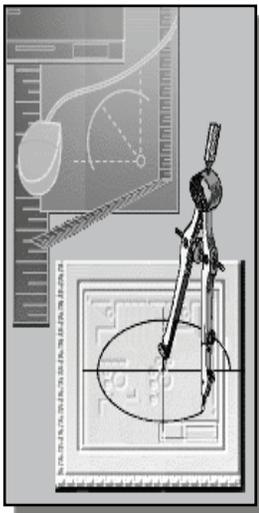
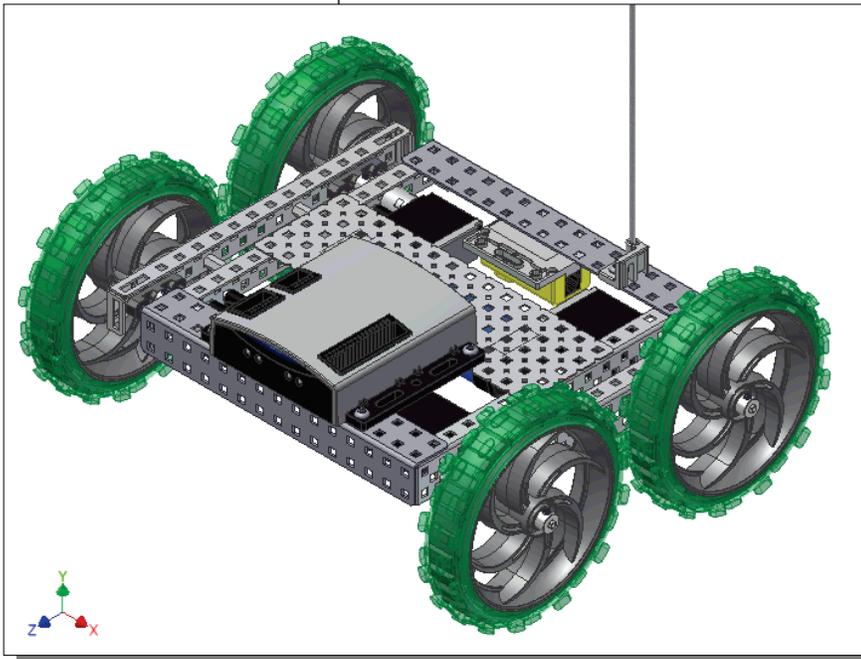


## Chapter 20 Assembly Model with VEX Robot Kit - Autodesk Inventor



### Learning Objectives

- ◆ Create an Assembly Using Parts from the VEX Robot Kit
- ◆ Understand and Perform Assembly Constraints
- ◆ Adjust Components' Orientations
- ◆ Create and Use Subassemblies in Assemblies

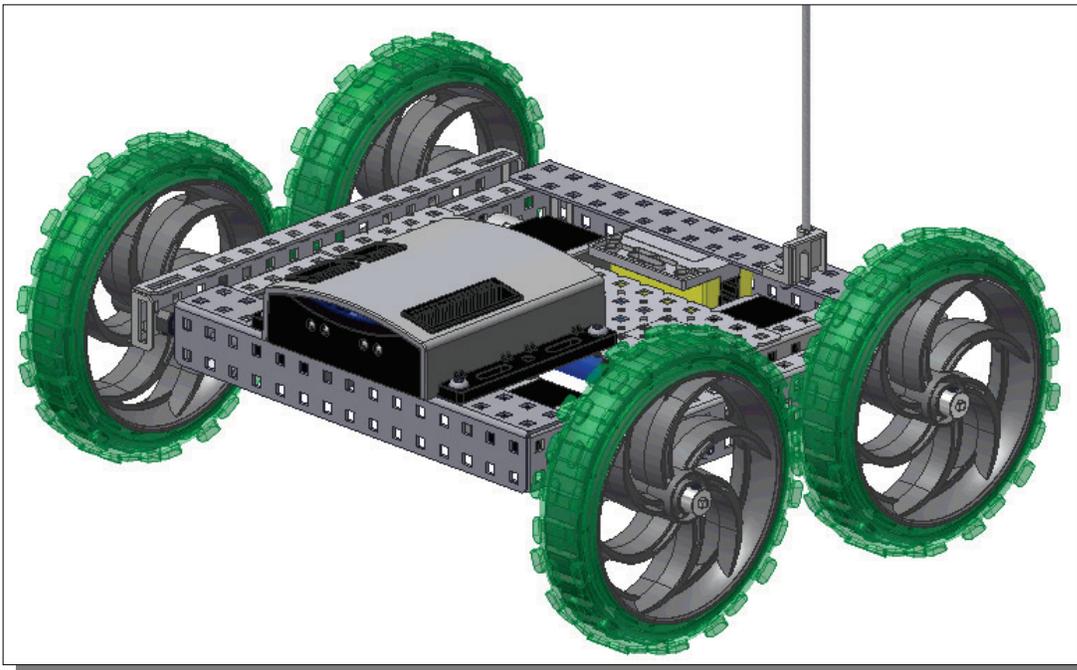
## Introduction

The rapid development in computer hardware technology, during the past few decades, has brought many changes in the practice of engineering in general. Many areas that were traditionally identified as electrical engineering or mechanical engineering are now multidisciplinary, integrating digital electronics, kinematics analysis, and computing together. Additionally, the use of microcontrollers and embedded systems has become inevitable in almost every engineering field. Given these developments, engineering education has also witnessed significant changes, such as adapting to project-oriented courses that emphasize real world applications, and the use of new educational tools such as robot kits.

The use of robot kits provides many benefits, through assembling, building, and following instructions, which help develop fine motor skills and hand-eye coordination. Students are exposed to multiple subjects such as mechanics, electronics, and programming. By working together to create robots that perform exciting challenges, students also gain valuable critical thinking, problem-solving and team-building skills. Students can also participate in several national/world robot competitions held annually, which can provide a strong sense of accomplishment.

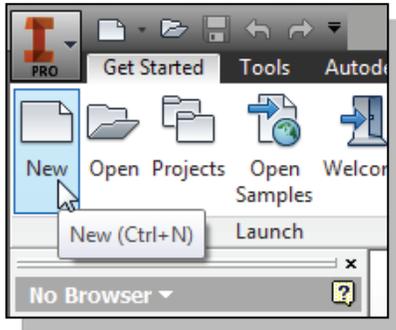
In this lesson, we will create a *Tumbler* assembly model using the VEX Robot Kit. The modeling process can be used as part of a design process, to simulate and confirm a design, prior to the actual construction of the project. All of the required parts have been modeled in Autodesk Inventor, and can be found on the companion CD. Refer to the companion CD for design ideas and additional resource information. Unzip all of the parts/subassemblies under a folder in the **Parametric-Modeling-Exercises** project folder before starting in the next section.

## The *Tumbler* Assembly



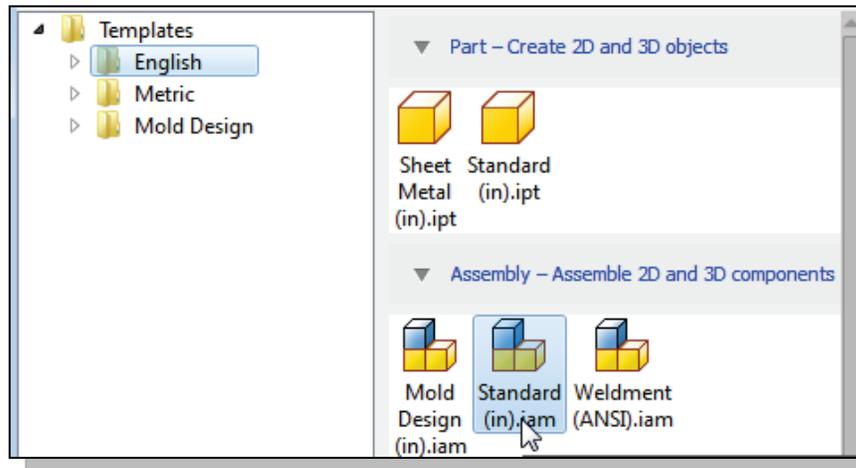
## Starting Autodesk Inventor

1. Start the **Autodesk Inventor** option on the *Start* menu or select the **Autodesk Inventor** icon on the desktop to start Autodesk Inventor. The Autodesk Inventor main window will appear on the screen.

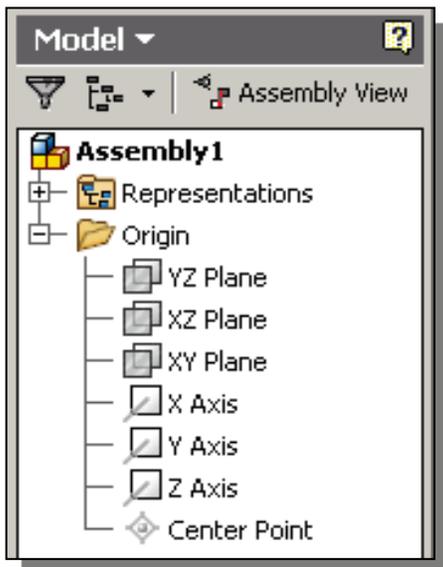


2. Select the **New File** icon with a single click of the left-mouse-button in the *Launch* toolbar as shown.

3. Select the **English** units set and in the *Template* list; select **Standard(in).iam** (*Standard Inventor Assembly Model* template file).



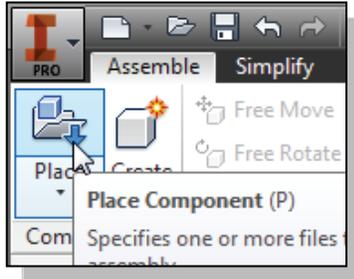
4. Click on the **OK** button in the *New File* dialog box to accept the selected settings.



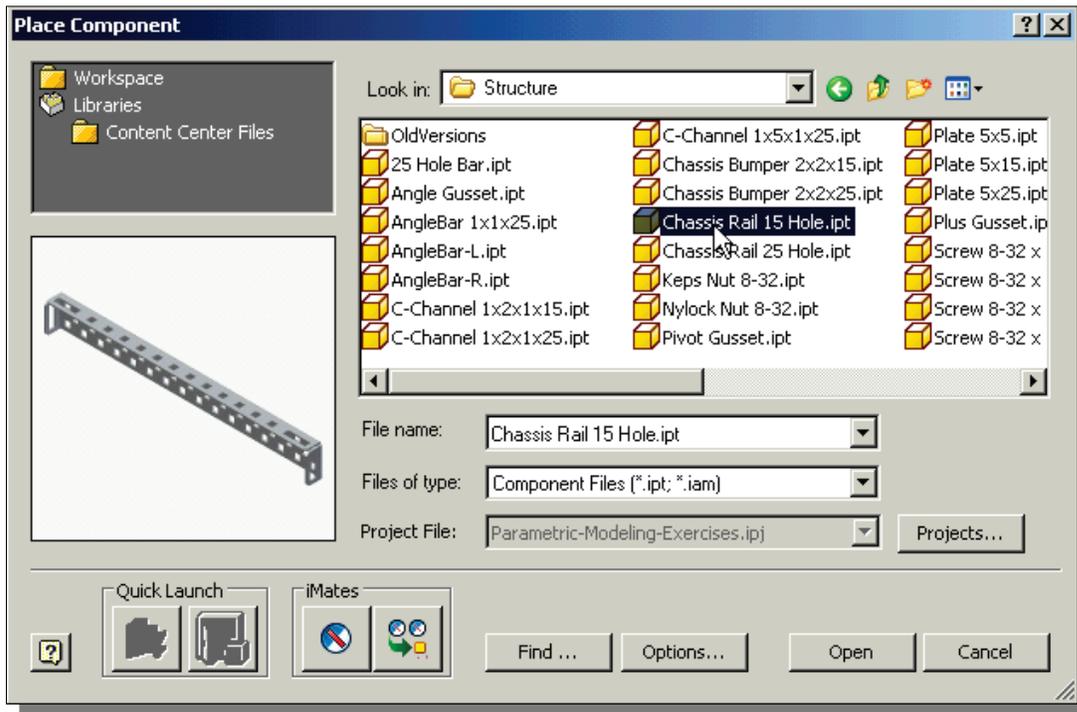
- In the *browser* window, **Assembly1** is displayed with a set of work planes, work axes and a work point. In most aspects, the usage of work planes, work axes and work points is very similar to that of the Inventor *Part Modeler*.

