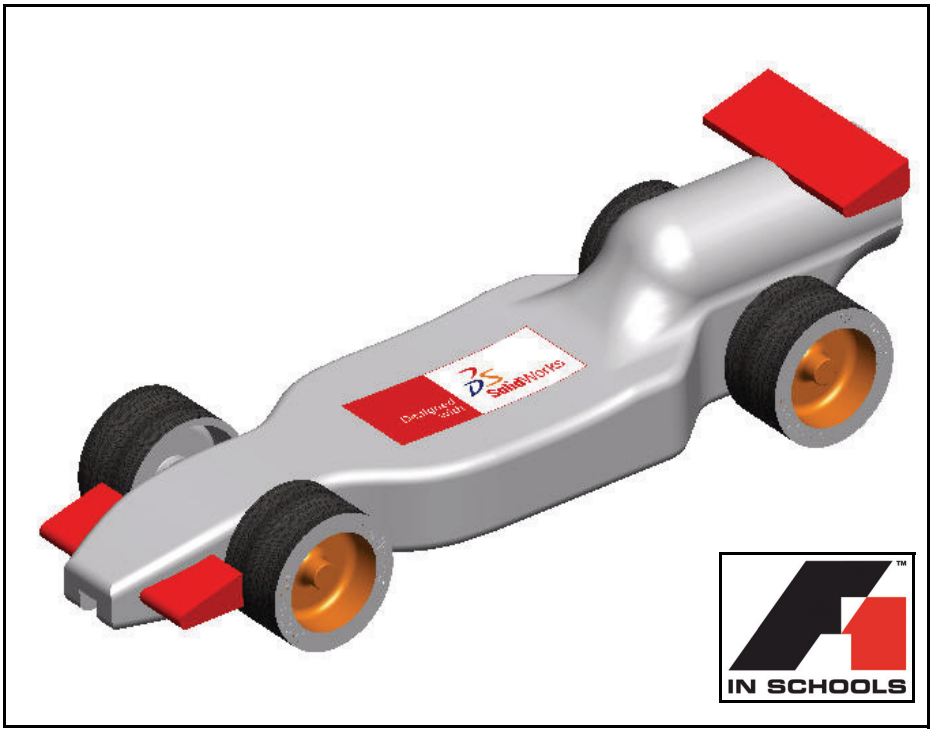
Engineering Design
and Technology Series

F1 in Schools™ Design Project with SolidWorks® 2011 Software



For Type-R Cars

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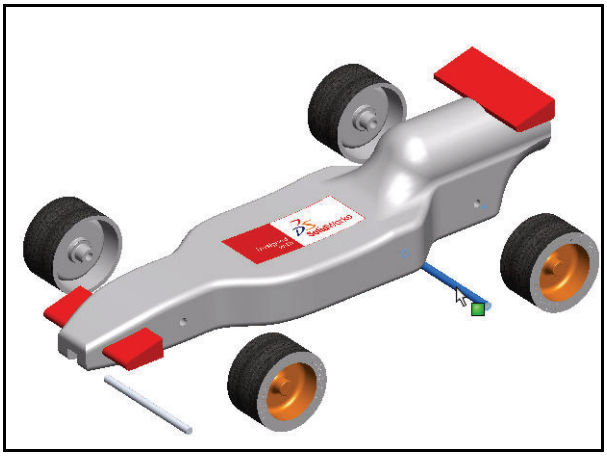
Lesson 2
Designing the Race Car

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.

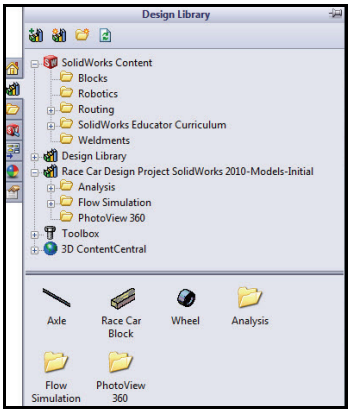
Start SolidWorks and open an existing part

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.



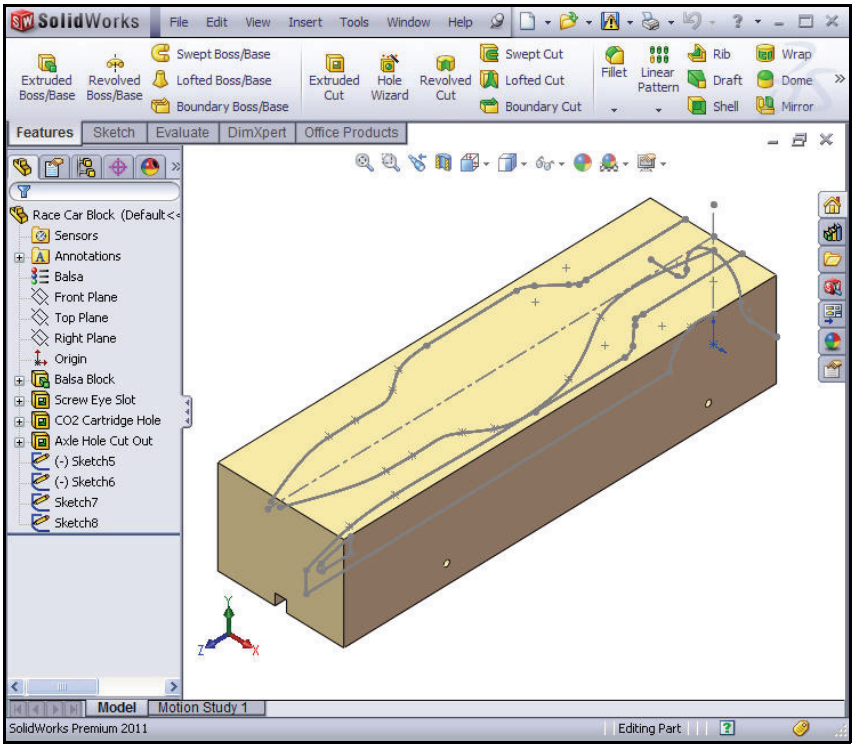
The contents of the folder is displayed in the lower portion of the Design Library window.

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.

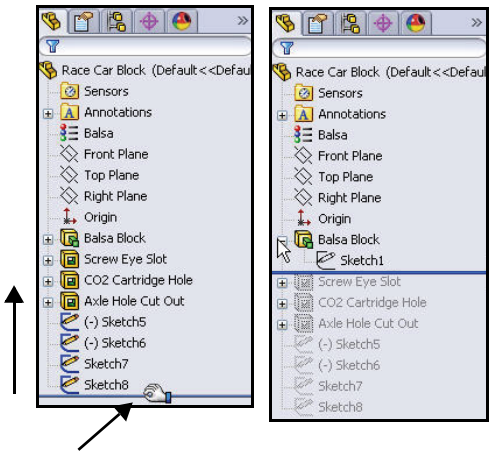
The FeatureManager design tree located on the left side of the SolidWorks window provides an outline view of the active model. This makes it easy to see how the model was constructed.

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.

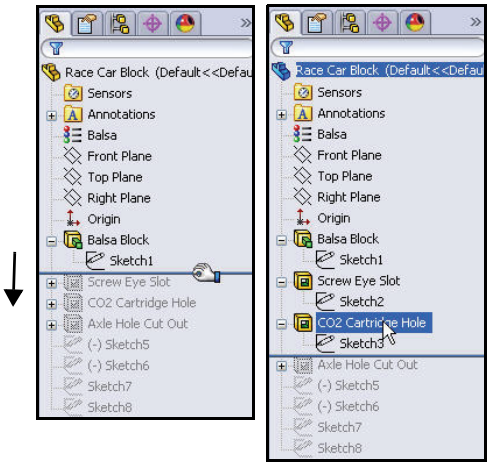


The `Balsa Block` feature is displayed.

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.



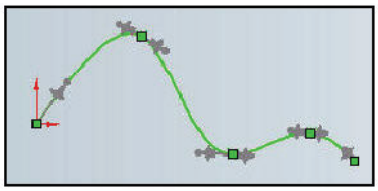
View the features in the graphics area.

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.

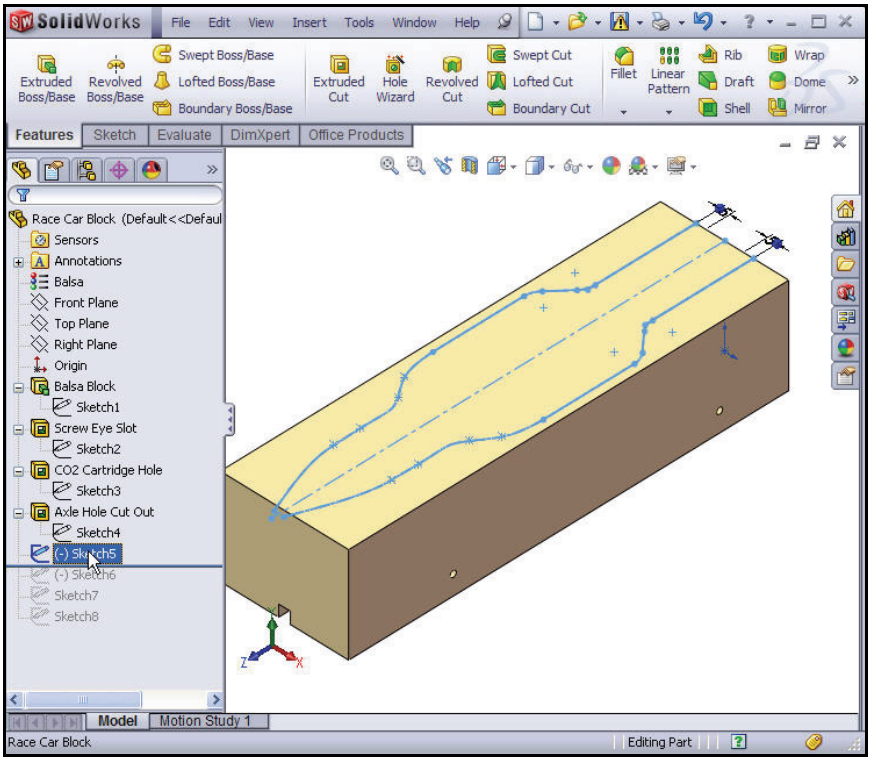
Drag the **rollback bar** downwards to a position before `(-) Sketch5`.

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

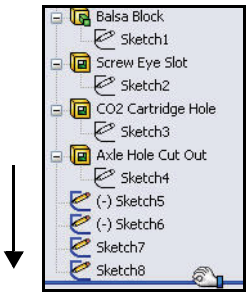
`(-) Sketch5` is the sketch of a Spline. Splines are used to sketch curves that have continuously changing shape. Splines are defined by a series of points between which the SolidWorks software uses equations to interpolate the curve geometry.

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`.



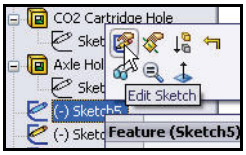
Click `Sketch8` from the FeatureManager.

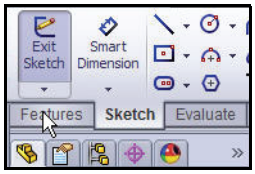
View `Sketch8` in the graphics area.

Click **inside** the graphics area.

Extruded Cut Feature

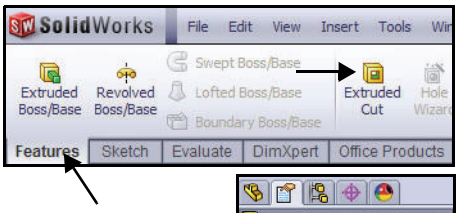
An Extruded Cut feature removes material from a part or an assembly. Remove material for the `Race Car Body`.





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.

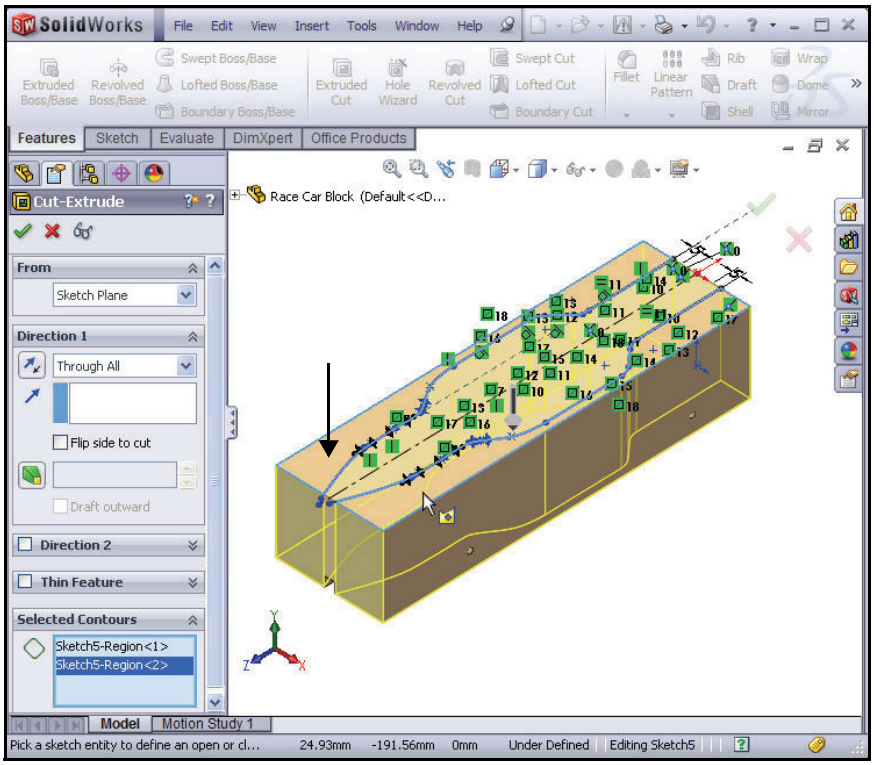
Select **Through All** for the `End Condition` in Direction 1.

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.

