top right of the car. The selected edges are displayed in the `Items To Fillet` box.

Rotate the car with the middle mouse button to view the left side of the car.

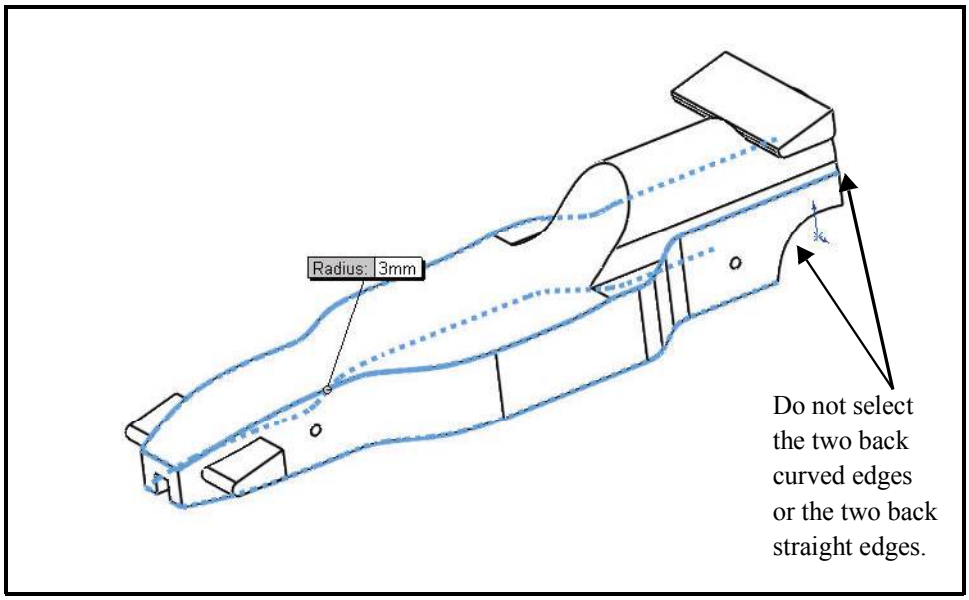
Click the **8 edges** on the top left of the car.

Click the **top front edge** of the car. The selected edges are displayed in the `Items To Fillet` box.



Rotate the car to view the bottom with the middle mouse button.

Click the **bottom edges** of the car. Do not select the two back curved edges or the two back straight edges as illustrated. The selected edges are displayed in the `Items To Fillet` box.



Click **OK** from the `Fillet` PropertyManager. View the `Fillet1` feature in the FeatureManager.

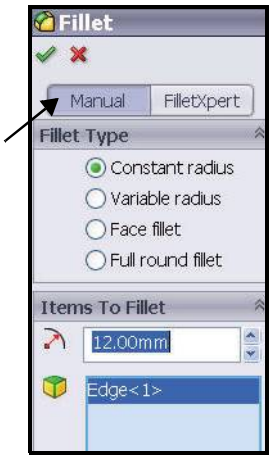
Click **Isometric** view from the Heads-up View toolbar.

2 Insert a second Fillet Feature. Fillet the Cockpit Area.

Click the **Fillet** tool from the Features toolbar. The `Fillet` PropertyManager is displayed.

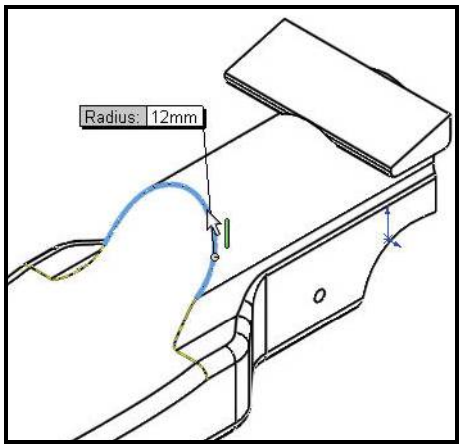
Click the **Manual** tab in the `Fillet` PropertyManager. `Constant radius` Fillet type is selected by default.

Enter **12**mm for `Radius`.