## Creating a Subassembly

- ❖ We are now ready to assemble the components together. We will start by assembling the **Chassis Rails**, **Motors** and **Wheels** into a subassembly. A sub-assembly is a unit assembled separately but designed to fit with other units in a manufactured product. Sub-assemblies are commonly used to help manage complex designs and when the same configurations are used multiple times in a design.



1. In the *Assembly* panel, select the **Place Component** command by left-mouse-clicking the icon.
2. Select **Chassis Rail 15 Hole.ipt** (switch to the appropriate folder if necessary) in the list window.



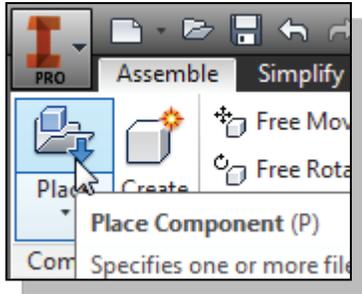
3. Click on the **Open** button to retrieve the model.



4. Right-mouse-click once to bring up the option menu and select **Place Grounded at Origin** to place the part.
5. Right-mouse-click once to bring up the option menu and select **OK** to end the command

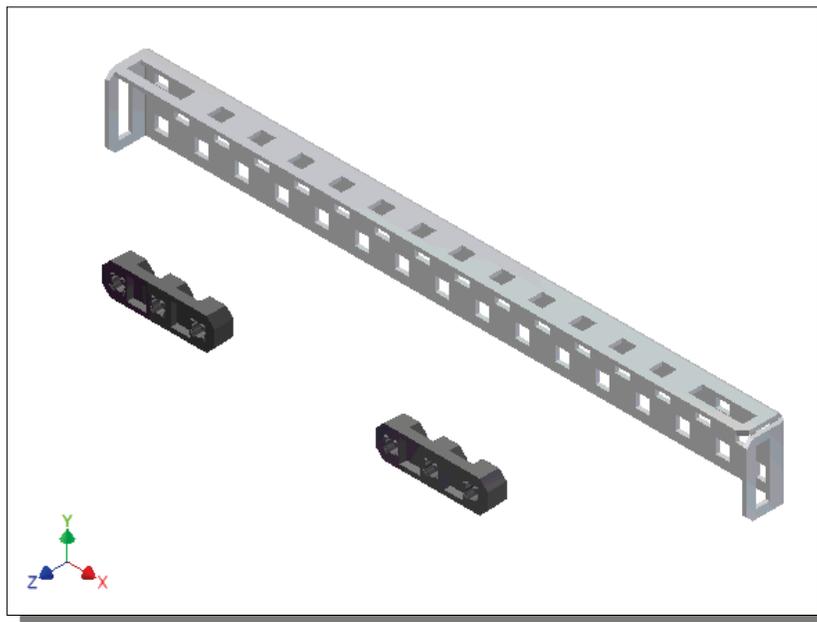
## Placing the Second Component

- We will retrieve the *Bearing Flat* part as the second component of the assembly model.



1. In the *Assembly* panel, select the **Place Component** command by left-mouse-clicking the icon.

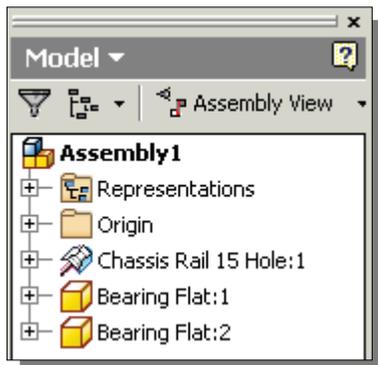
2. Select the **Bearing Flat** design in the list window. Click on the **Open** button to retrieve the model.



3. Place **two** copies of the *Bearing Flat* toward the left side of the graphics window, as shown in the figure.



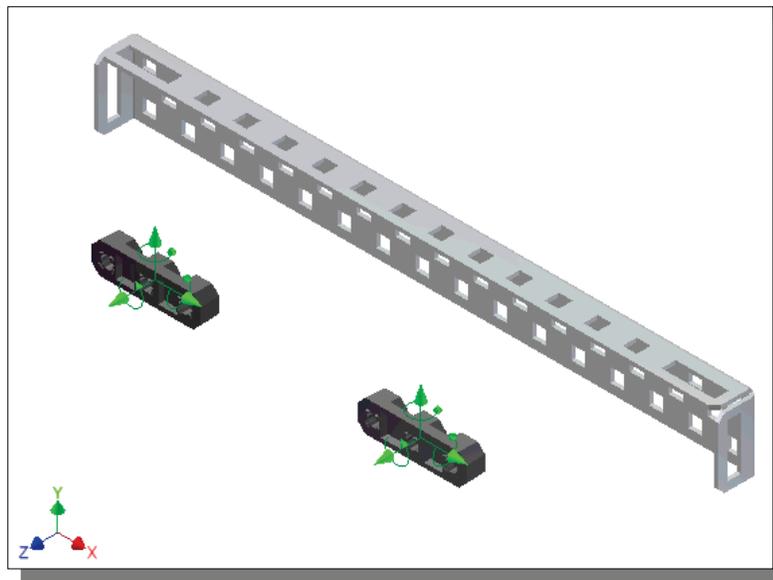
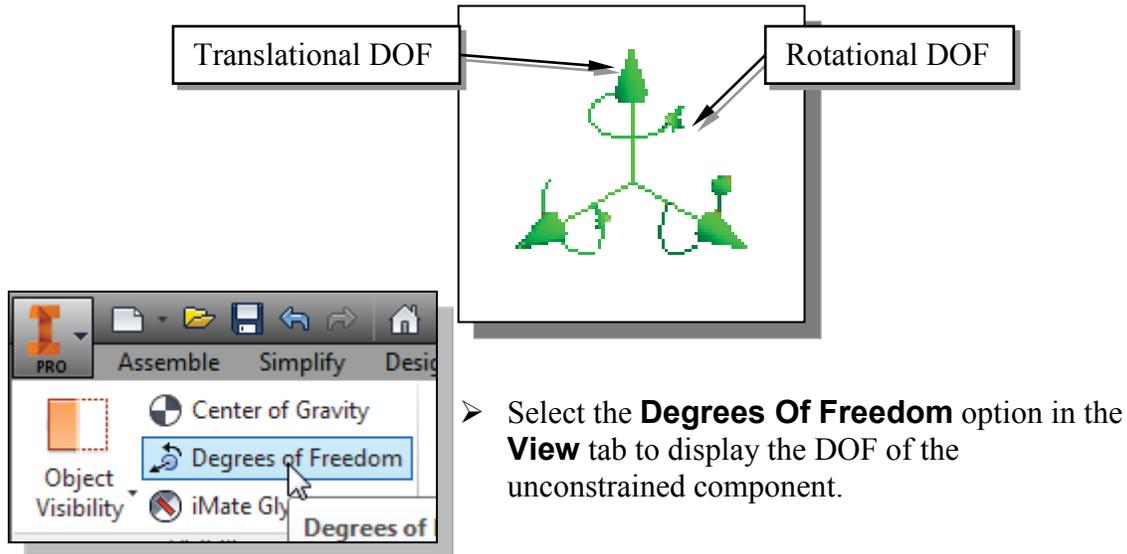
4. Inside the graphics window, right-mouse-click once to bring up the option menu and select **OK** to end the placement of the *Bearing Flat* parts.



- Inside the *browser* window, the retrieved parts are listed in their corresponding order. The **pin** icon in front of the *Chassis Rail* signifies the component is grounded and all *six degrees of freedom* are restricted. The number behind the name is used to identify the number of copies of the same component in the assembly model.

## Degrees of Freedom Display

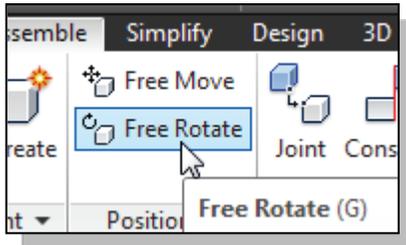
- Each component in an assembly has six **degrees of freedom (DOF)**, or ways in which rigid 3D bodies can move: movement along the X-, Y-, and Z-axes (translational freedom), plus rotation around the X-, Y-, and Z-axes (rotational freedom). *Translational DOFs* allow the part to move in the direction of the specified vector. *Rotational DOFs* allow the part to turn about the specified axis.



- In *parametric modeling*, the degrees of freedom symbol shows the remaining degrees of freedom (both translational and rotational) for the components of the active assembly. Note that each component has its own degrees of freedom, even if the same part is placed multiple times within the same assembly. The assembly constraints are also applied independently to each component. The two separate degrees of freedom symbols, as shown in the figure above, signify the two copies of the **Bearing Flat** are unconstrained and should be constrained independently.

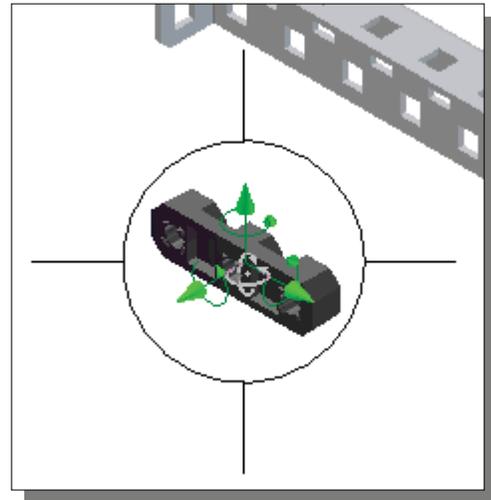
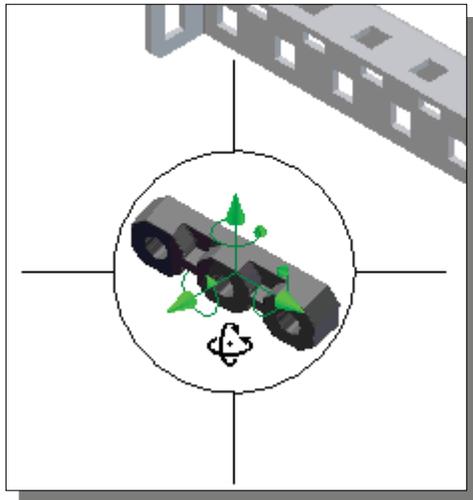
## Adjusting the Component's Orientation

- To assemble components into an assembly, we need to establish the assembly relationships between components. It is a good practice to assemble components the way they would be assembled in the actual manufacturing process. Although it is possible to rely solely on the placement of **assembly constraints** to properly align the components, it can be very helpful to first set the orientation of the components.