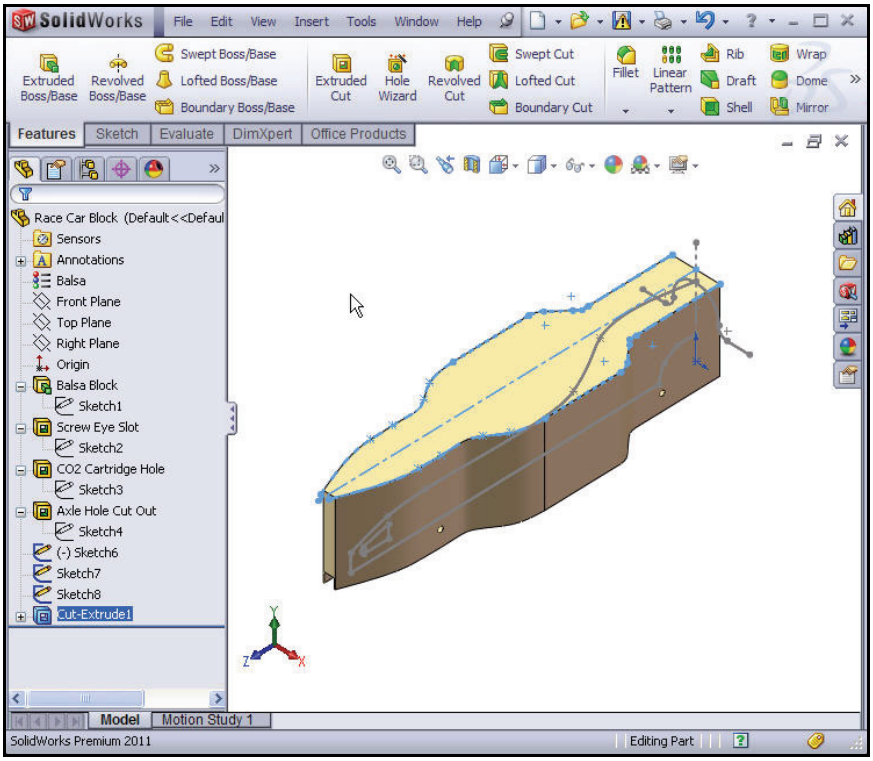
Click **inside** the graphics area. View the results.



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

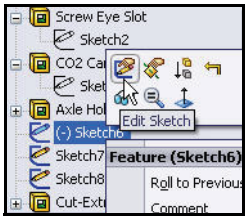
2 Save the model.

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



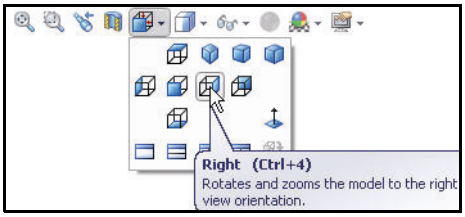
3 Create the second Extruded Cut Feature.

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



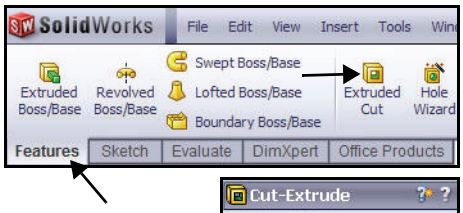
Click **Edit Sketch** from the Context toolbar. The Sketch toolbar is displayed in the CommandManager.

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

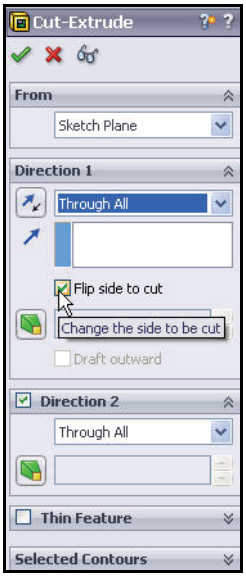


Press the **z** key to Zoom out. Press the **Z** key to Zoom in. Press the **f** key to fit the model to Graphics area.

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



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

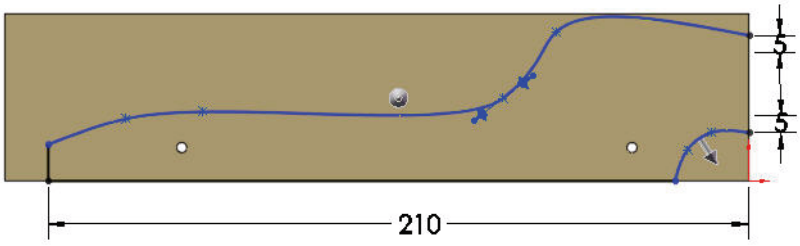


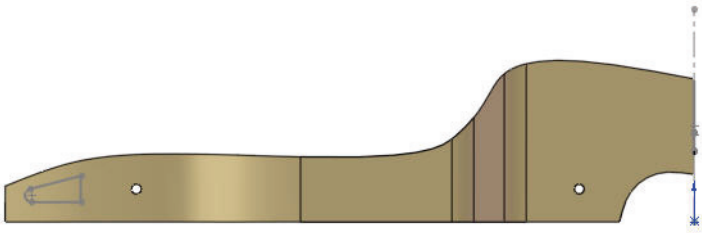
Note: `Through All` is selected for `End Condition` in Direction 1 and Direction 2.

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

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

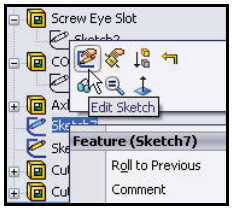
Click **Save** from the Menu bar toolbar.





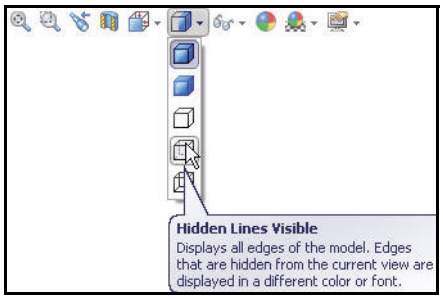
4 Create the third Extruded Cut Feature.
Create the hole for the CO_2 cartridge.

Right-click `Sketch7` from the FeatureManager.



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

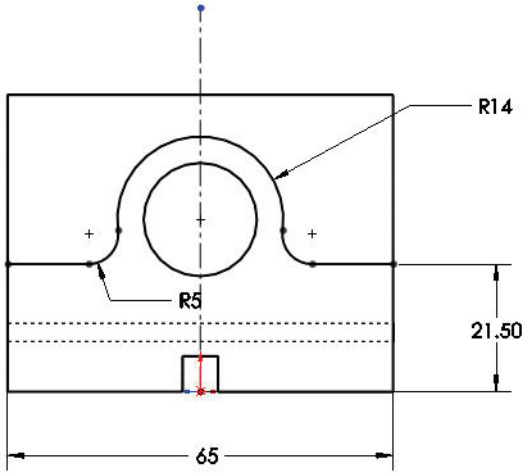
Click **Back** view from the Heads-up View toolbar.



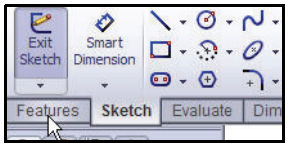
Click **Hidden Lines Visible** from the Heads-up View toolbar.

View the dimensions of the sketch.

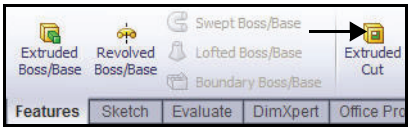
Note: `Sketch7` is the sketch for the CO_2 cartridge hole.



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

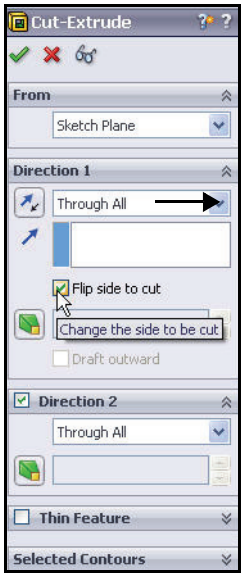


Click the **Extruded Cut** tool. The `Cut-Extrude` PropertyManager is displayed.

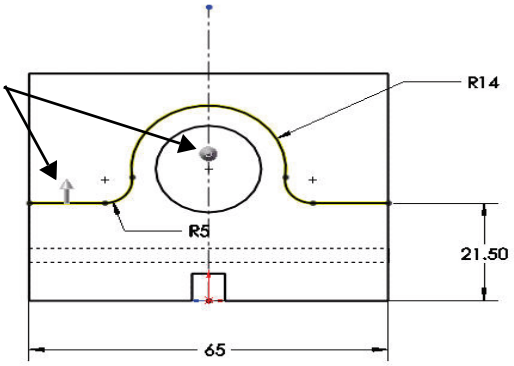


Click **Through All** for `End Condition` in Direction 1 and Direction 2.

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



Note: View the direction of the extrude feature arrows.

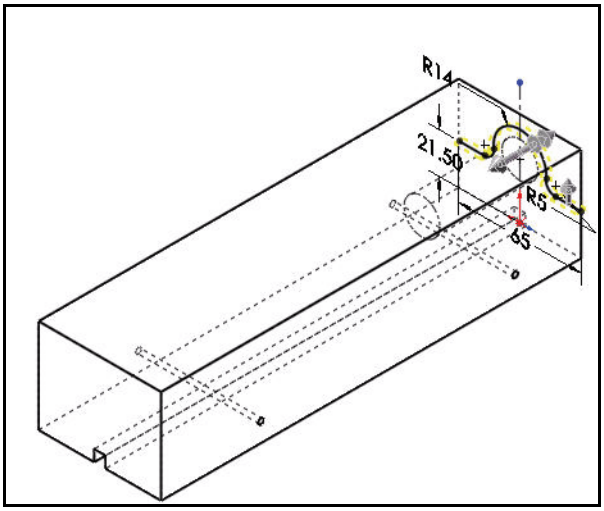


Click **Isometric** view from the Heads-up View toolbar.

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

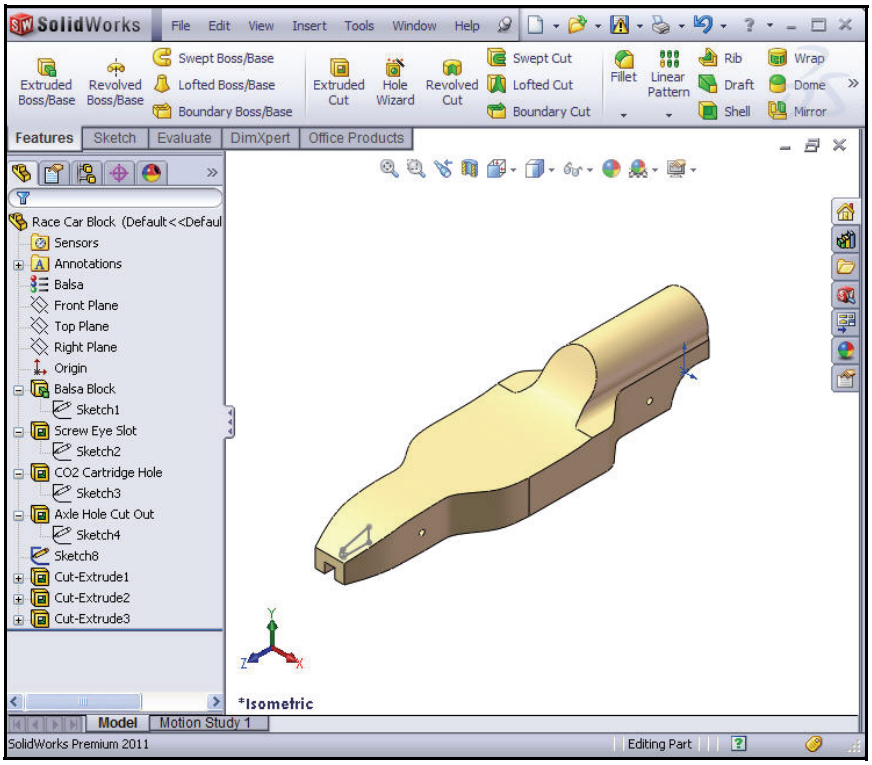
Click **inside** the graphics area.

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



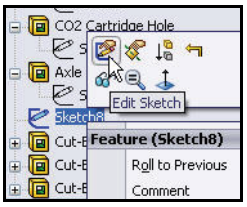
5 Save the model.

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.

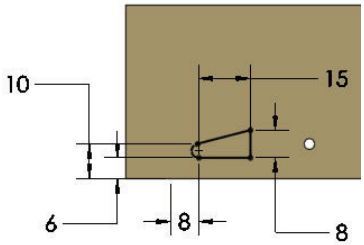


Click **Edit Sketch** from the Context toolbar. The Sketch toolbar is displayed in the CommandManager.

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

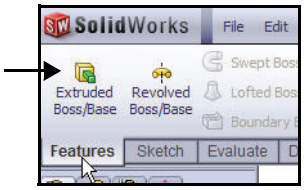
Click the **z** key to fit the model in the graphics area.

View the sketch dimensions.

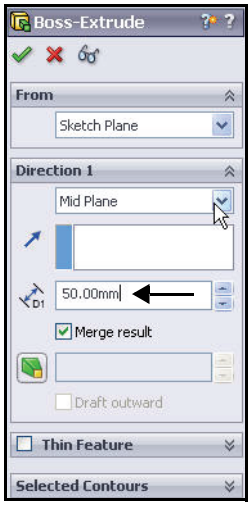


2 Create an Extruded Boss Feature.
An Extruded Boss feature adds material to the model.

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



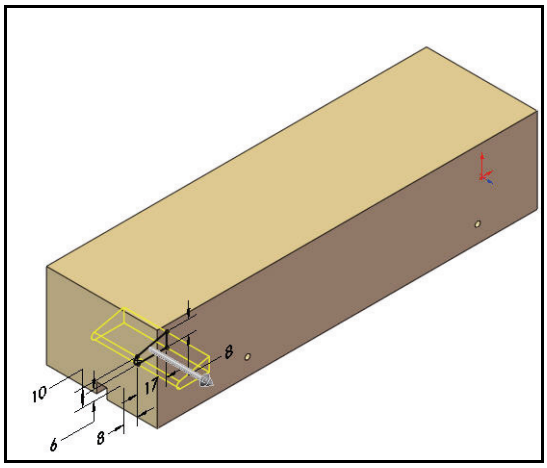
Click **Extruded Boss/Base** from the Features toolbar. The `Boss-Extrude` PropertyManager is displayed.