Click the illustrated **back edge**. Edge1 is displayed in the `Items To Fillet` box.

Click **OK** from the `Fillet` PropertyManager. View the `Fillet2` feature in the FeatureManager.



3 Save the model.

Click **Save** from the Menu bar toolbar.

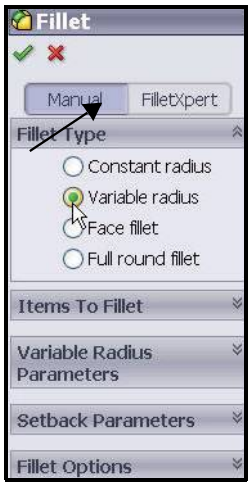
4 Create a Variable Fillet.

Rotate the model using the middle mouse button to view the back curved edges with the middle mouse button.

Click the **Fillet** tool from the Features toolbar. The `Fillet` PropertyManager is displayed.

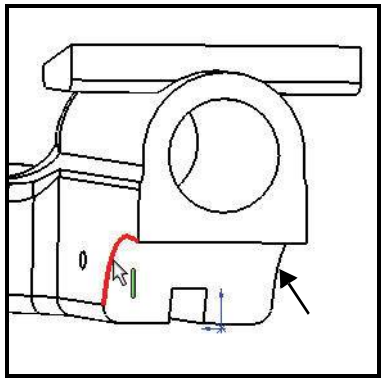
Click the **Manual** tab in the `Fillet` PropertyManager. `Constant radius` Fillet Type is selected by default.

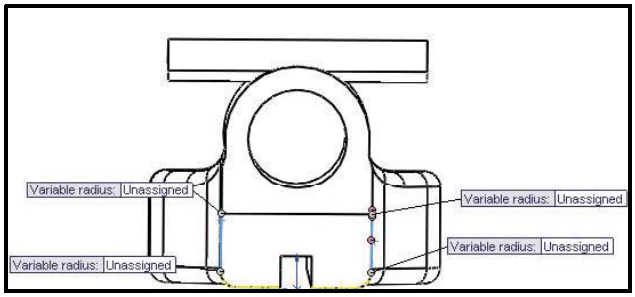
Check the **Variable radius** box for `Fillet Type`.



Click the **two curved edges**.

Click and drag the **Variable radius** boxes off the model.





Click **inside** the top left `Unassigned` box.

Enter **15**mm.

Click **inside** the top right `Unassigned` box.

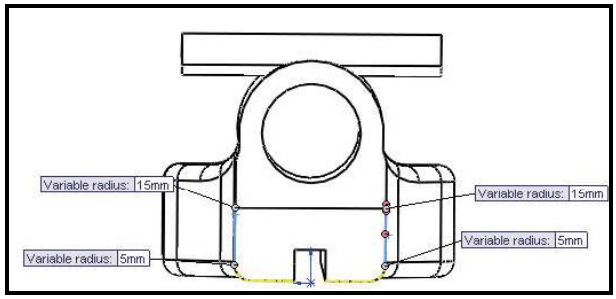
Enter **15**mm.

Click **inside** the bottom left `Unassigned` box.

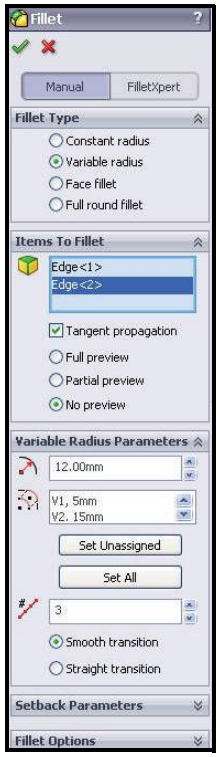
Enter **5**mm.

Click **inside** the bottom right `Unassigned` box.

Enter **5**mm.



Click **OK** from the `Fillet` PropertyManager. View the `VarFillet1` feature in the FeatureManager.



Click **Isometric** view from the Heads-up View toolbar.

Click **Shaded** from the Heads-up View toolbar.

5 Save the model.

Click **Save** from the Menu bar toolbar.

View the model.