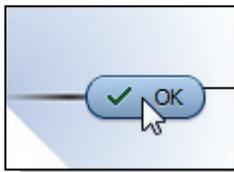


1. Switch back to the *Assembly* panel; select the **Free Rotate** command by left-mouse-clicking once on the icon.

2. Select one of the **Bearing Flat** parts and notice the free-orbit control is displayed around the selected component as shown.



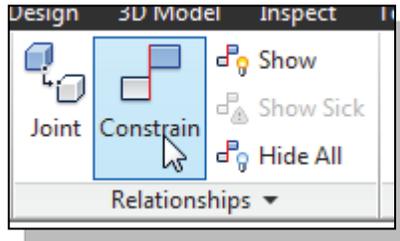
3. On your own, use the left-mouse-button and rotate the part roughly about 180 degrees, about the vertical axis, as shown.



4. Inside the graphics window, right-mouse-click once to bring up the option menu and select **OK** to end the **Rotate Component** command.

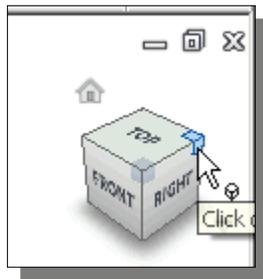
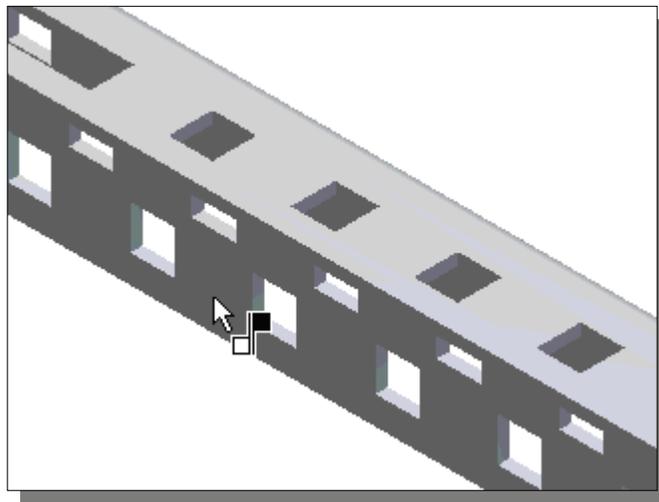
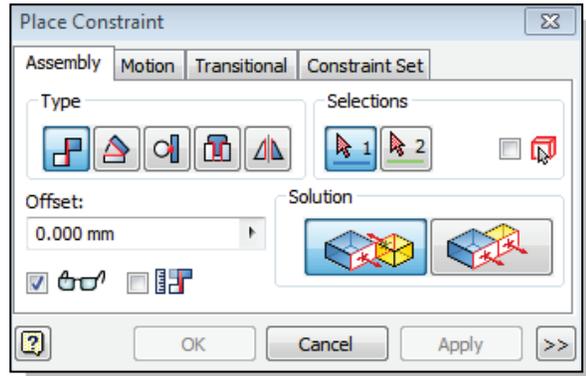
5. On your own, repeat the above steps and rotate the other **Bearing Flat** part to the same orientation.

## Apply Assembly Constraints



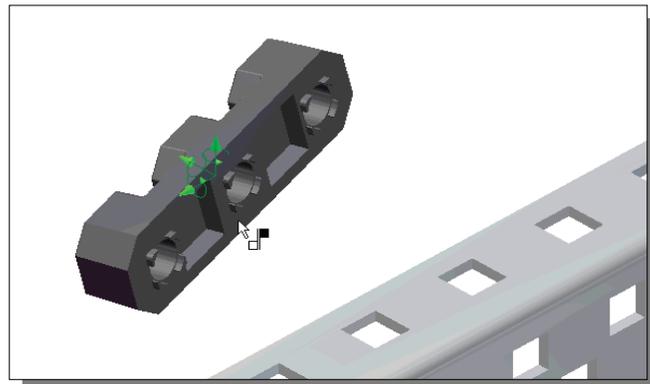
1. In the *Assembly* panel, select the **Constrain** command by left-mouse-clicking once on the icon.

2. In the *Place Constraint* dialog box, confirm the constraint *Type* is set to the **Mate** constraint.
3. Select the vertical surface of the base component, facing the **30mm Block**, as the first item for the *Mate* alignment command.



4. On your own, use the *ViewCube* to adjust the displayed model to view the back of the rotated **Bearing Flat** part as shown.

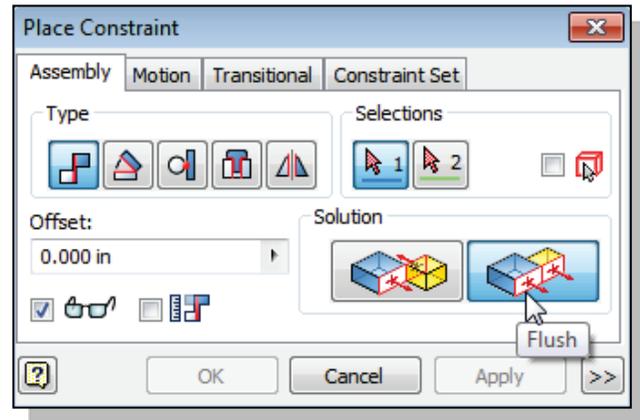
5. Click on the back face of the **Bearing Flat** part as the second part selection to apply the constraint.



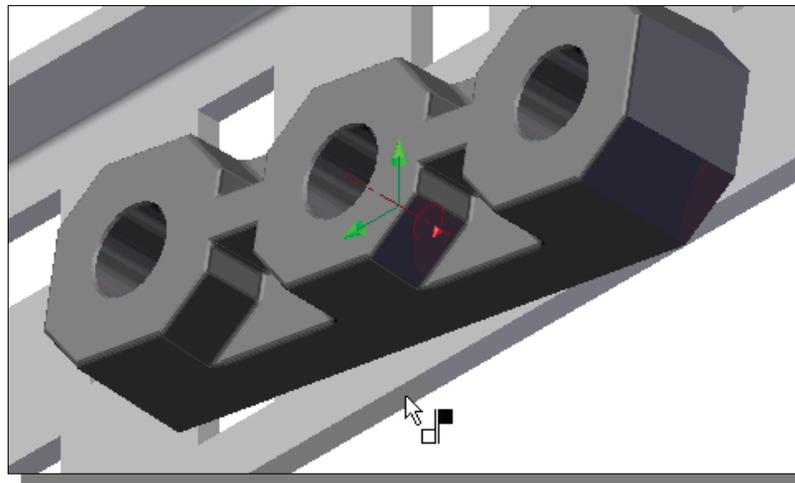


- Click on the **Apply** button to accept the selection and apply the Mate constraint.

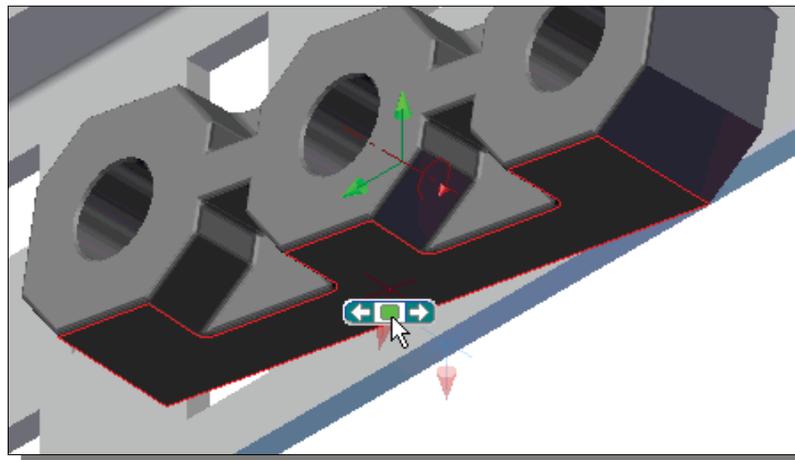
- In the *Place Constraint* dialog box, set the constraint *Type* to the **Flush** constraint.



- Select the bottom surface of the base component, the **Chassis Rail**, as the first item for the **Flush** alignment command



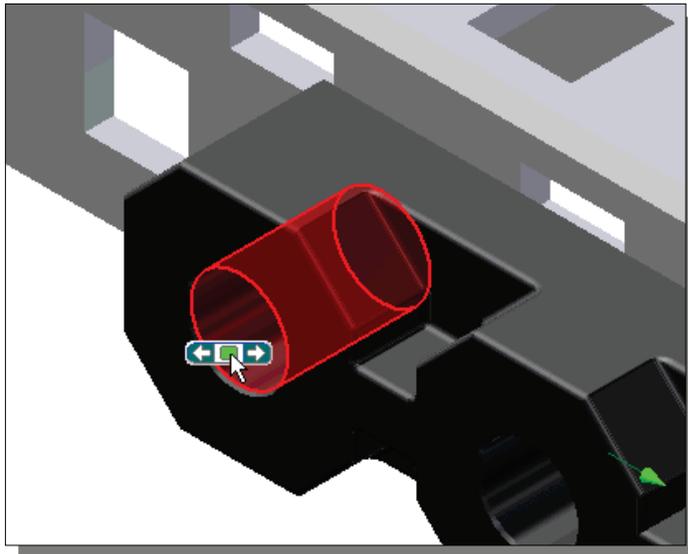
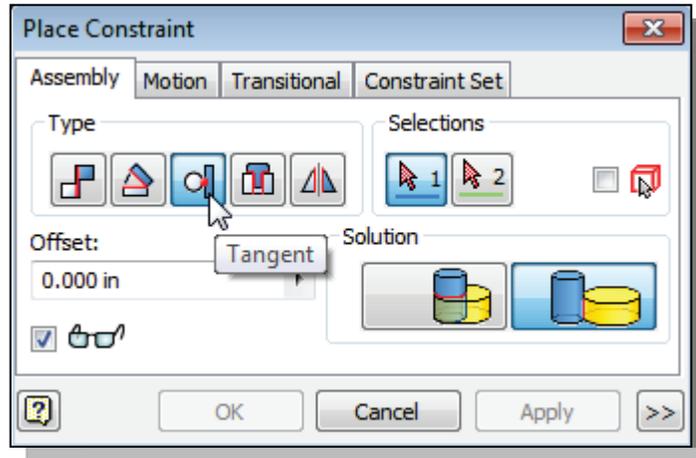
- Click on the corresponding face of the **Bearing Flat** part as the second item to apply the constraint.





10. Click on the **Apply** button to accept the selection and apply the Flush constraint.

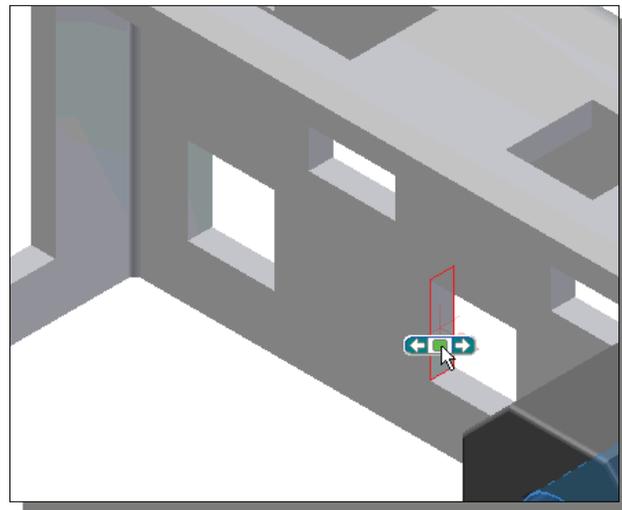
11. In the *Place Constraint* dialog box, set the constraint *Type* to the **Tangent** constraint.