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

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

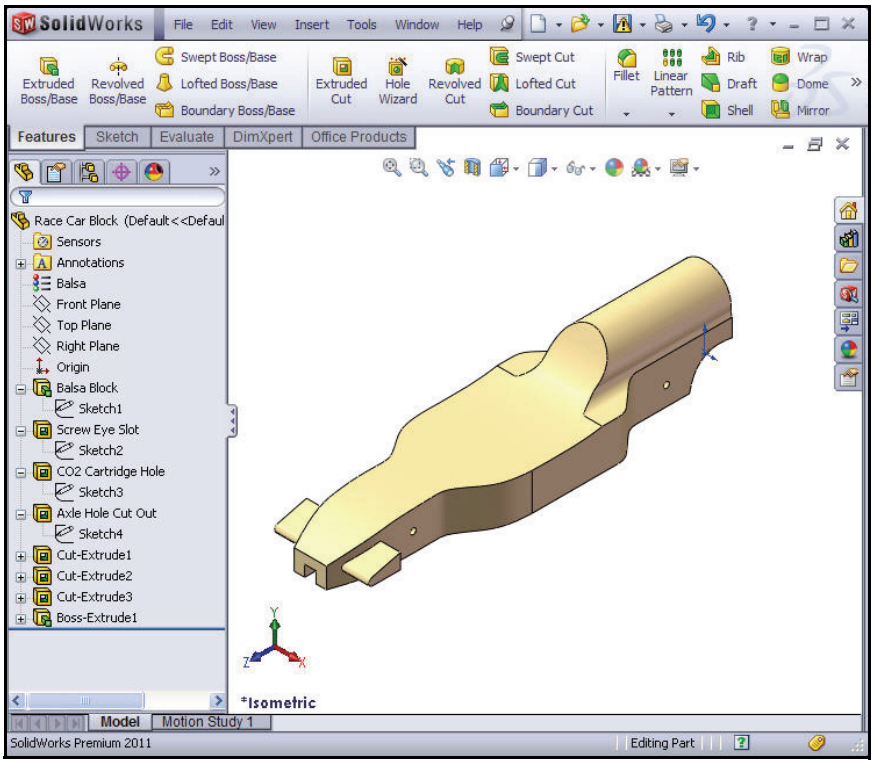
Click **Isometric** view from the Heads-up View toolbar. View the Extruded Boss feature.



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

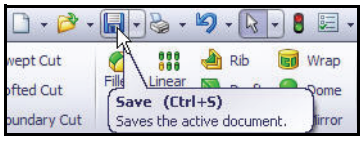
Click **inside** the graphics area.

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.

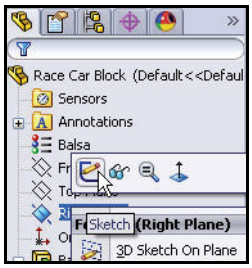


Create the Rear Wing

1 Create a Sketch.

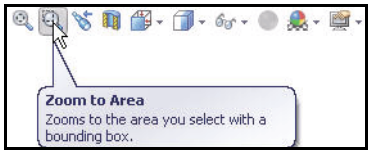
Click **Hidden Lines Removed** from the Heads-up View toolbar.

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



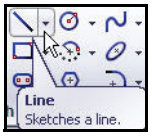
Click **Sketch** from the Context toolbar. The Sketch toolbar is displayed. Right Plane is your Sketch plane.

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.

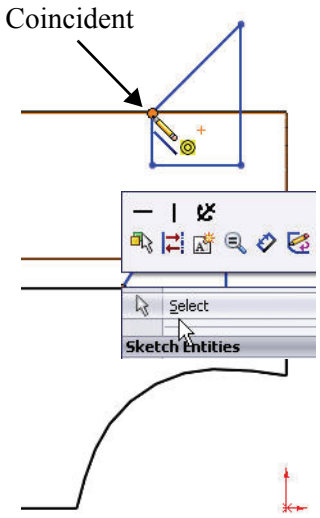


Zoom in on the back of the car as illustrated.

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.

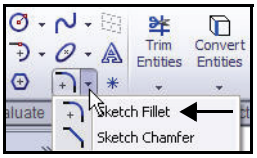
Sketch **four lines** as illustrated. The first point is Coincident with the top horizontal edge of the car.

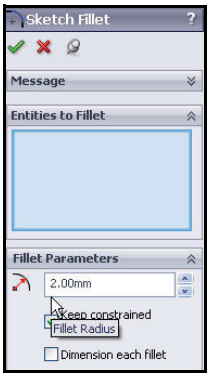


2 **Deselect the Line Sketch tool.**
Right-click **Select** in the graphics area.

3 Apply the Sketch Fillet tool.

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

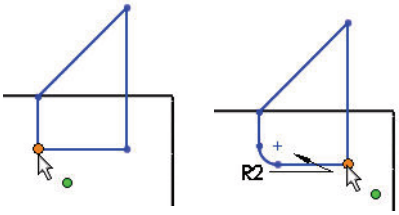




Enter **2**mm for `Fillet Radius`.

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.

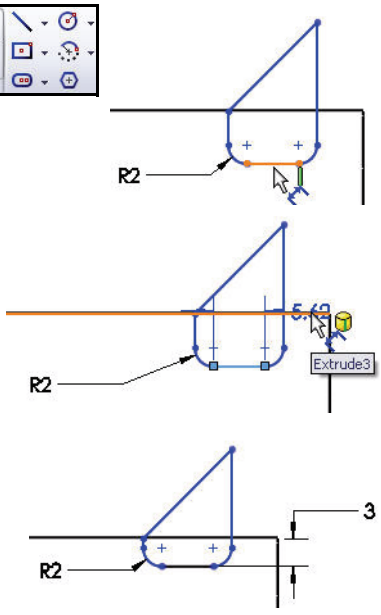
4 Dimension the Rear Wing.

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.

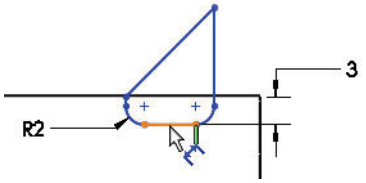
Enter the **3**mm dimension.

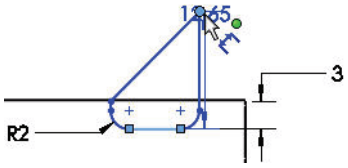


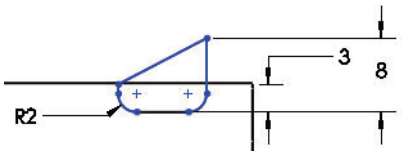
Click the illustrated **edge** and **point**.

Click a **position** to the right.

Enter the **8**mm dimension.



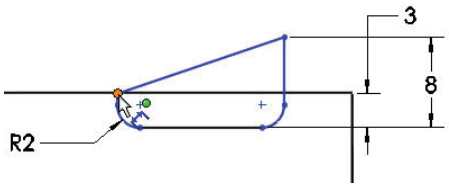


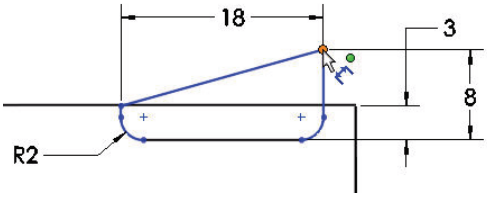


Click the illustrated **two points**.

Click a **position** above the model.

Enter the **18**mm dimension.



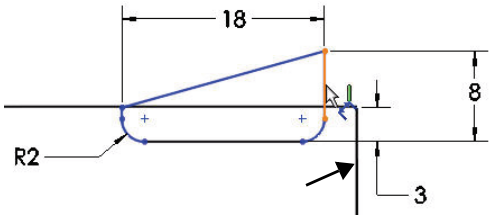


Click the illustrated **two edges**.

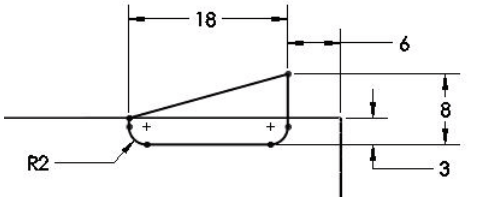
Enter the **6**mm dimension.

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

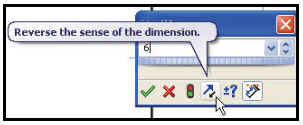
`Sketch9` is fully defined and is displayed in black.

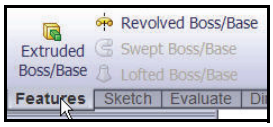


Note: If needed, click the `Reverse the sense of dimension` icon in the Modify dialog box.



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.

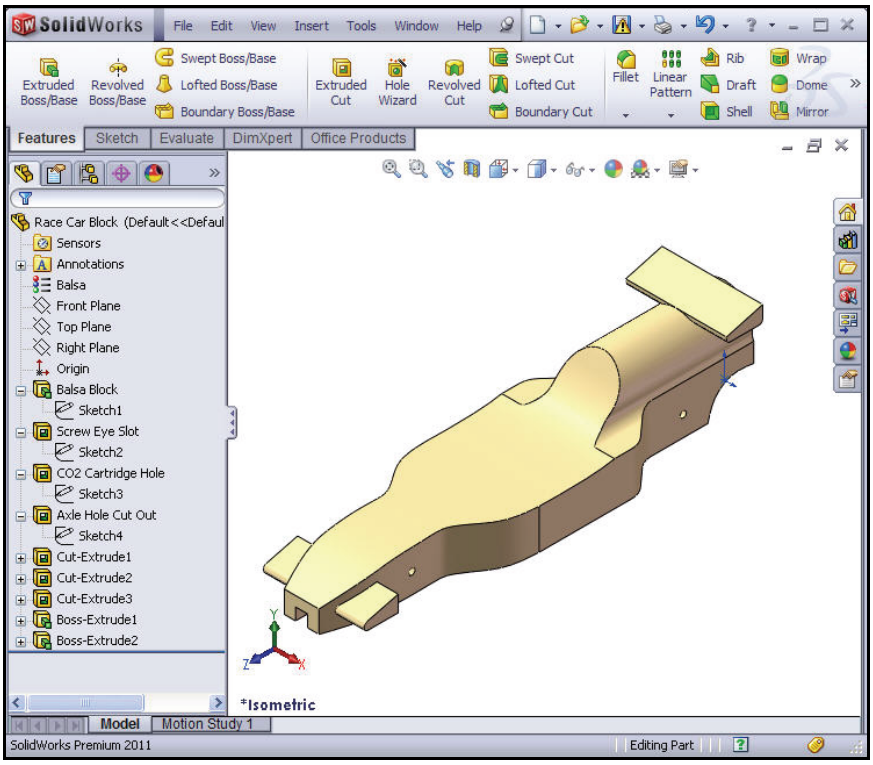
Select **Mid Plane** for the `End Condition` from the drop-down menu.

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.

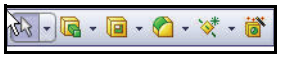
Click **inside** the graphics area. View the results.



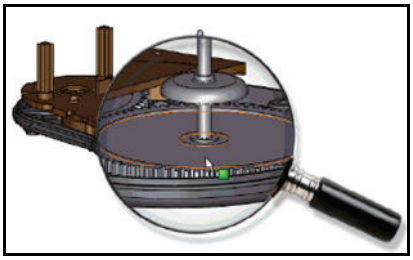
6 Save the model.

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

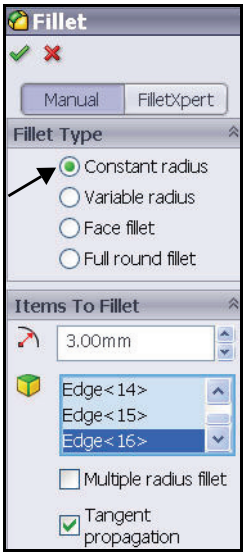
Note: Press the **s** key to view the previous commands in the graphics area.



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.

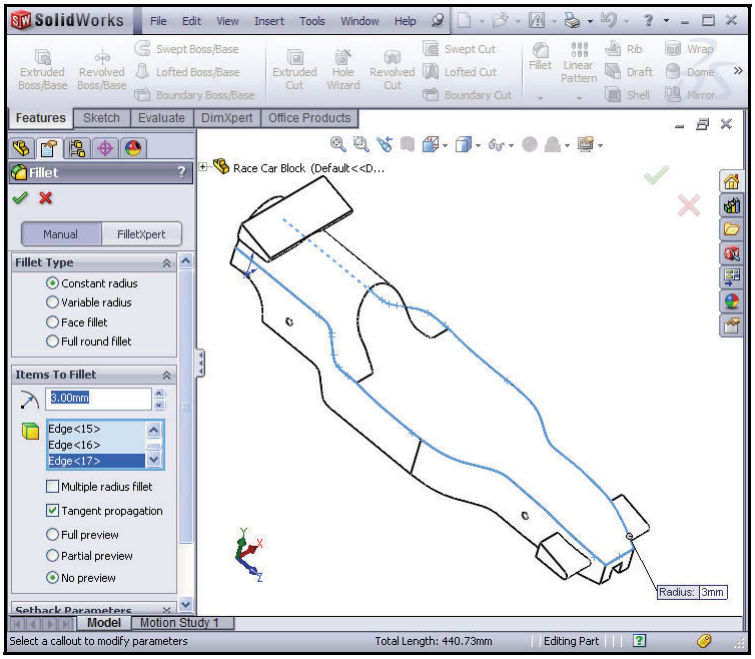
Enter **3**mm for `Radius`.

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.

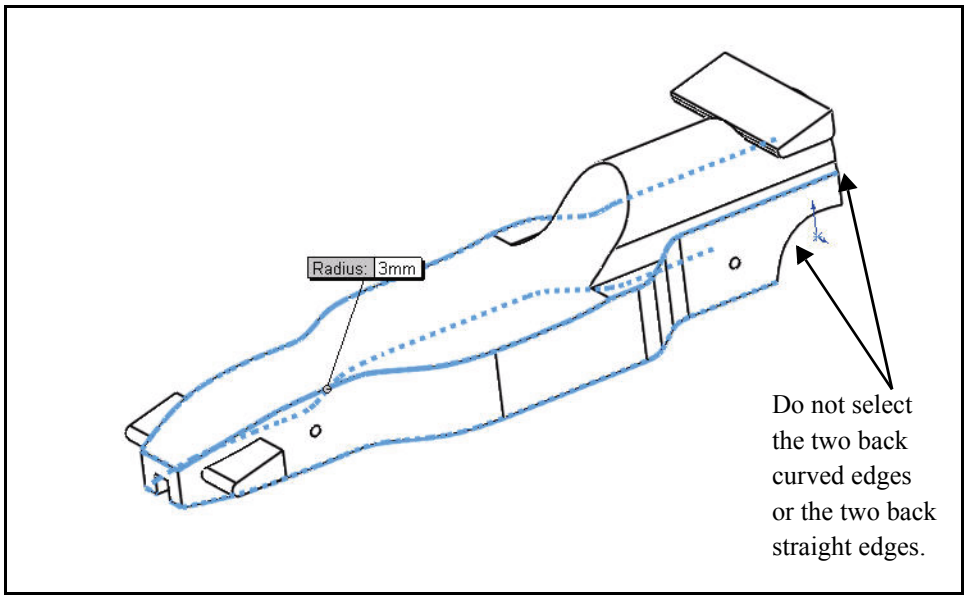
Click the **8 edges** on the top left of the car.

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.

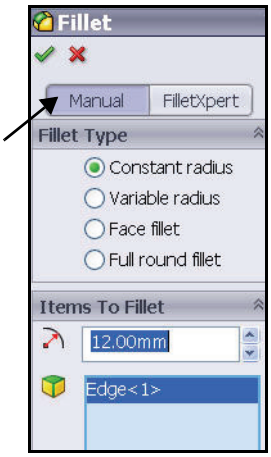
Click **Isometric** view from the Heads-up View toolbar.

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

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

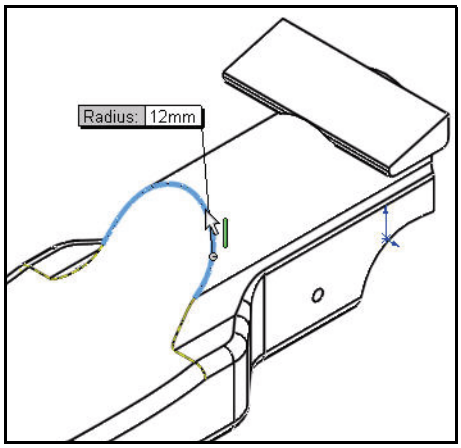
Click the **Manual** tab in the `Fillet` PropertyManager. `Constant radius` Fillet type is selected by default.

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.

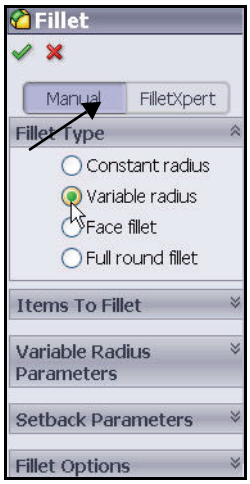
4 Create a Variable Fillet.

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.

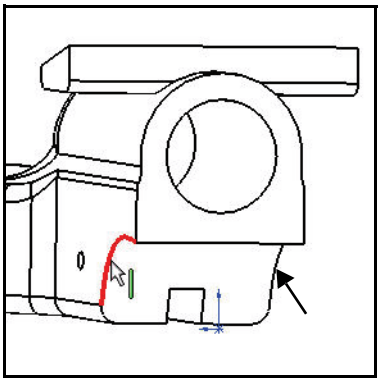
Click the **Manual** tab in the `Fillet` PropertyManager. `Constant radius` Fillet Type is selected by default.

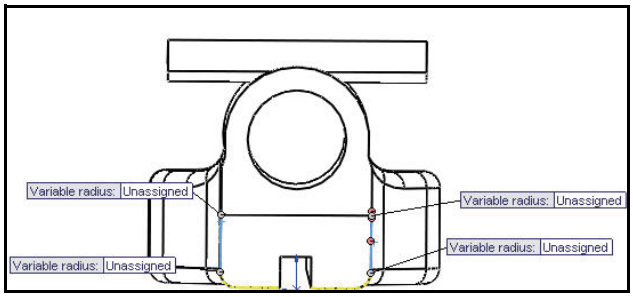
Check the **Variable radius** box for `Fillet Type`.



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.

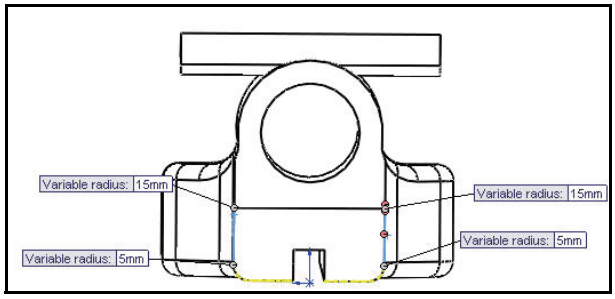
Enter **15**mm.

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

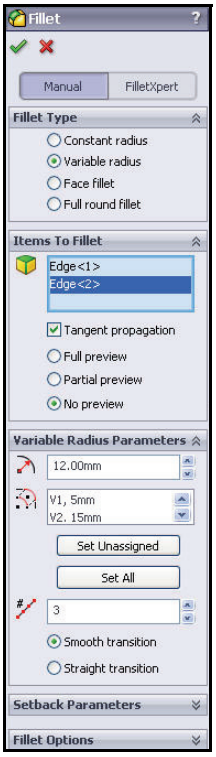
Enter **5**mm.

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

Enter **5**mm.



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



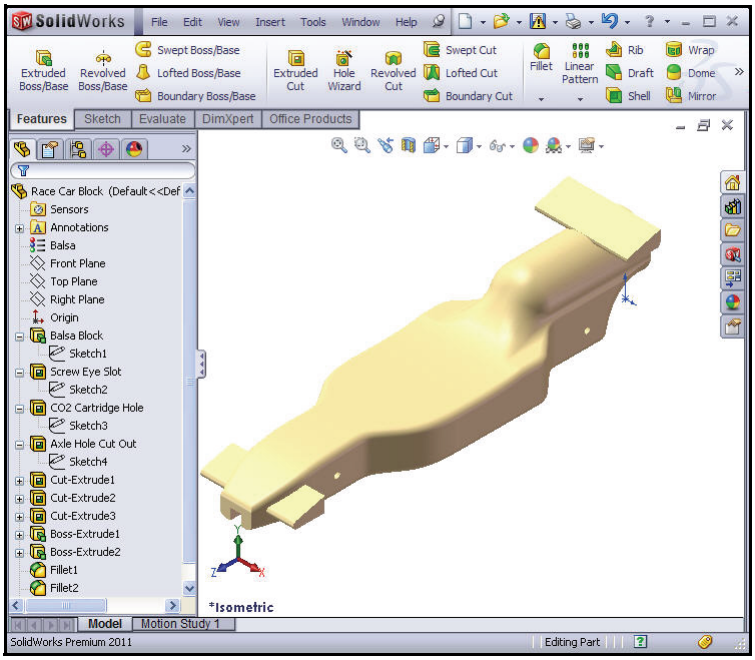
Click **Isometric** view from the Heads-up View toolbar.

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

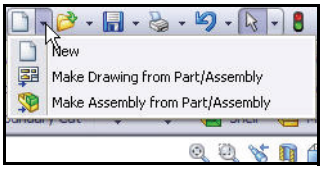
5 Save the model.

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

View the model.



Create an Assembly

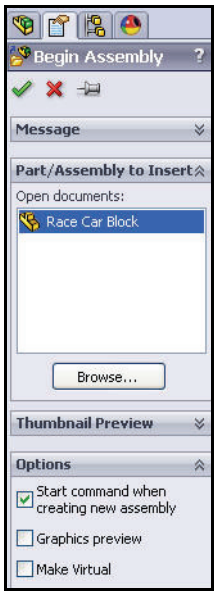


Create an assembly with the `Race Car Block`. Insert the Wheels and Axles.

1 Create an assembly.
Click the **Make Assembly from Part/Assembly** tool from the Menu bar toolbar.

Click **OK** to accept the default Assembly template. The `Begin Assembly` PropertyManager is displayed.

The `Race Car Block` part file is listed in the `Open documents` box.

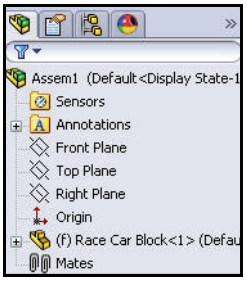


2 Locate the Component.

Click **OK** from the `Begin Assembly` PropertyManager. The `(f) Race Car Block` is displayed in the assembly FeatureManager design tree as fixed.

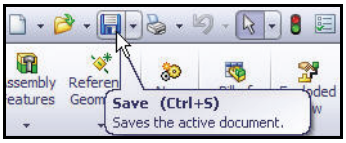
3 Deactivate the Planes.
If needed, click **View**, un-check **Planes** from the Menu bar menu.

Note: The initial component added to the assembly is fixed by default. A fixed component cannot be moved unless you float it.



4 Set Isometric view with Hidden Lines Removed.
Click **Isometric** from the Heads-up View toolbar.

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



5 Save the assembly.

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

Save the assembly under the name `Race Car` in the downloaded folder.

Note: If needed, click **View**, un-check **All Annotations.**

6 Insert the Axles.

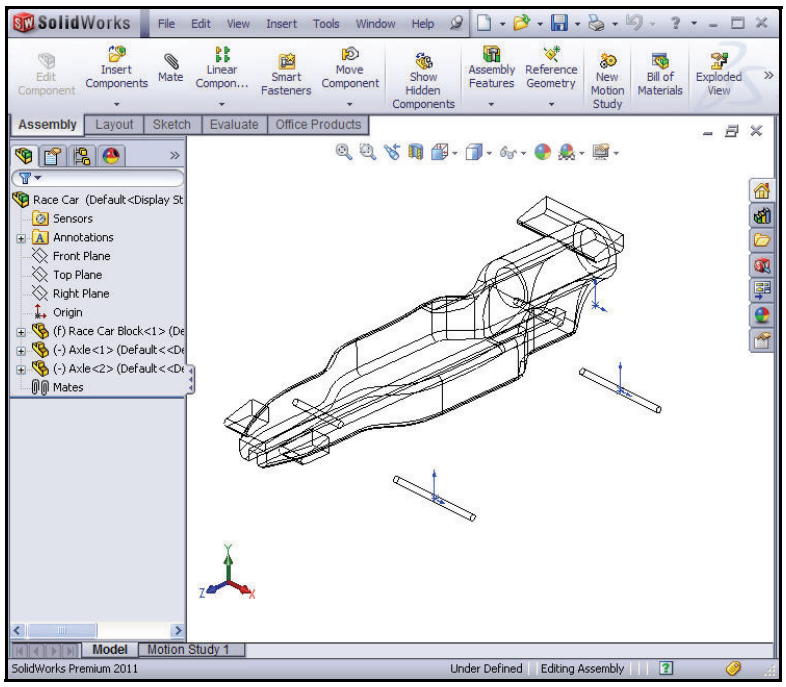
Click and drag the **Axle** part from the Design Library window.

Click a **position** near the rear of the car. The Insert Components PropertyManager is displayed. A second Axle is displayed on the mouse pointer.

Drag the **second Axle** to the front of the car. Click a **position**.

Click **Cancel** from the `Insert Component` PropertyManager. View the FeatureManager.

`Axle <1>` and `Axle <2>` are displayed.



7 Insert the first Wheel.

Click and drag the **Wheel** part from the Design Library window.

Click a **position** near the right rear of the car. The Insert Components PropertyManager is displayed. A second Wheel is displayed on the mouse pointer.

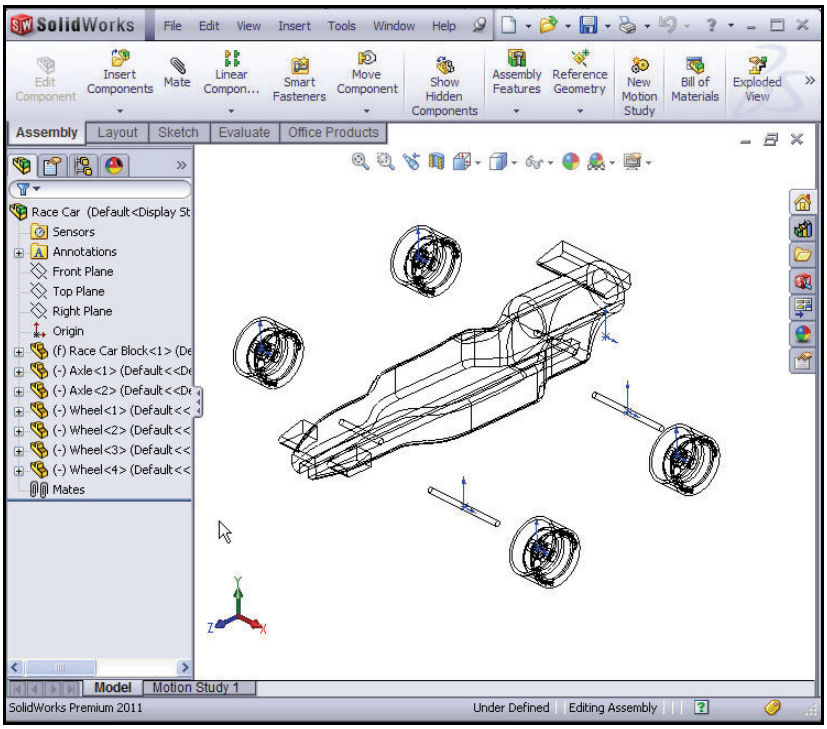
8 Insert the other three Wheels.

Insert the **second Wheel** near the right front of the car; `Wheel<2>`.

Insert the **third Wheel** near the left rear of the car; `Wheel<3>`.

Insert the **fourth Wheel** near the left front of the car; `Wheel<4>`.

Click **Cancel** from the `Insert Component` PropertyManager. View the updated FeatureManager.



9 Deactivate the Origins.

Click **View**, un-check **Origins** from the Menu bar menu.

10 Save the model.

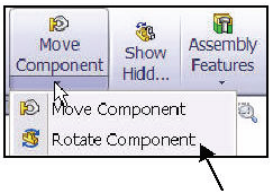
Click **Save** from the Menu bar toolbar.

11 Apply the Rotate Component tool.

Rotate the two Wheels located on the left side of the model.

Click the **Assembly** tab from the CommandManager.

Click `Wheel<3>` from the FeatureManager. This is the rear left wheel.