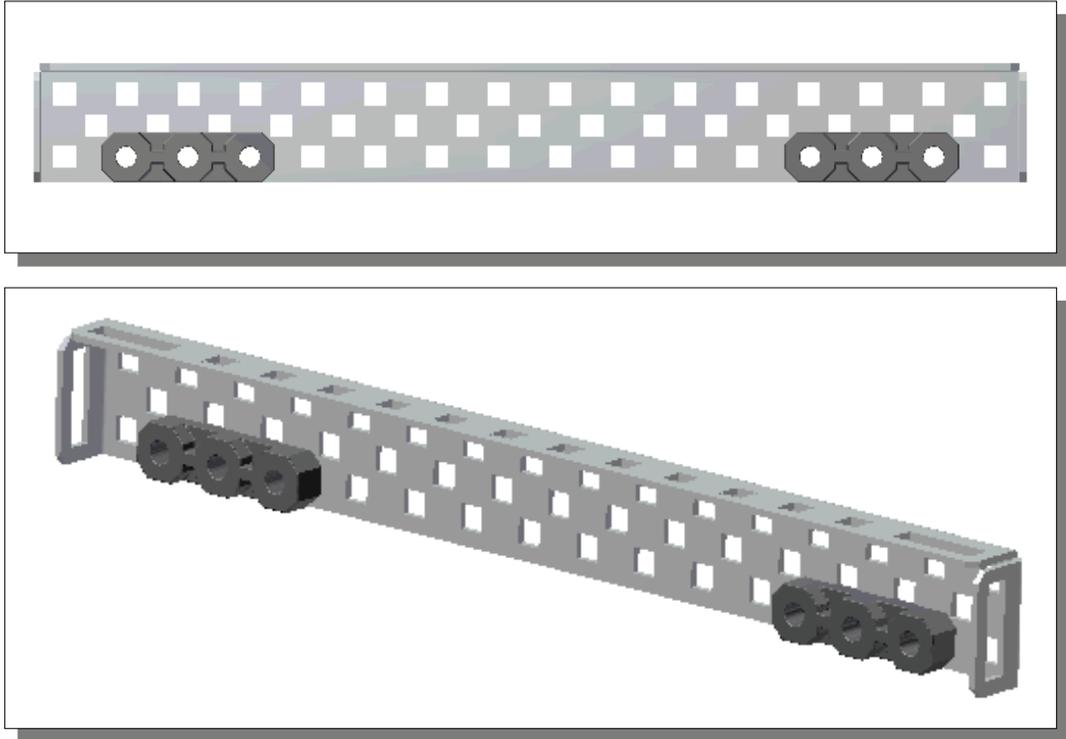
12. Select the left cylindrical surface of the **Bearing Flat** part as the first item to apply the constraint.

13. Select the vertical surface of the second square hole of the **Chassis Rail** as the second item for the Tangent alignment command.

14. Click on the **OK** button to accept the selection and apply the constraint.



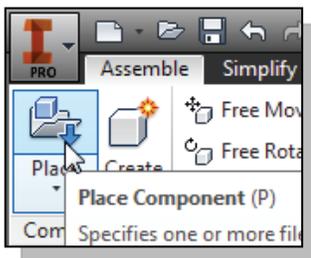
- On your own, repeat the above steps and constrain the second copy of **Bearing Flat** as shown.



- Note the degrees of freedom symbol is removed once the component is fully constrained.

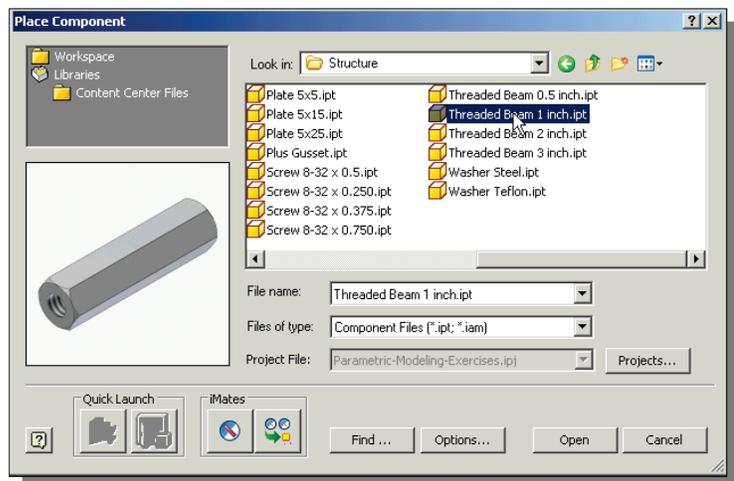
## Assemble the Next Component

- Next, we will assemble two copies of the *Threaded Beam 1 inch* part.

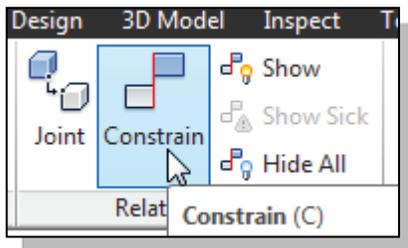
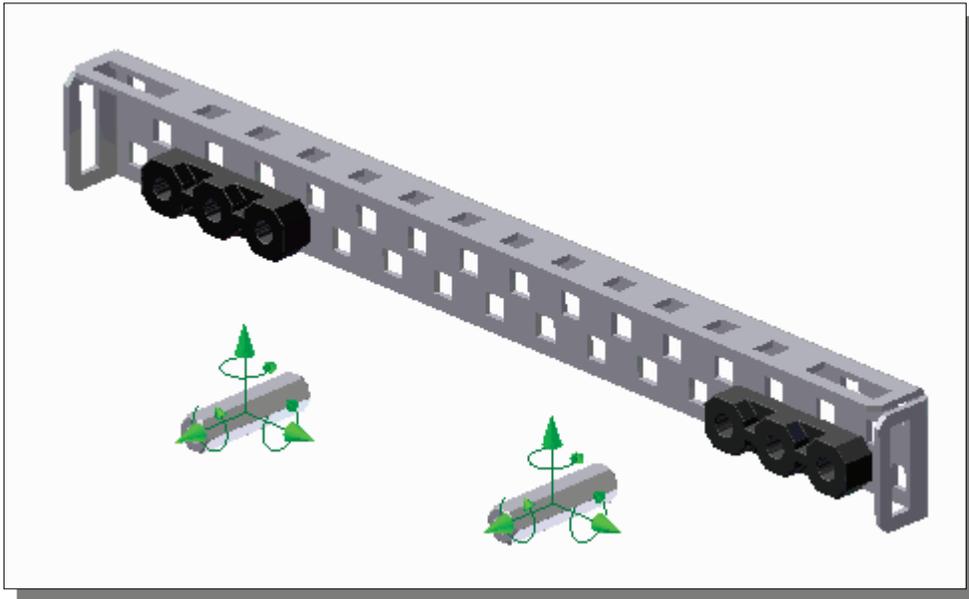


- In the *Assembly* panel, select the **Place Component** command by left-mouse-clicking the icon.

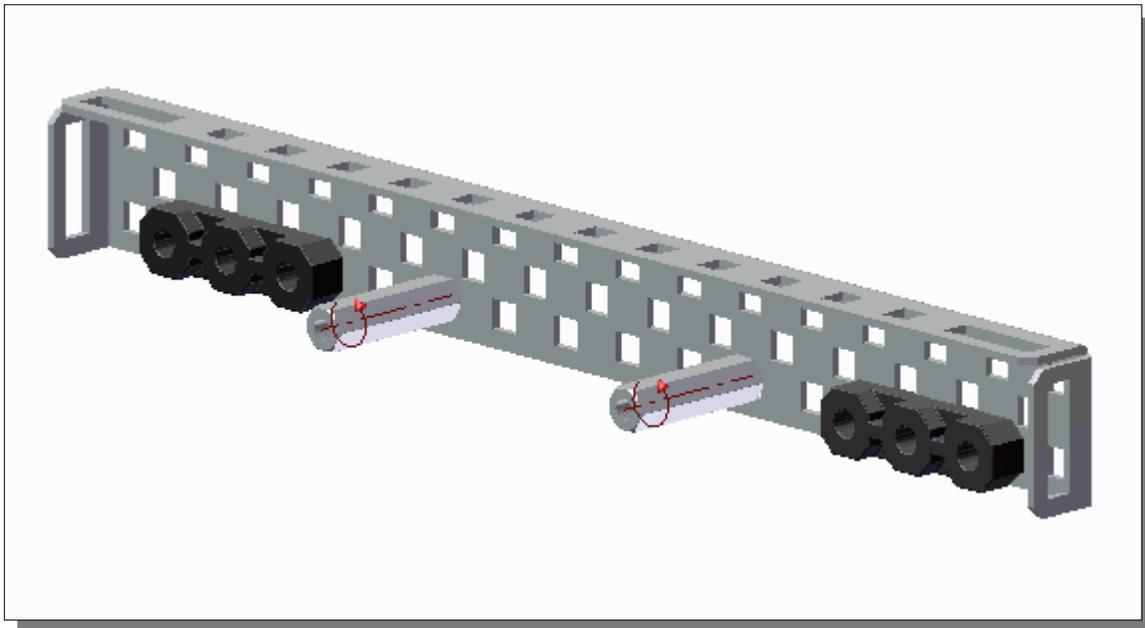
- Select the **Threaded Beam 1 inch** design in the list window. Click on the **Open** button to retrieve the model.



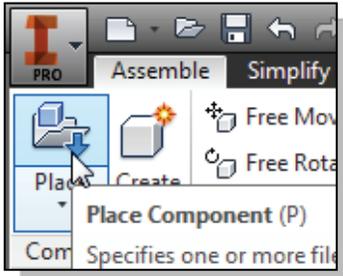
- Place **two** copies of the *Threaded Beam* toward the left side of the graphics window, as shown in the figure.



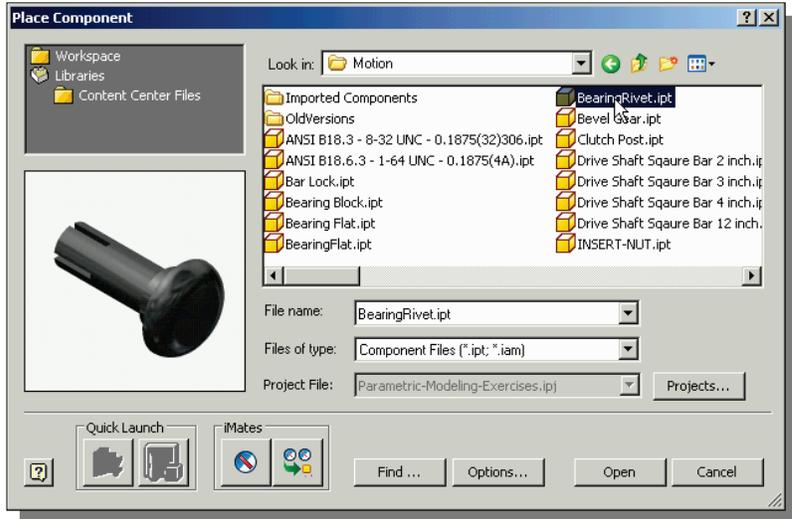
- In the *Assembly* panel, select the **Constrain** command by left-mouse-clicking once on the icon.
- On your own, apply the **Mate** and **Tangent** constraints to fully assemble the part as shown. Note the two parts still have one degree of freedom available; they can still rotate about their center axes.