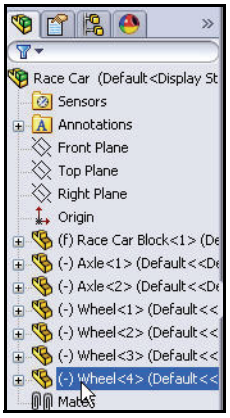
Click the **Rotate Component** tool from the Assembly toolbar. The `Rotate Component` PropertyManager is displayed.

Rotate `Wheel<3>` as illustrated.

Click `Wheel<4>` from the fly-out FeatureManager. This is the front left wheel.

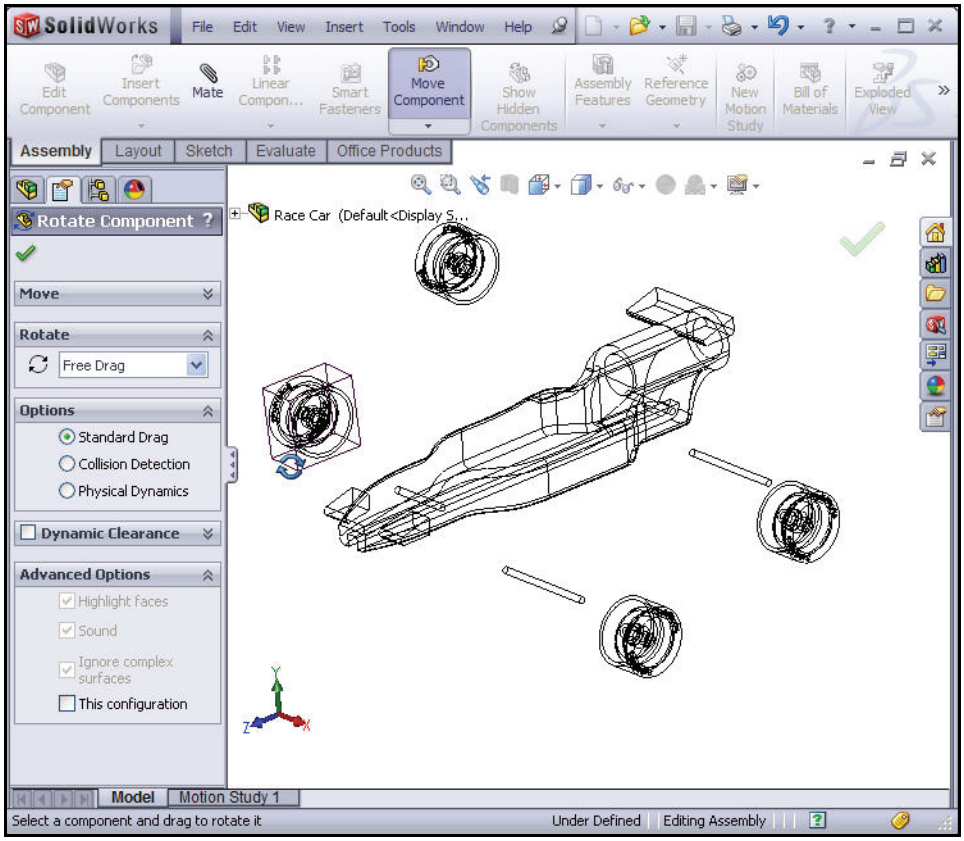
Rotate `Wheel<4>` as illustrated.

Click **OK** from the `Rotate Component` PropertyManager.



12 Rebuild the model.

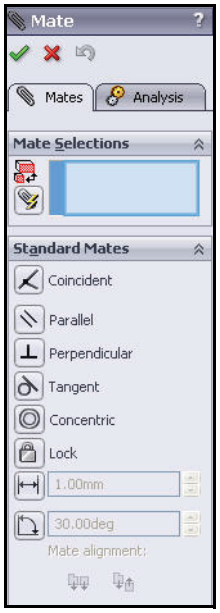
Click **Rebuild** from the Menu bar.



Insert Mates

An assembly is a document in which two or more parts and other assemblies (sub-assemblies) are mated together. Parts and sub-assemblies are called components in an assembly. Mates are used to create relationships between components. Faces are the most commonly used geometry in mates. In this case the existing sub-assemblies are mated to build an assembly based on the car part you created.

There are three types of mates; **Standard Mates**, **Advanced Mates** and **Mechanical Mates**.



Standard Mates

- Coincident
- Parallel
- Perpendicular
- Tangent
- Concentric
- Lock
- Distance
- Angle

Advanced Mates

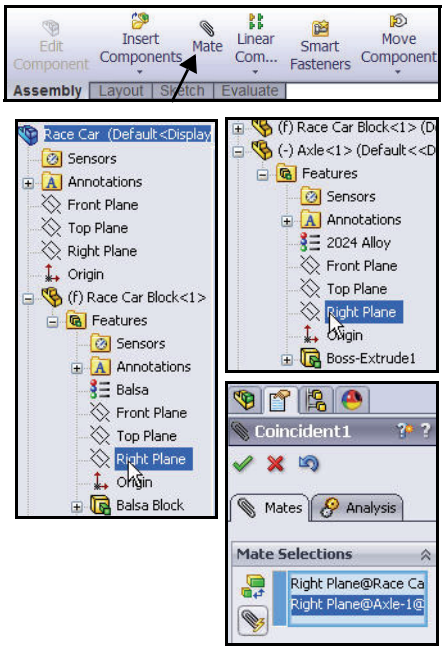
- Symmetric
- Width
- Path Mate
- Linear/Linear Coupler
- Distance/Angle Limit

You can select many different types of geometry to create a mate:

- Faces
- Planes
- Edges
- Vertices
- Sketch lines and points
- Axes and Origins

Note: In this section, position the model to view the correct sketch entity. Apply the **Zoom to Area** tool in the Heads-up View toolbar, the middle mouse button, and the **f** and **z** keys.

1 Mate the Axles to the body.
Create a Coincident mate between the rear axle and the body.



Click the **Mate** tool from the Assembly toolbar. The `Mate` PropertyManager is displayed.

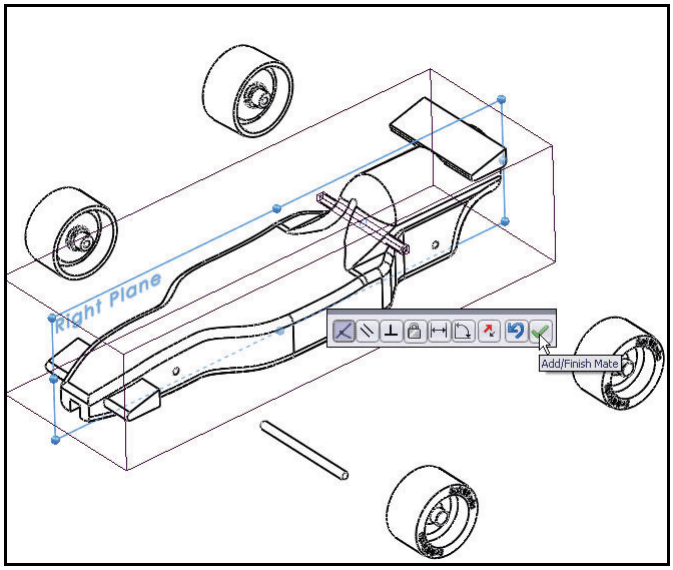
Tip: Zoom and/or rotate the view to make it easier to select the faces or edges you want to mate.

Expand the fly-out `Race Car` FeatureManager in the graphics area.

Click the `Race Car Block/ Right Plane` in the fly-out FeatureManager.

Click the `Race Car Axle<1>/ Right Plane` in the fly-out FeatureManager. Coincident mate is selected by default.

The selected planes are displayed in the `Mate Selections` box.



Click **Add/Finish Mate** to accept the mate.

2 **Insert a Concentric mate.** Create a Concentric mate between the rear axle and the body.

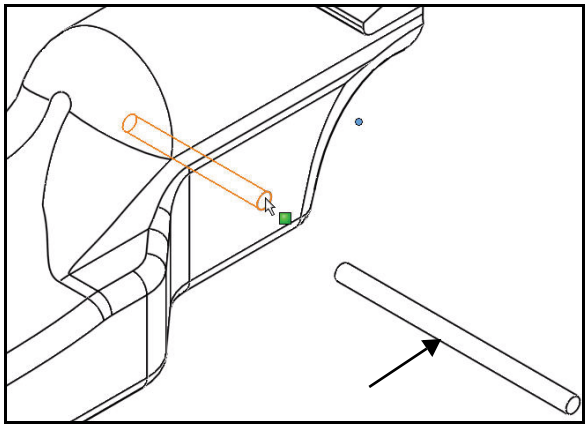
Drag `Axle<1>` as illustrated.

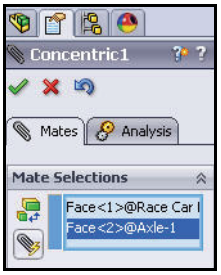
Click the **inside cylindrical face** of the rear hole.

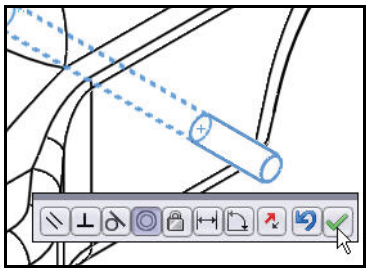
Click the **cylindrical outside face** of `Axle<1>`.

Concentric mate is selected by default.

Click **Add/Finish Mate** to accept the mate.







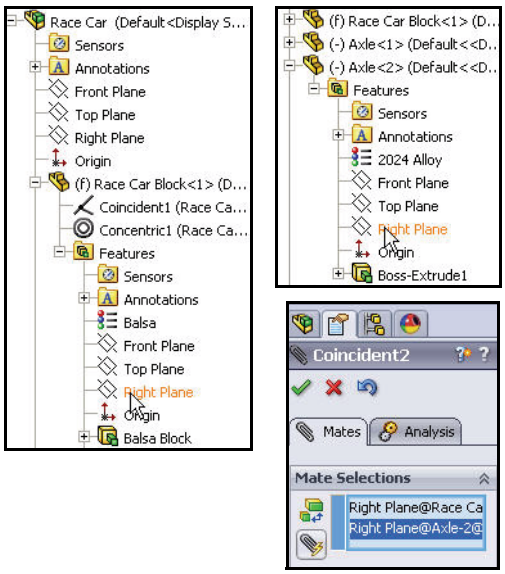
Note: In this section, position the model to view the correct sketch entity. Apply the **Zoom to Area** tool, the middle mouse button, and the **f** and **z** keys.

3 Insert a Coincident Mate.
Create a Coincident mate between the front axle and the body.

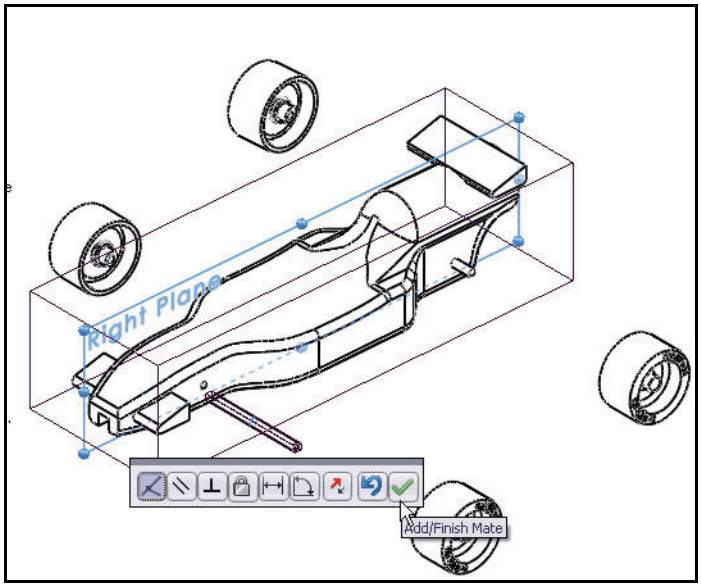
Click the `Race Car Block/ Right Plane` in the fly-out FeatureManager.

Click the `Race Car Axle<2>/Right Plane` in the fly-out FeatureManager.

Coincident mate is selected by default.



Click **Add/Finish Mate** to accept the mate.



4 Insert a Concentric Mate. Create a Concentric mate between the front axle and the body.

Drag `Axle<2>` as illustrated.

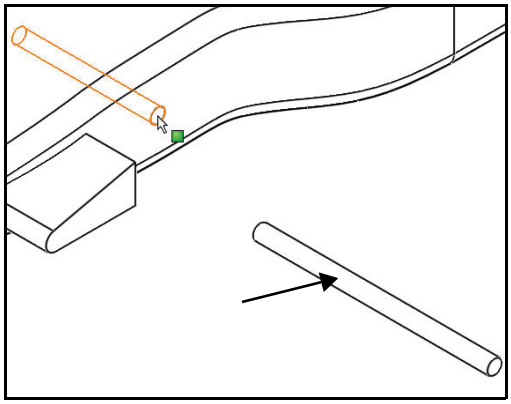
Click the **inside cylindrical face** of the front hole.

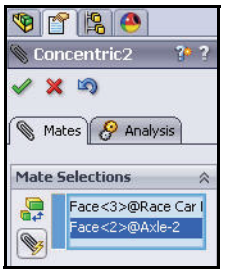
Click the **cylindrical outside face** of `Axle<2>`.

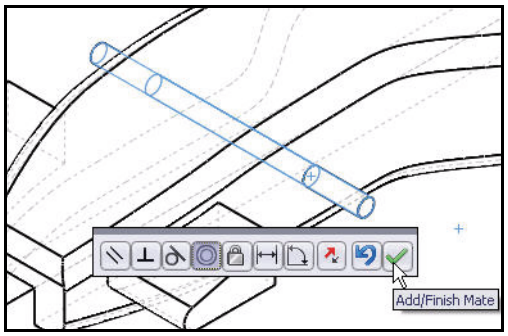
Concentric mate is selected by default.

Click **Add/Finish Mate** to accept the mate.

In the next section mate the Wheels with the Axles.







1 Mate the Wheels to the Axles.
Create a Concentric mate between the front axle and the front right wheel.

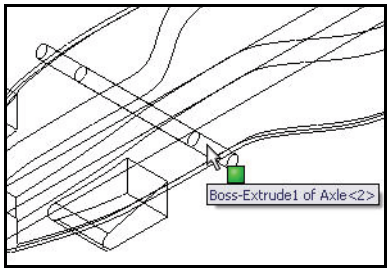
Click the **cylindrical outside face** of `Axle<2>`.

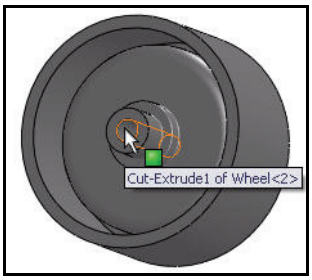
Click the **cylindrical inside face** of the front right `Wheel<2>`.

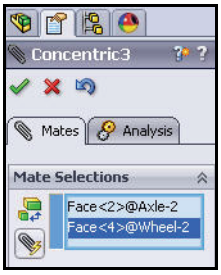
Concentric is selected by default.

Click **Add/Finish Mate** to accept the mate.

Note: Position the model to view the correct sketch entity.



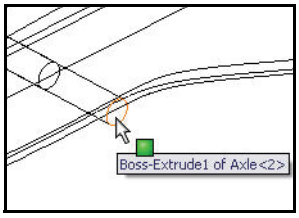




2 Create A Distance Mate.

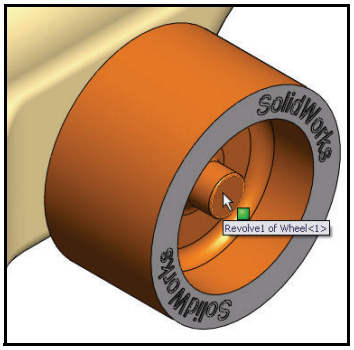
Create a Distance mate between the outside end face of the front right `Axle<2>` and the outside face of the front right `Wheel<2>`.

Click the **outside end face** of the front right `Axle<2>`.



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

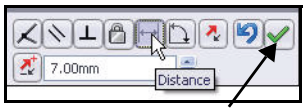
Click the **outside face** of the right front `Wheel<2>` as illustrated.



Click the **Distance Mate** tool.

Enter **7**mm.

Click **Add/Finish Mate** to accept the mate.



3 Mate the three remaining Wheels to the Front and Rear Axles.

Repeat the **above procedures** to create Concentric mates between the Axles and the Wheels.

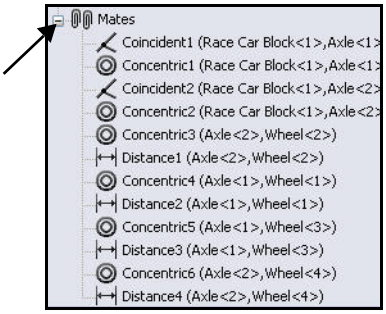
Create Distance mates between the outside end face of the Axles and the outside face of the Wheels.

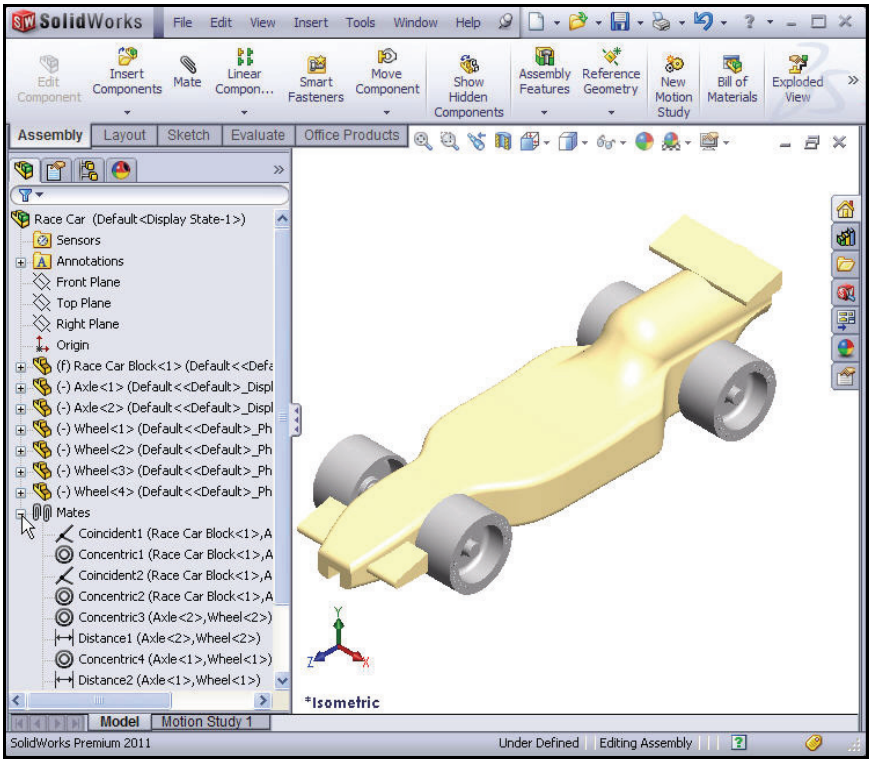
Click **OK** from the `Mate` PropertyManager.

4 View the Created Mates.

Expand the `Mates` folder from the FeatureManager.

View the created mates.

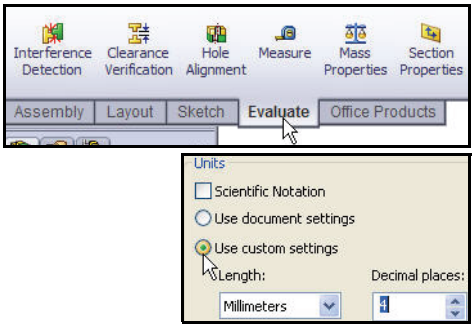


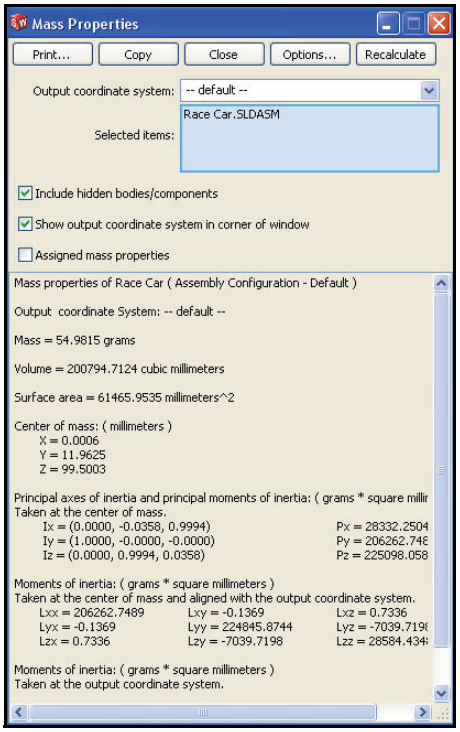


5 Save the model.

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

Calculate the Weight of the Race Car





When you are finished and ready to race, your car has to weigh no less than 55 grams. This does not include the CO_2 cartridge. Check the weight of the model. Apply the `Mass Properties` tool.

1 Click the **Evaluate** tab from the CommandManager.

Click **Mass Properties** from the Evaluate toolbar. The `Mass Properties` dialog box is displayed.

Click the **Options** button.

Check the **Use custom setting** box.

Select **4** for `Decimal place`.

Click **OK**.

The Mass = 54.9815 grams.

Note: The mass can be different if you did not fillet all of the edges or too many.

There will be eye hooks, paint, decals, and sanding. Use this mass as an estimate and make sure to weigh the completed car before racing. A list of critical dimensional rule requirements are provided at the end of this lesson.

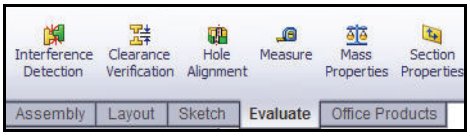
Note: The mass of the Axle part using 2024 Alloy is .9896 grams. If the Axle part was changed to AISI 304, the total mass increase of the `Race Car` would be approximately 3.67 grams. Explored this as an exercise.

Close the Mass Properties dialog box.

2 Save the model.

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

Calculate the Overall Length of the Race Car



When you are finished and ready to race, your car can't exceed 210mm in length and the Wheels have a minimum of 26mm and a maximum of 34mm. Apply the `Measure` tool to obtain these measurements of the `Race Car` assembly.

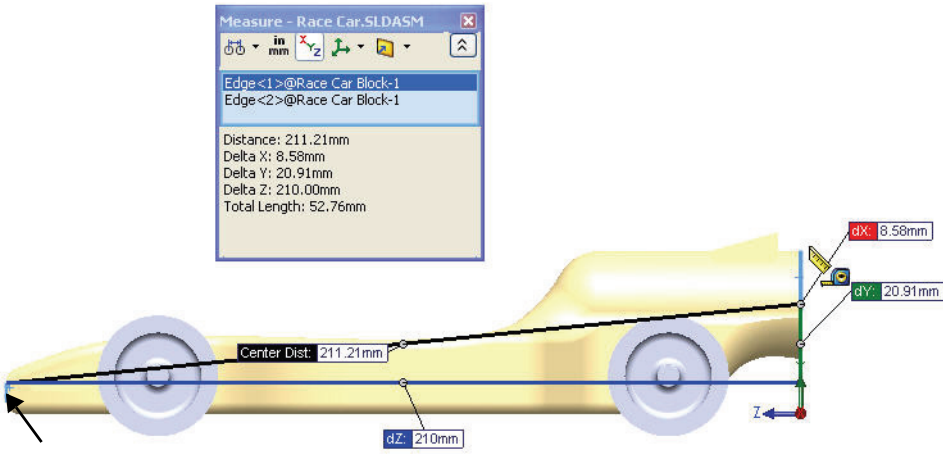
1 Measure the Overall Length of the Car.

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

Click the **Measure** tool from the Evaluate toolbar. The `Measure - Race Car` dialog box is displayed.

Click the **front edge** of the `Race Car`. **Zoom in** if needed to select the edge.

Click the **back edge** of the `Race Car`. Note: Select an edge, not a point or face. View the results.

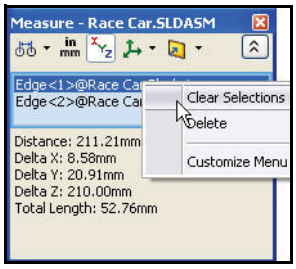


Note: The `Balsa Block` is 223mm x 50mm x 65mm. If you plan to use a fixture to machine your car, you must make sure that your design is no longer that 210mm. Most fixtures have a nose plate that holds the front of the `Balsa Block` and if your design is too long, it can/will end up breaking the endmill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

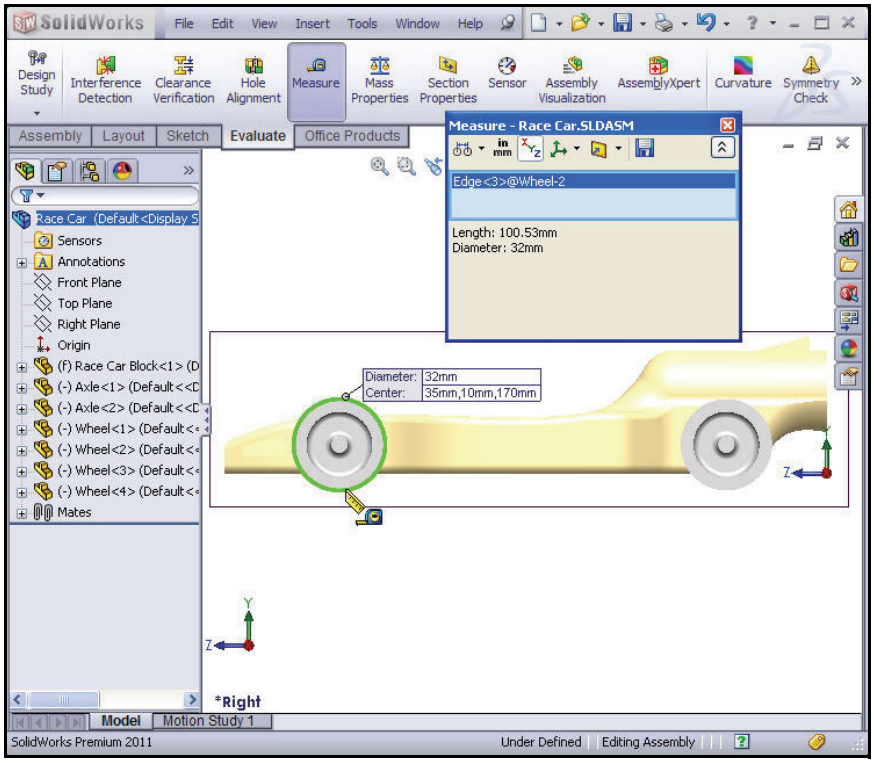
2 Measure the Wheel<2> diameter.
Right-click inside of the `Selection` box.

Click **Clear Selections**.

Click the **diameter** of the front `Wheel<2>`.
The diameter of `Wheel<2>` is 32mm.

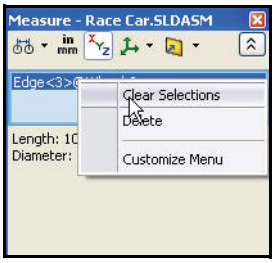


Note: Remember your wheels need to be between 26mm and 34mm in diameter.



3 Measure the center distance between the two Wheel hubs.

Right-click inside of the `Selection` box.