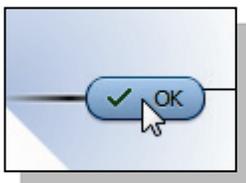
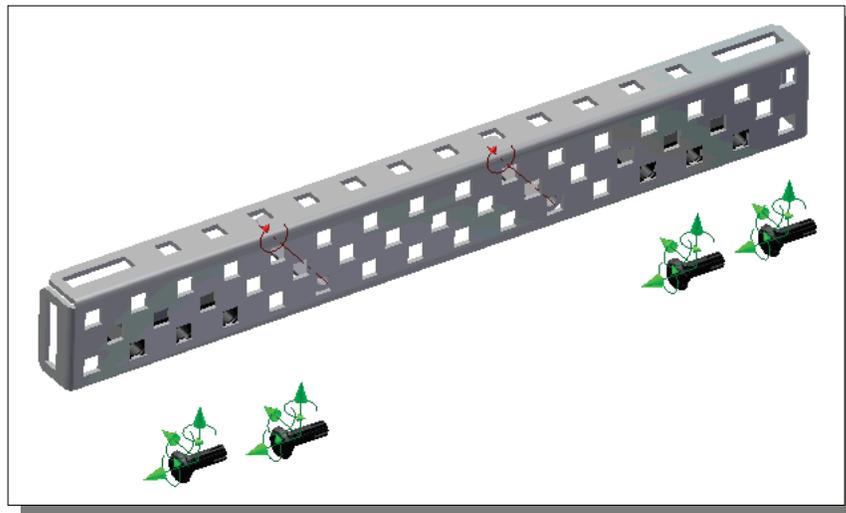
## Assembling Bearing Rivets and Screws



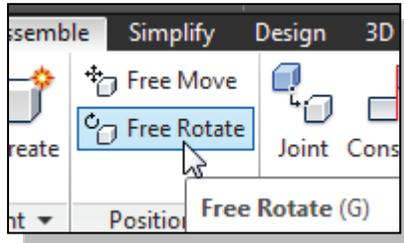
1. In the *Assembly* panel, select the **Place Component** command by left-mouse-clicking the icon.
2. Select the **Bearing Rivet** design in the list window. Click on the **Open** button to retrieve the model.



3. Place four copies of the part toward the right side of the assembly as shown.

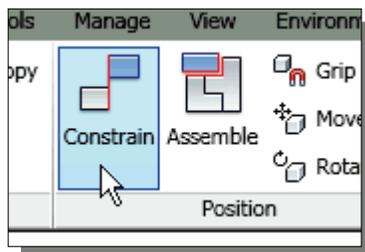
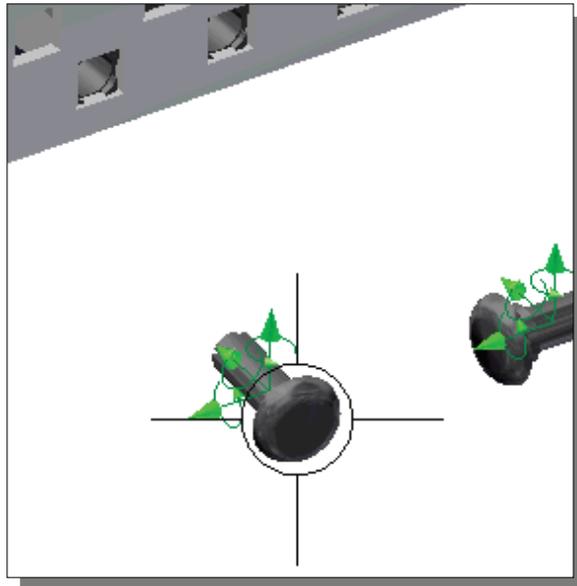


4. Inside the graphics window, right-mouse-click once to bring up the option menu and select **OK** to end the placement of the part.

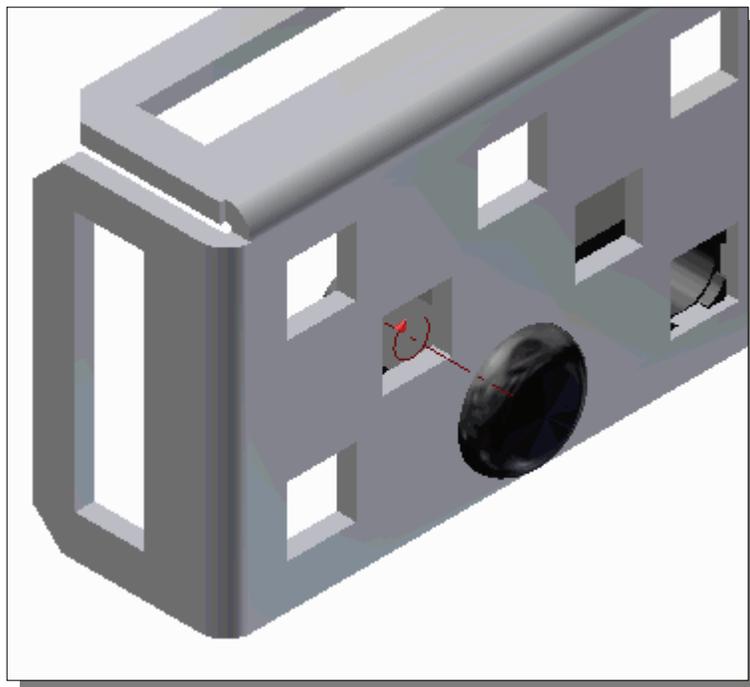


5. Select the **Free Rotate** command by left-mouse-clicking once on the icon.

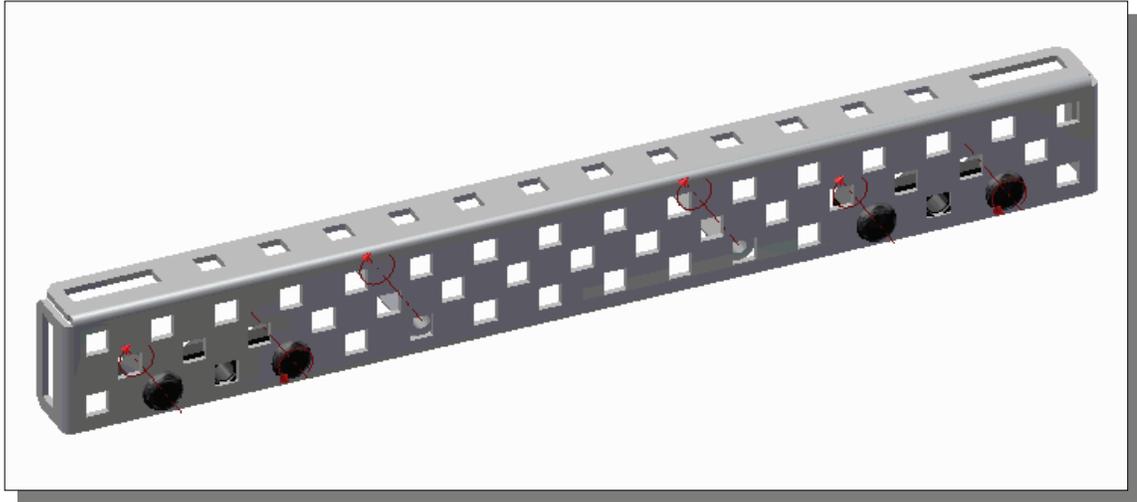
6. On your own, use the left-mouse-button and rotate one of the parts to the assembly orientation as shown.



7. In the *Assembly* panel, select the **Constrain** command by left-mouse-clicking once on the icon.
8. On your own, apply two **Mate** constraints to assemble the part as shown. (Hint: Mate the center axis of the *Rivet* part to the inside cylindrical surface of the *Bearing*.)

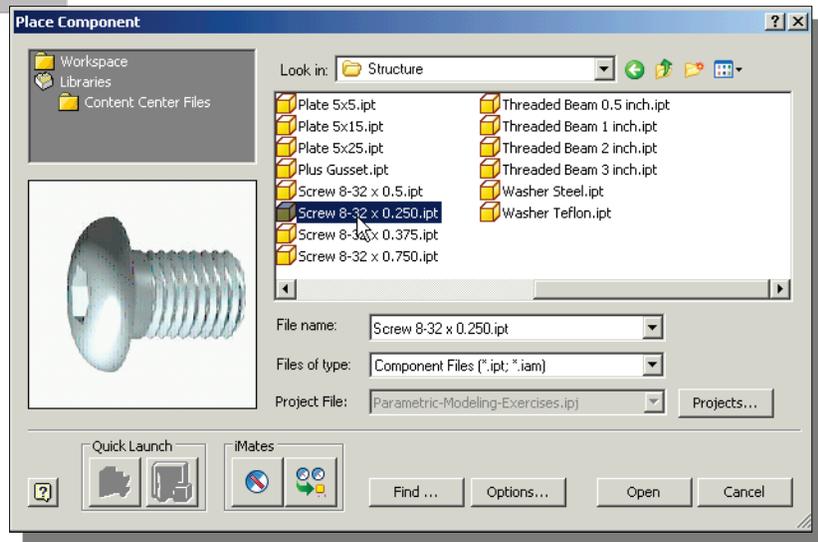


- On your own, repeat the above steps and constrain the other copies of the **Bearing Rivet** as shown.

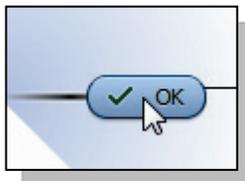


- In the *Assembly* panel, select the **Place Component** command by left-mouse-clicking the icon.

- Select the **Screw 8-32 x 0.25** design in the list window. Click on the **Open** button to retrieve the model.

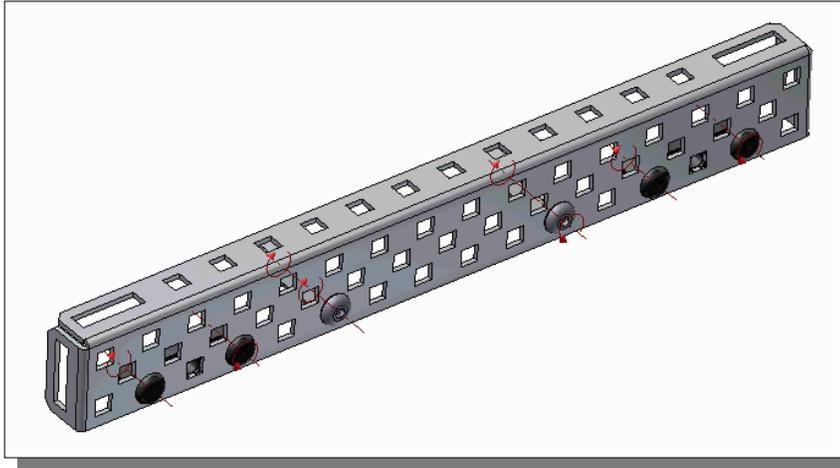


- Place two copies of the part toward the lower right corner of the graphics window.