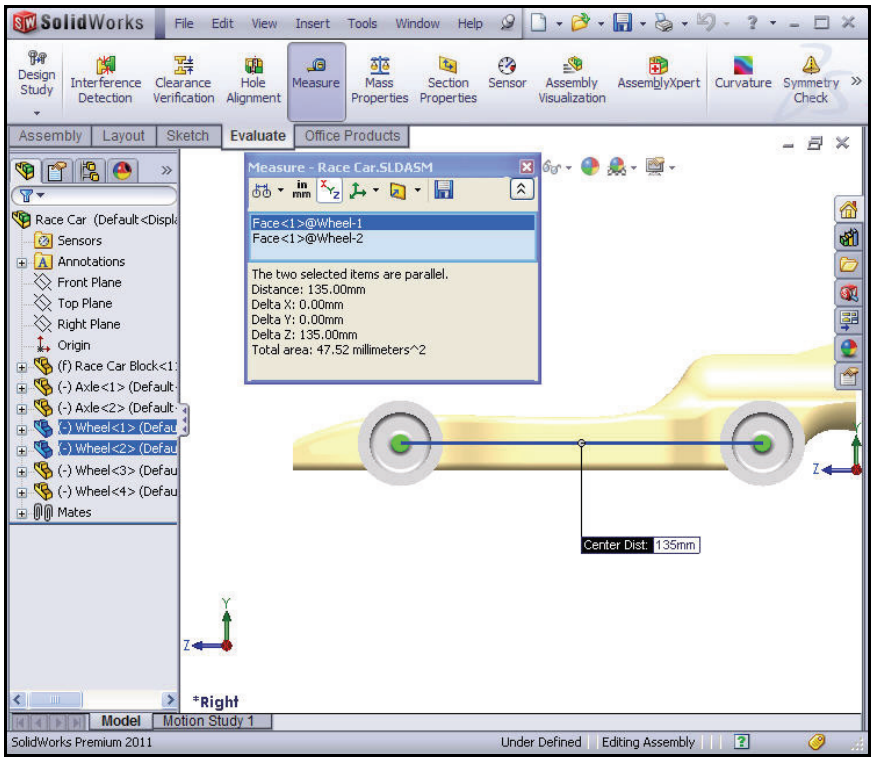


Click **Clear Selections**.

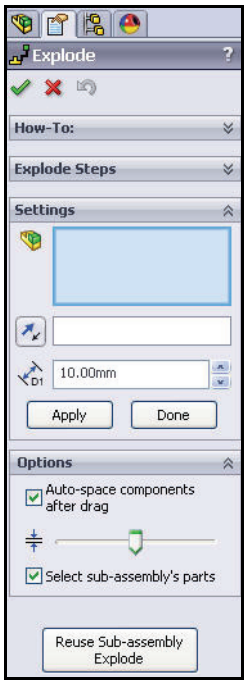
Click the **front hub face** of front `Wheel<1>`.

Click the **front hub face** of back `Wheel<2>`. The center distance between the two Wheel hubs is 135mm.

Close the `Measure – Race Car` dialog box.



Create an Exploded view



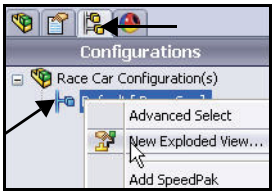
For manufacturing purposes, it is often useful to separate the components of an assembly to visually analyze their relationships. Exploding the view of an assembly allows you to look at it with the components separated.

An exploded view consists of one or more explode steps. An exploded view is stored with the assembly configuration with which it is created. Each configuration can have one exploded view.

The `Explode` PropertyManager is displayed when you create or edit an exploded view of an assembly.

Note: While an assembly is exploded, you cannot add mates to the assembly.

1 Create an Exploded view Configuration.



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

Click the **ConfigurationManager** tab.

Right-click **Default** from the ConfigurationManager.

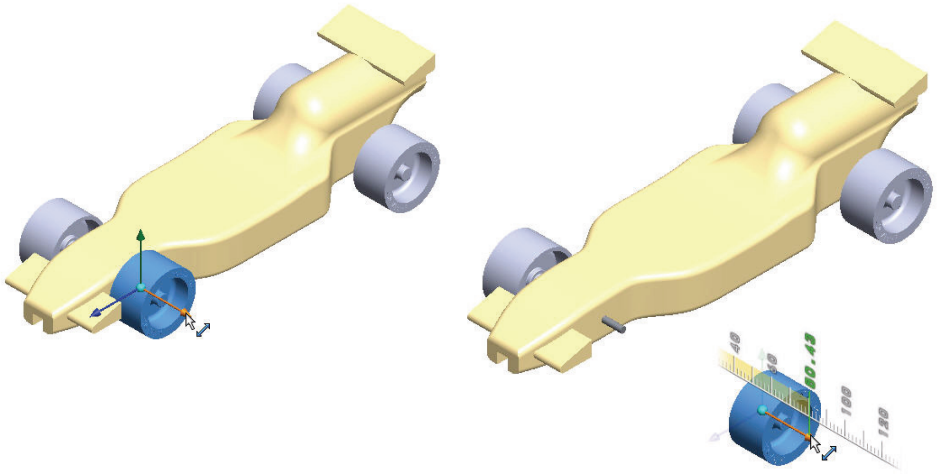
Click the **New Exploded View** tool. The `Explode` PropertyManager is displayed.

Click the **right front** `Wheel<2>` of the model in the graphics area. A Triad is displayed.

Click and drag the **red/orange Triad** arrow to the right.

Note: Drag the wheel far enough to the right to leave room for `Axle<2>`.

Click the **Done** button from the `Settings` box.

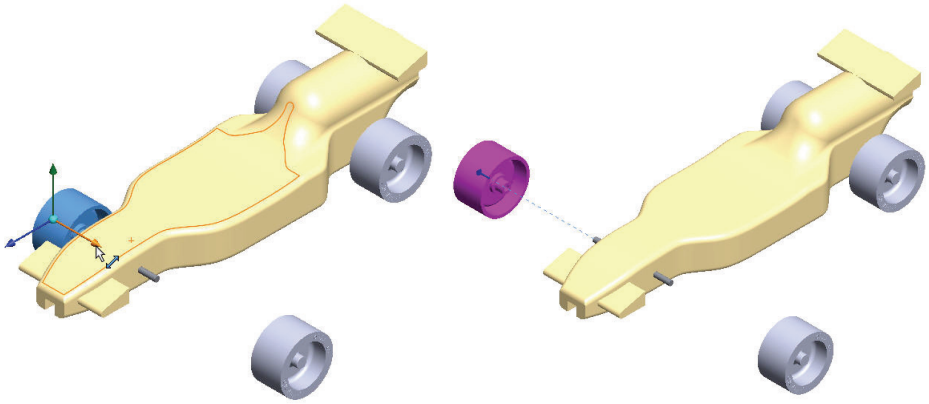


2 Create Explode Step2.

Click the **left front** `Wheel<4>` of the model. A Triad is displayed.

Click and drag the **red/orange Triad** arrow to the left.

Click the **Done** button from the `Settings` box.



3 Create Explode Step3.

Click the **right back** `Wheel<1>` of the model. A Triad is displayed.

Click and drag the **red/orange Triad** arrow to the right. Drag the wheel far enough to the right to leave room for `Axle<1>`.

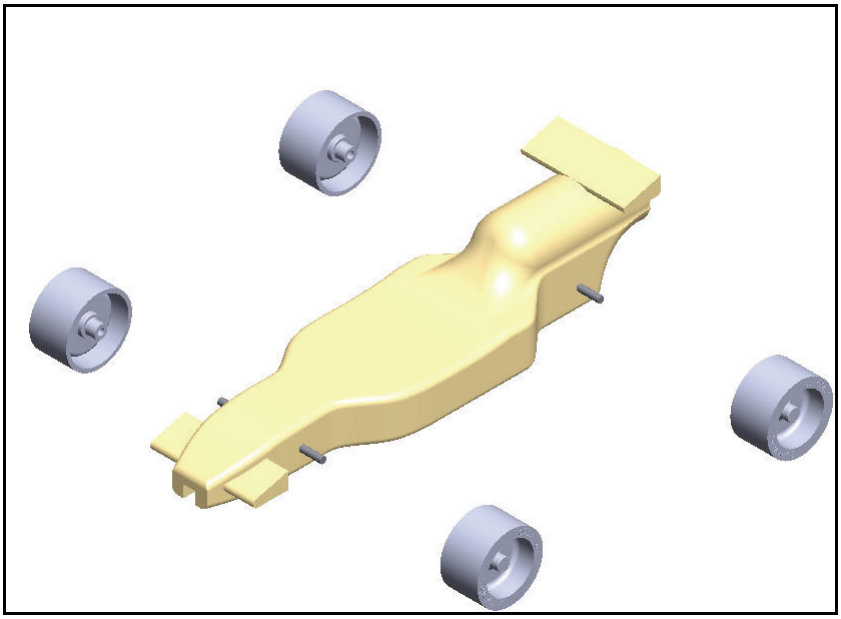
Click the **Done** button from the `Settings` box.

4 Create Explode Step4.

Click the **left back** `Wheel<3>` of the model. A Triad is displayed.

Click and drag the **red/orange Triad** arrow to the left.

Click the **Done** button from the `Settings` box. View the results.



5 Create Explode Step5.

Click the **front** `Axle<2>` of the model. A Triad is displayed.

Click and drag the **red/orange Triad** arrow to the right.

Click the **Done** button from the `Settings` box.

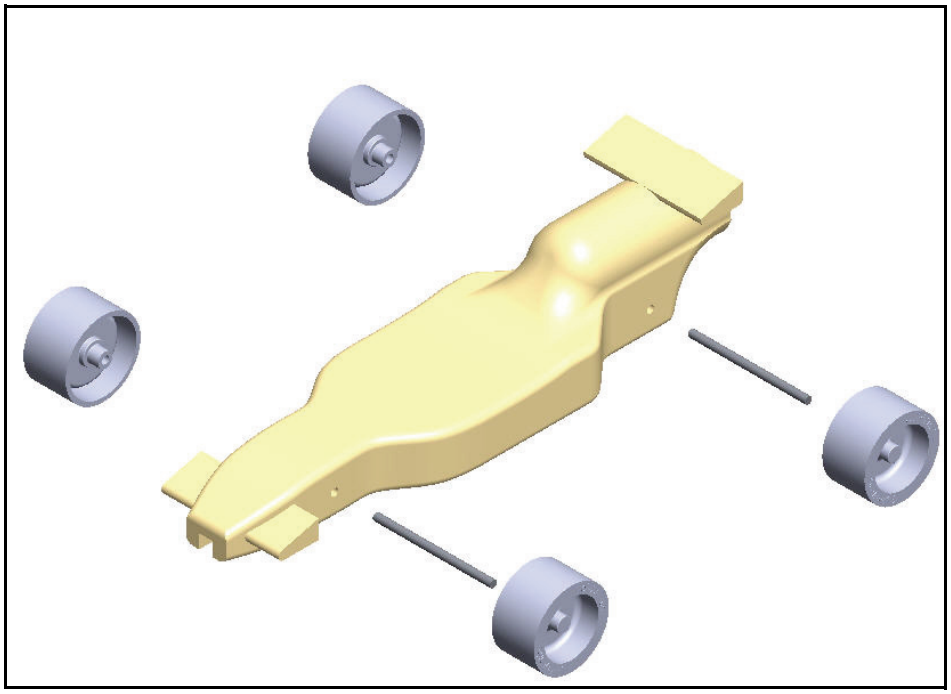
6 Create Explode Step6.

Click the **right back** `Axle<1>` of the model. A Triad is displayed.

Click and drag the **red/orange Triad** arrow to the right.

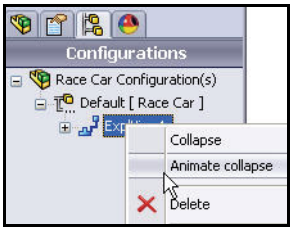
Click the **Done** button from the `Settings` box. View the model.

Expand each **Explode Step** in the `Explode Steps` box. View the results.



7 Return to the ConfigurationManager.

Click **OK** from the `Explode` PropertyManager.



8 Animate the assembly.

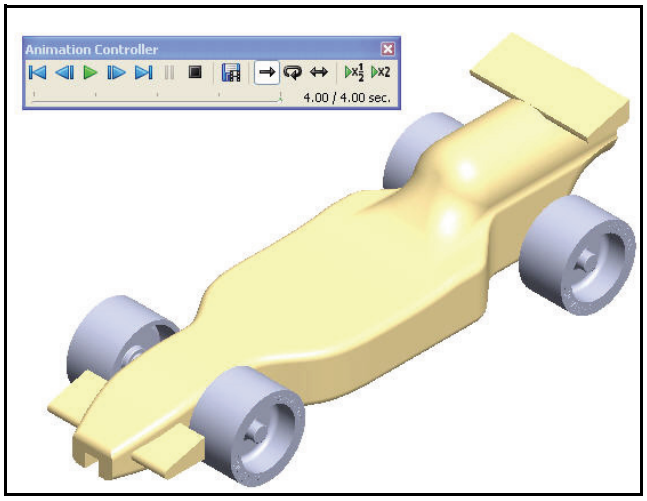
Expand the **Default** configuration. `ExpView1` is displayed.

Right-click **ExplView1.**

Click **Animate collapse**. View the results.

Click the **Play** button from the `Animation Controller` dialog box. View the Animation of the `Race Car`.

Close the `Animation Controller` dialog box.

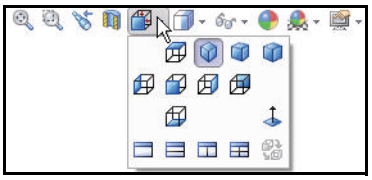


9 Return to the FeatureManager.

Click the **FeatureManager** tab.

10 Save the model.

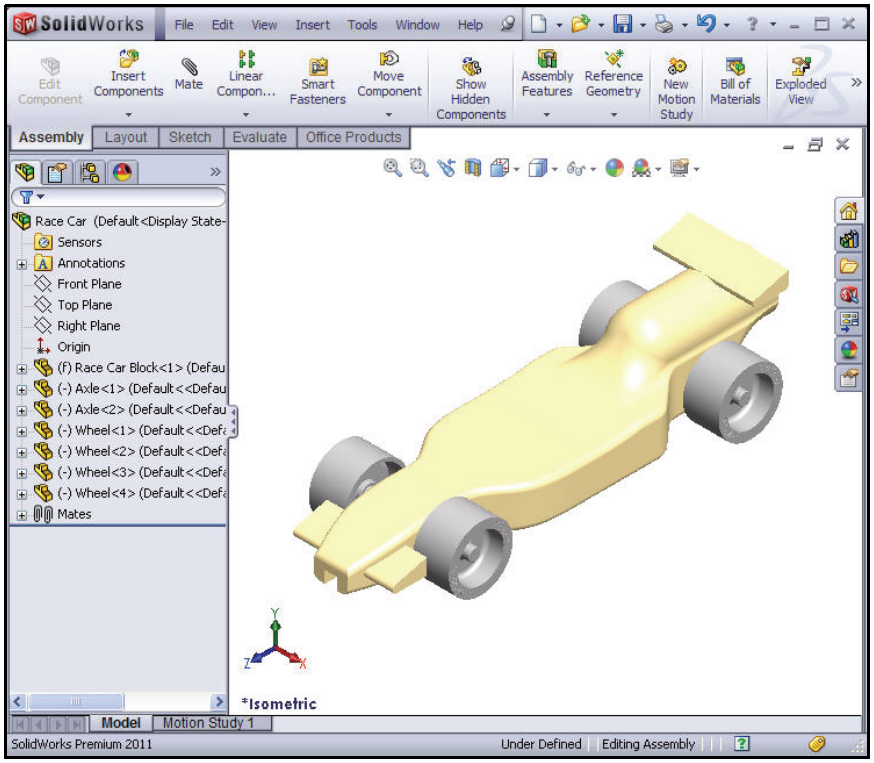
Click **Isometric** from the Heads-up View toolbar.