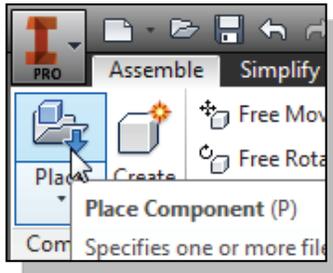
- Inside the graphics window, **right-mouse-click** once to bring up the *option menu* and select **OK** to end the placement of the part.

14. On your own, apply the **Mate** constraints to assemble the two copies of the **Screw 8-32** part to the model as shown.

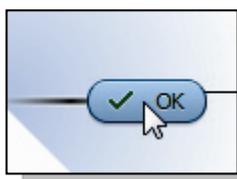
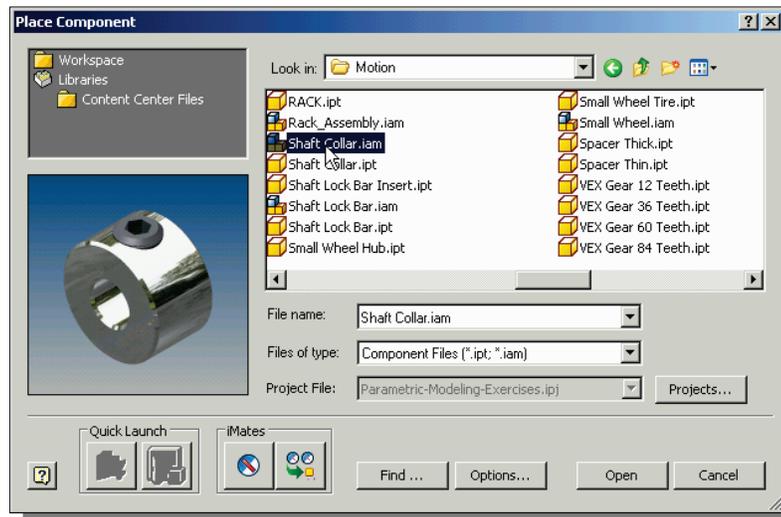


### Assembling Shaft Collars, Shafts and Motors

- In *parametric modeling*, a sub-assembly can be placed into another assembly/sub-assembly model, and a sub-assembly behaves just like a regular part. Each component in an assembly has **six degrees of freedom**; a sub-assembly is treated as a component and thus possesses six degrees of freedom.

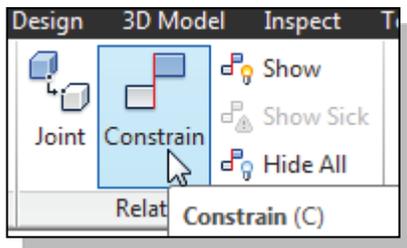
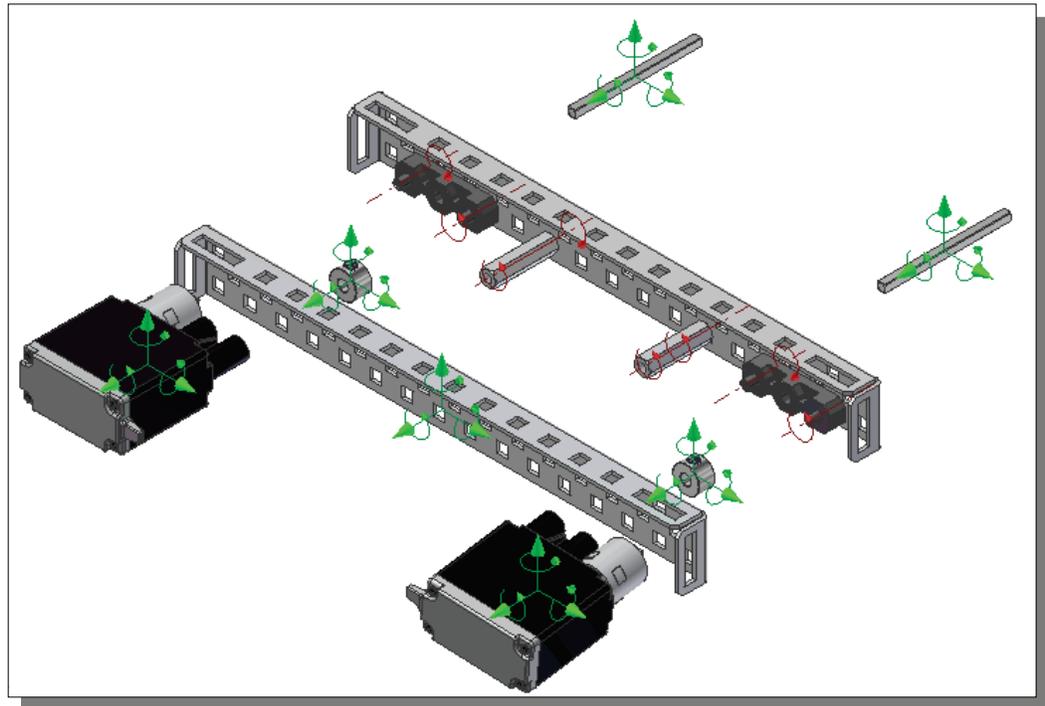


- In the *Assembly* panel, select the **Place Component** command by left-mouse-clicking the icon.
- Select the **Shaft Collar.iam** assembly in the list window. Click on the **Open** button to retrieve the model.

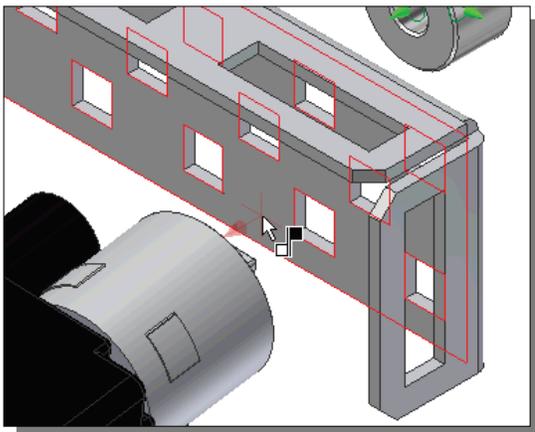


- Place two copies of the **Shaft Collar** toward the left side of the assembly.
- Inside the graphics window, right-mouse-click once and select **OK** to end the command.

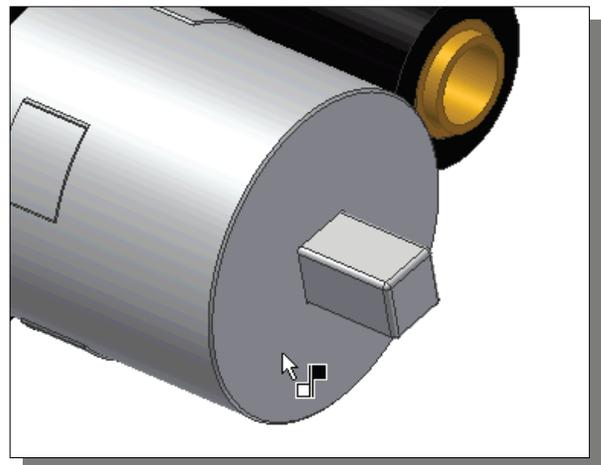
- On your own, repeat the above steps and place another copy of the **Chassis Rail 15 Hole** part, two copies of the **Drive Shaft Square Bar 3 inch** part and two copies of the **VEX Motor** assembly as shown.



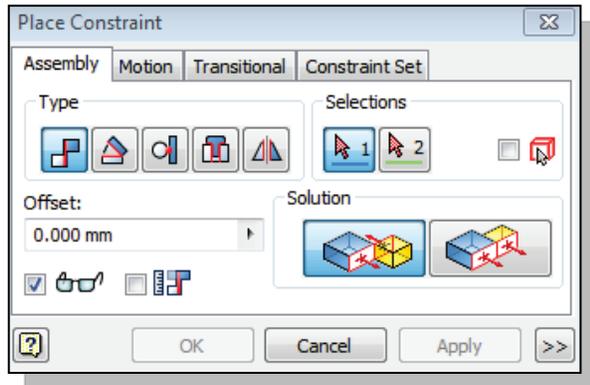
- In the *Assembly* panel, select the **Constrain** command by left-mouse-clicking once on the icon.
- In the *Place Constraint* dialog box, confirm the **Mate** constraint is activated.



- Align the two faces of the two parts as shown.

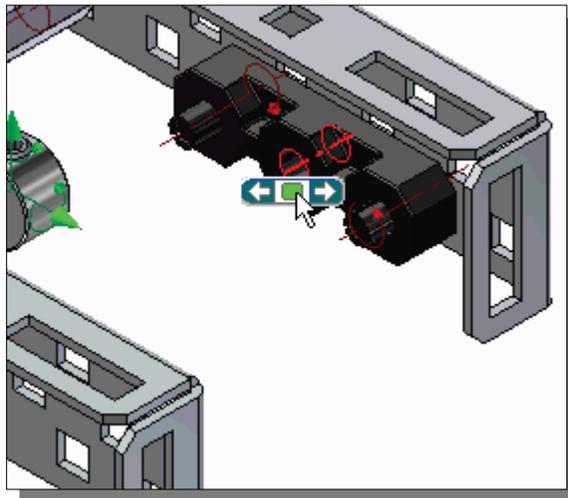
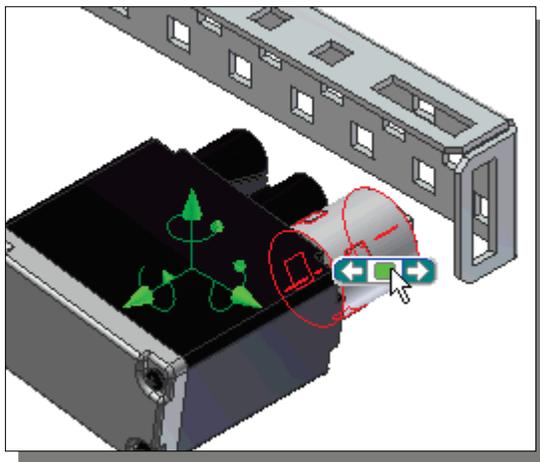


- Click on the **Apply** button to accept the selection and apply the **Mate** constraint.



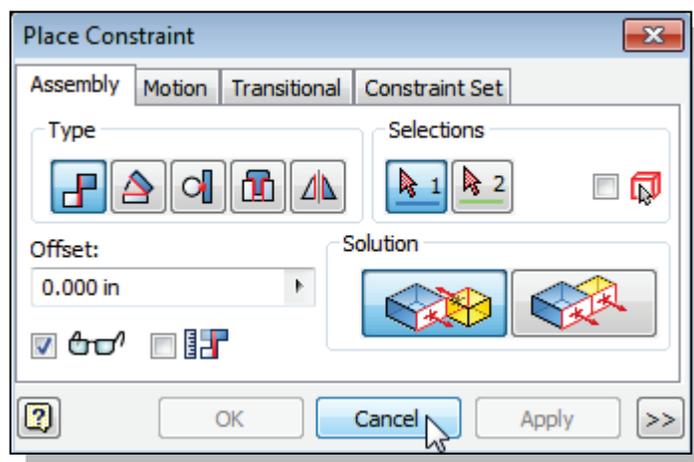
10. In the *Place Constraint* dialog box, set the *Type* to the **Mate** constraint.