Click **Save** from Menu bar.

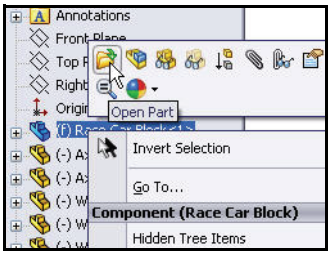
You are finished with the assembly.

In the next section, open individual parts from the assembly and apply the Measure tool.



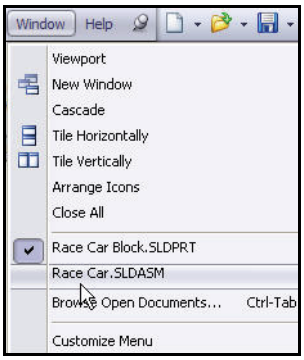
1 Open the Race Car Block Part from the Assembly.

Right-click `(f) Race Car Block<1>` from the FeatureManager.



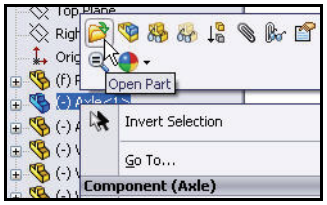
Click **Open Part** from the Context toolbar. The `Race Car Block` FeatureManager is displayed.

2 Return to the Race Car Assembly.
Click `Window, Race Car` from the Menu bar menu. The `Race Car` assembly is displayed.



3 Open the Axle Part from the Assembly.
Right-click `Axle<1>` from the FeatureManager.

Click **Open Part** from the Context toolbar. The `Axle` FeatureManager is displayed.

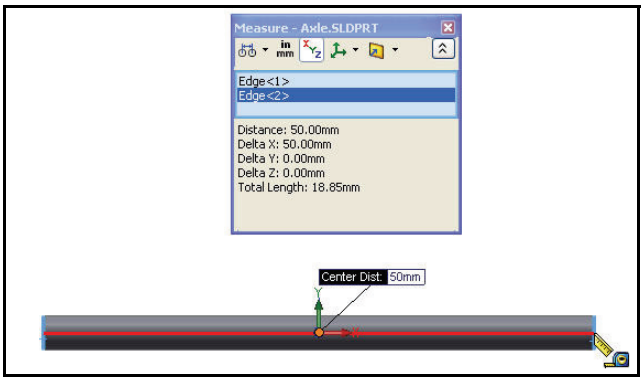


4 Apply the Measure tool to the Axle.
Measure the overall length.

Click **Front** view from Heads-up View toolbar.

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

Click the **Measure** tool from the Evaluate toolbar. The `Measure - Axle` dialog box is displayed.



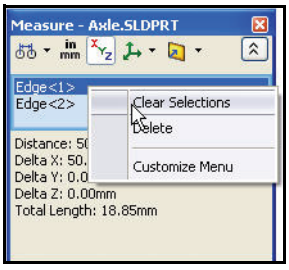
Click the **left edge** of `Axle<1>`.

Zoom in if needed to select the edge.

Click the **right edge** of `Axle<1>`.

View the results.

5 Measure the diameter of the Axle.
Right-click inside of the `Selection` box as illustrated.



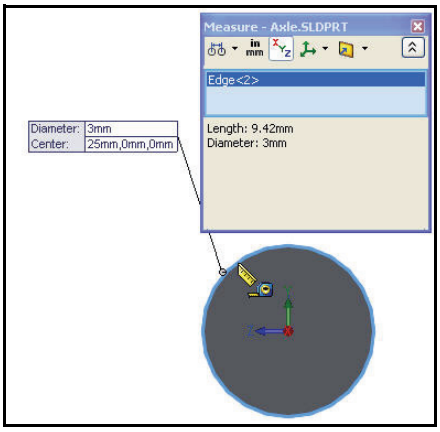
Click **Clear Selections**.

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

Click the **circumference** of the `Axle<1>`. The diameter is 3mm.

Close the `Measure - Axle` dialog box.

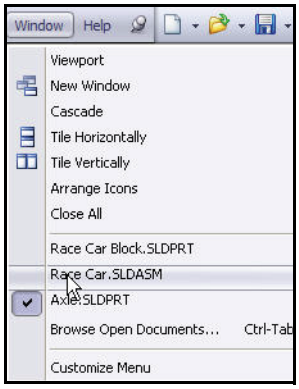
Click **Isometric** view from the Heads-up View toolbar.



6 Return to the Race Car assembly.

Click `Window, Race Car` from the Menu bar menu.

The `Race Car` assembly is displayed.



1 Explore various Scenes and View Settings.

Click the drop-down arrow from the **Apply scene** tool in the Heads-up View toolbar.

View your options.

Click **Backdrop - Ambient White**.

View the results in the graphics area.

Click **Plain White**.

View the results in the graphics area.

Click **Warm Kitchen**.

Click the drop-down arrow from the **View settings** tool in the Heads-up View toolbar.

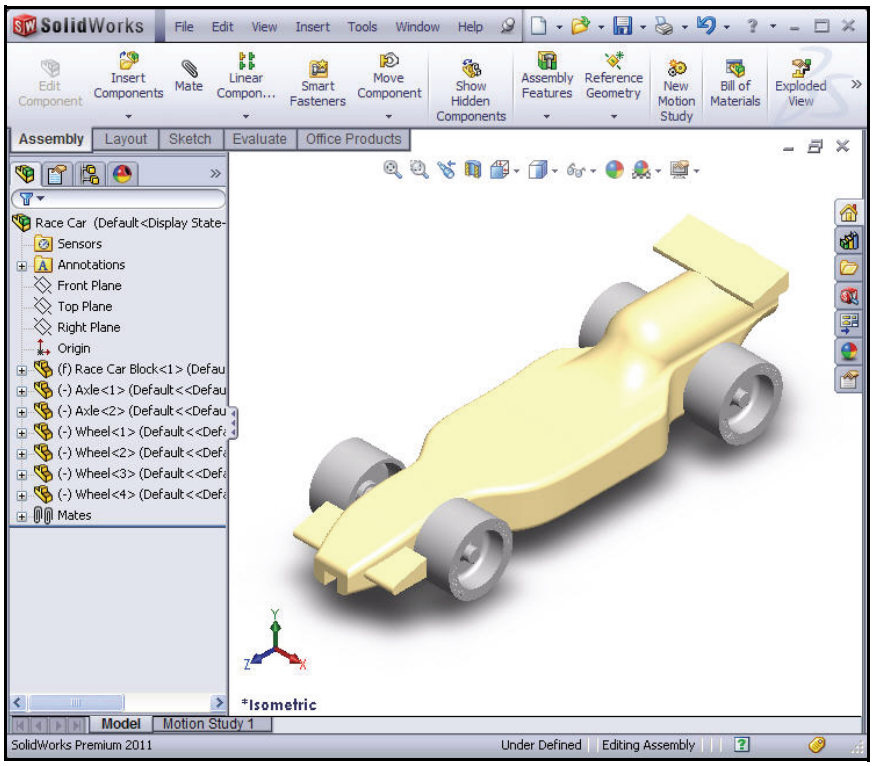
Click the **Shadows In Shaded Mode** icon.

Rotate the model with your middle mouse button. View the results.

2 Save the model.

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

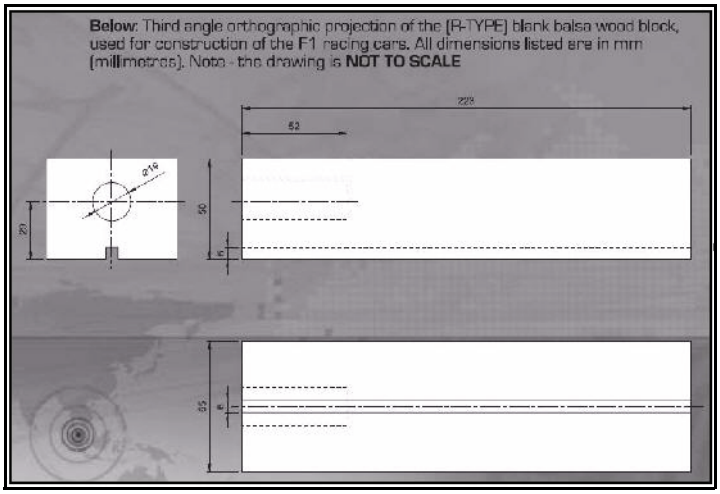
Click **Shaded** from the Heads-up View toolbar.



Click **Save** from the Menu bar. You are finished with the assembly. Review below for some of the dimensional rule requirements for the `CO2 Cartridge Race Car` assembly. In the next lesson, you will create an `Race Car` assembly drawing with dimensions.

Race Car Dimensional Requirements

Below are some of the dimensional requirements (Type-R) for the `Race Car Block` and the CO2 cartridge hole. Review the dimensional requirements. Apply the Measure tool to confirm that you meet the design requirements!



Body dimensions copied from the 2010 - 2011 Rules and Regulations folder from the F1inschools.co.uk site.

Body Dimensions

No.	Structure	Min.	Max.
3a.	Full body length *	170	210
3b.	Body height above the track* (excluding eyelets) including side pods and wings	3	10
3c.	Body width at side pods*	50	65
3d.	Total body width, including wheels *	60	85

(all dimensions stated in millimetres, mm.)

No.	Structure	Min. Weight
3e.	Body weight without the CO_2 cartridge	55.0

(all weight values stated in grams, g.)

3f. No part of the body should be less than 3mm thick - this excludes air foils / wings

3g. Maximum body height (including aerofoils) 60

* Additional Notes

3a. measured between front and rear extemeties of body.
3b. measured from track surface to the car body.
3c. measured from side-to-side of the car body - the side pods are the part of the car that flanks the sides of the cockpit area of the car. The outside face of the side pods when viewed from the side the pods must present a surface measuring not less than 30X15 mm - a sticker of 30X15mm will be applied to both side pods and must be 100% visible when viewed from the side. Side pods can be convex, concave or flat but capable of taking the F1 in Schools promotional logo decal.
3d. measured between outside edges of the wheels or body, whichever is widest.

Wheel dimensions copied from the 2010 - 2011 Rules and Regulations folder from the F1inschools.co.uk site.

Wheel Dimensions

4a. All F1 cars must have 4 wheels, two at the front, two at the rear and all wheels must be cylindrical.

4b. All wheels must fit the following criteria:

No.	*Structure*	*Min.*	*Max.*
4c.	Front wheel diameter *	26	34
4d.	Front wheel width * (at surface contact point)	15	19
4e.	Rear wheel diameter *	26	34
4f.	Rear wheel width * (at surface contact point)	15	19

(all dimensions stated in millimetres, mm.)

4g. All 4 wheels must touch the racing surface at the same time and all wheels should roll easily.

4h. Wheel dimensions must be consistent with the whole diameter/circumference of the wheel.

4i. A school/college/organised youth group may manufacture their own wheels, as long as they fit within the set specification.

* Additional Notes

4c. & 4e. measured to the extreme outer edges of each wheel.
4d. & 4f. measured between the extreme edges (including any protrusions).

Wheel to Body dimensional design requirements copied from the 2010 - 2011 Rules and Regulations folder from the F1inschools.co.uk site.

Wheel to Body Dimensions

The wheels are not allowed to be inside the car body and 100% of the wheel should be visible from the plan, side and views.

No.	*Structure*	
5a.	Front wheel visible (from the plan/side view)	Yes / No
5b.	Rear wheel visible (from the plan/side view)	Yes / No

Power Plant dimensional design requirements copied from the 2010 - 2011 Rules and Regulations folder from the F1inschools.co.uk site.

Power Plant

The event organisers will provide all CO_2 cartridges for the regional finals, national finals and World Championship.

No.	*Structure*	*Min.*	*Max.*
6a.	CO_2 cartridge chamber diameter	19.1	19.9
6b.	Lowest point of chamber to the track surface *	22.5	30
6c.	Depth of hole	50	60
6d.	Wall thickness around cartridge *	3.1	_

6e. No paint is allowed inside the chamber (please seal off or protect the chamber while painting).

* Additional Notes

6b. measured from track surface to lowest surface part of the CO_2 chamber.
6d. clear space surrounding the CO_2 cartridge below 3 mm the car will not be allowed to race and loose marks accordingly.

Car Body and Wings dimensional design requirements copied from the 2010 - 2011 Rules and Regulations folder from the F1inschools.co.uk site

Car Body and Wings

8a. The car body including side pods AND rear wing, must be machined from a single piece of balsa wood. Aerofoils at the front may be machined as part of the car body or from a seperate material - non-metallic.

8b. The design of the completed R-TYPE car should resemble an actual F1 car and shall include the following features:
An aerofoil on the front nose of the car, an aerofoil on the rear of the car and side pods on both sides of the car

No.	*Structure*	*Min.*	*Max.*
8c.	Rear/Front Wing width (where the wing is split by the body of the car, the width is calculated as a sum of both parts.)	40	65
8d.	Rear/Front wing depth	15	25
8e.	Front wing thickness	1	12
8f.	Rear wing thickness	3	12

* Additional Notes

The whole of the front aerofoil when viewed from the side must be in front of the centre line of the front axle.
The whole of the rear aerofoil when viewed from the side must be behind the centre line of the rear axle.
A driver cockpit/driver is an opptional feature.
Designs will be tested and examined for any implants or voids hidden within the car body.

8e/8f. The minimum depth of both front and rear wings is to be measured at the narrowest point on each wing.