11. Align the **larger center axis of the *Motor* part** to the **middle axis of the *Bearing* part** as shown.

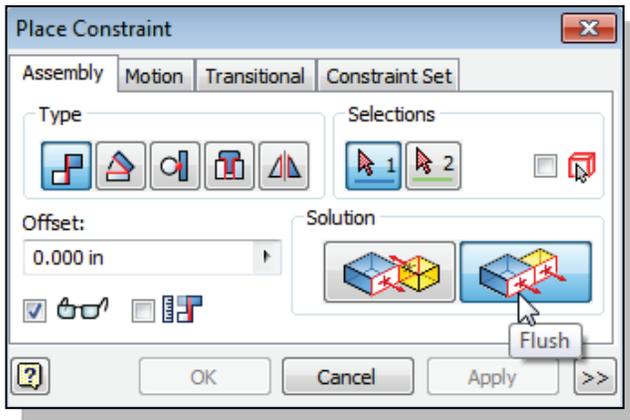
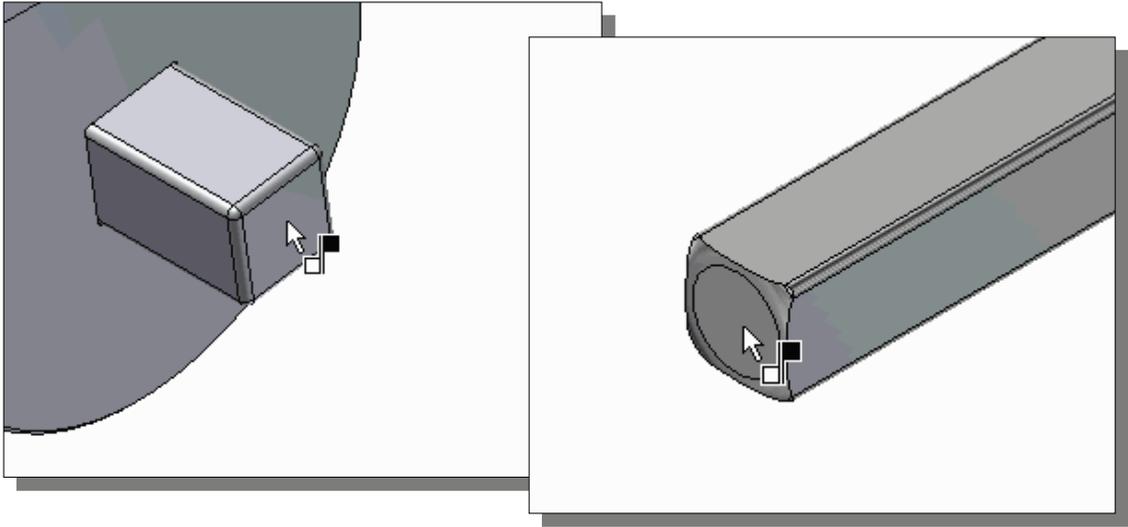


12. Click on the **Apply** button to accept the selection and apply the **Mate** constraint.

13. If necessary, exit the **Constrain** command and reposition the parts by **drag and drop**.

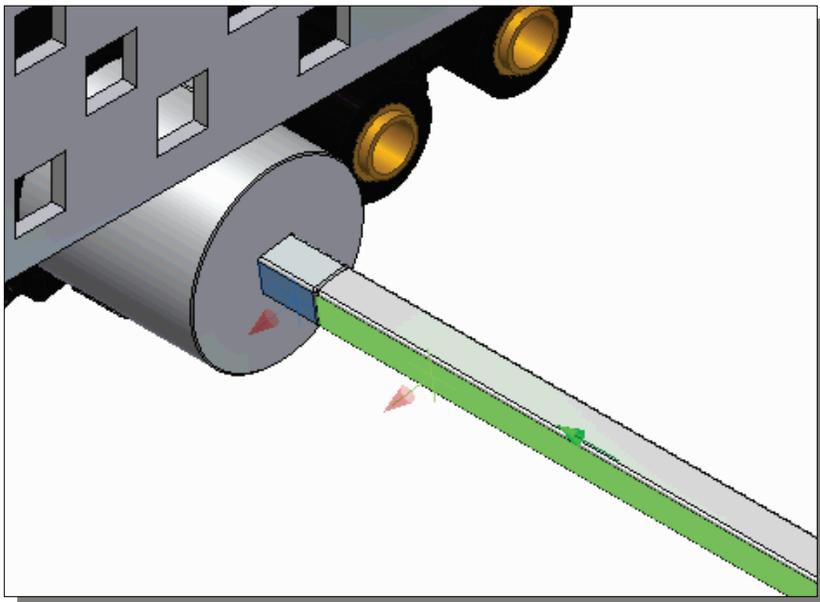


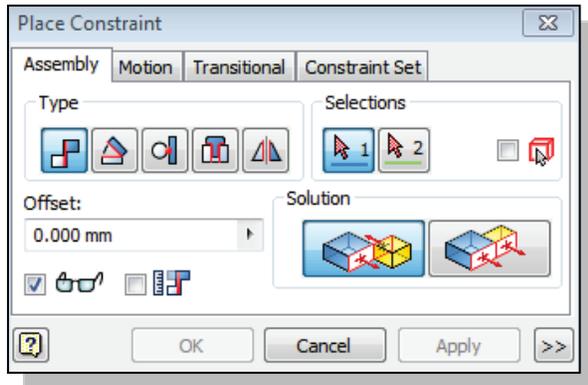
14. Repeat the above steps and **Mate** the two faces of the **Motor** and the **Shaft** as shown.



15. Click on the **Apply** button to accept the selection and apply the Flush constraint.

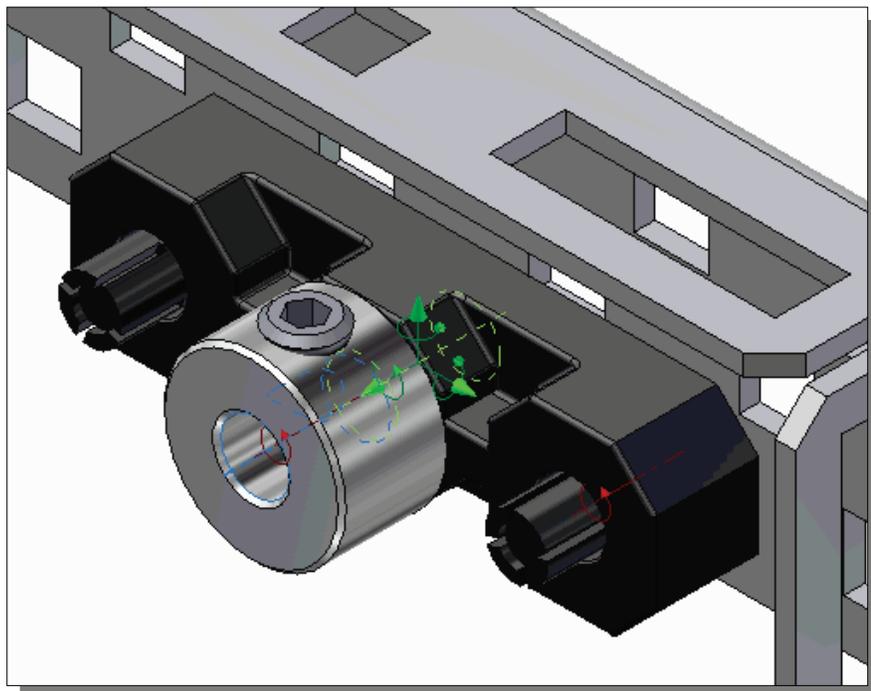
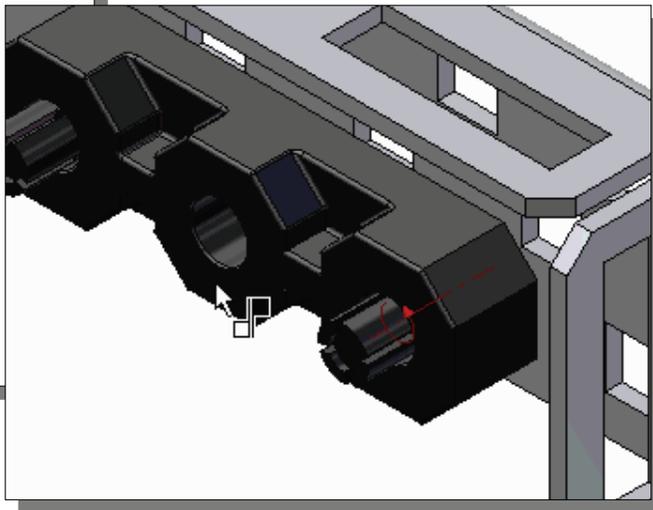
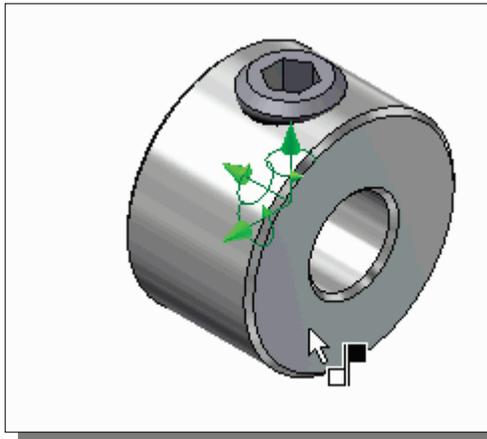
16. On your own, align the **Shaft** to the **Motor** as shown.

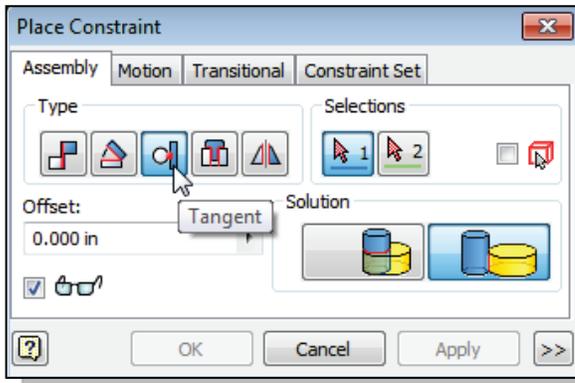




17. In the *Place Constraint* dialog box, switch to the **Mate** constraint.

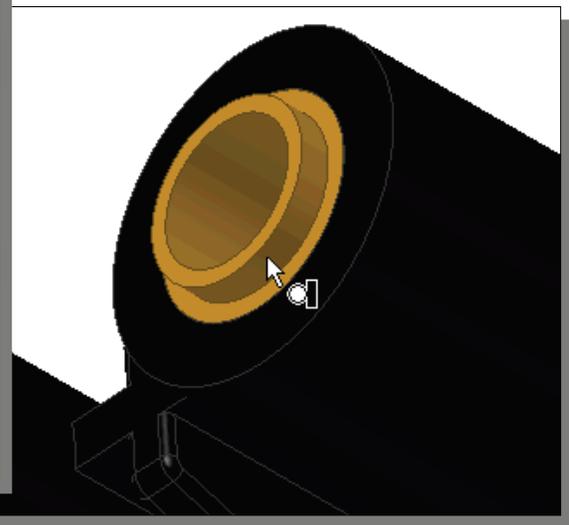
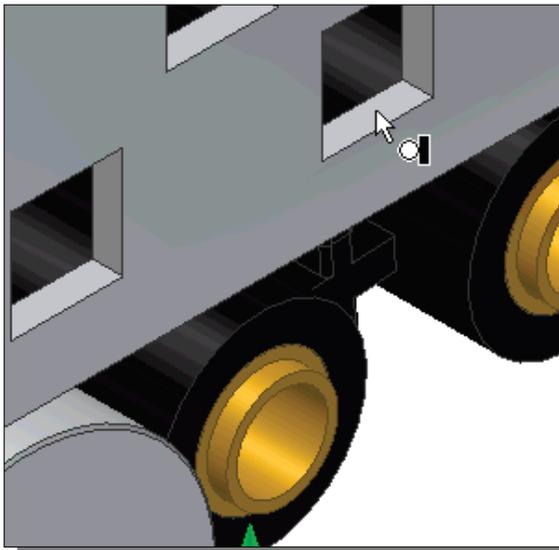
18. On your own, align the **Shaft Collar** to the **Bearing** as shown.



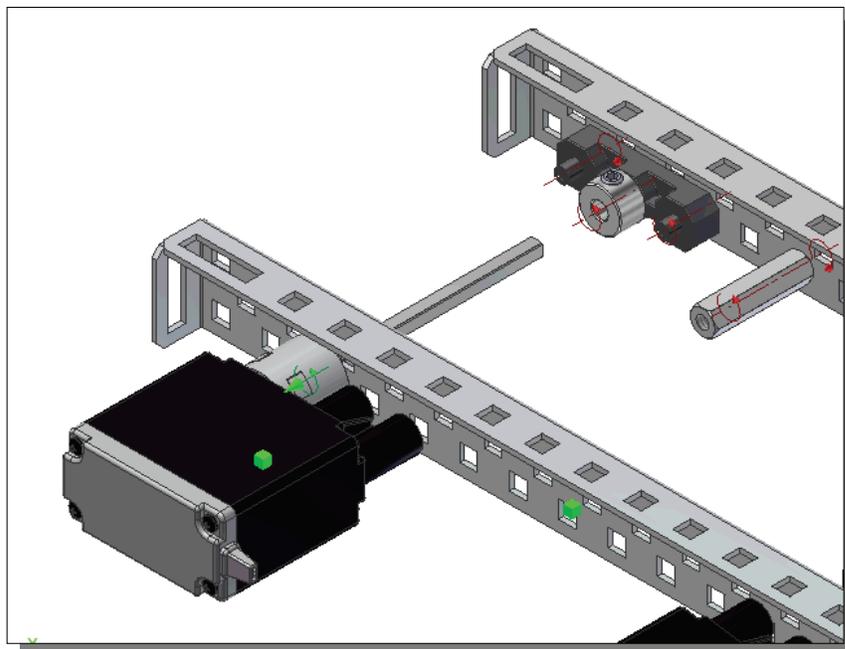


19. In the *Place Constraint* dialog box, switch to the **Tangent** constraint.

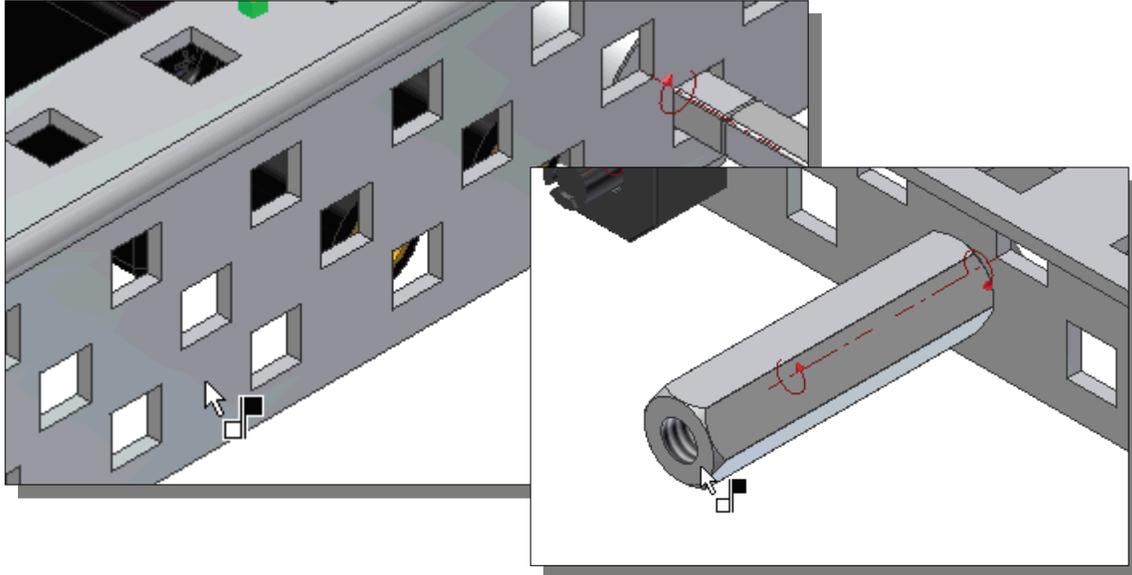
20. Align the two surfaces of the **Motor** and the **Chassis Rail** as shown.



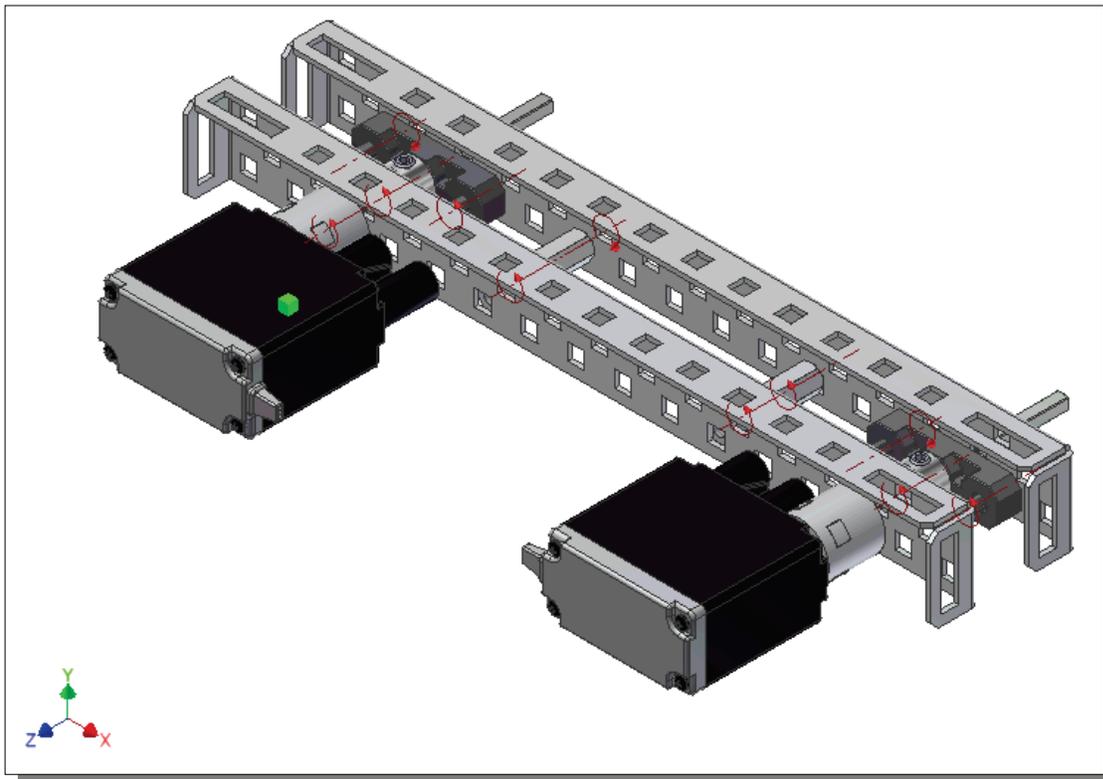
21. On your own, assemble the parts to the other end as shown.



22. On your own, assemble the **Chassis Rail** to the **Threaded Beam** as shown.



23. On your own, align the two **Chassis Rails**; the completed assembly should appear as the figure below.

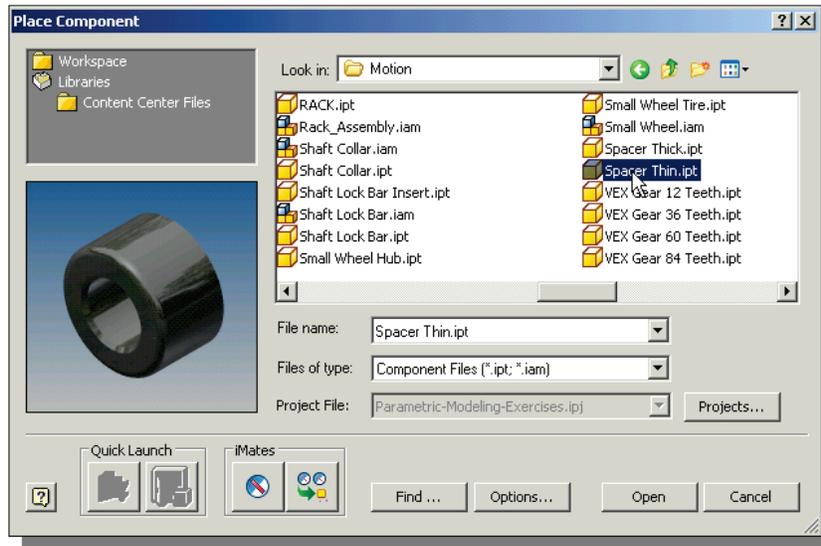


- Note that we did not add some of the motor screws to the assembly; the applied constraints are sufficient to position the motors and shafts. Also, note that there are still some rotational degrees of freedom not removed; these DOF reflect the moving parts in the assembly.

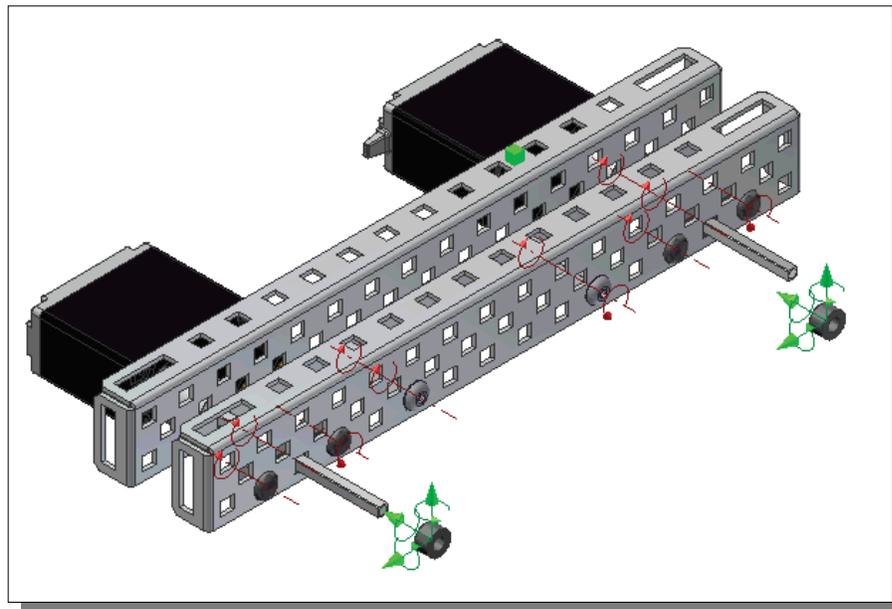
## Assemble the Wheels



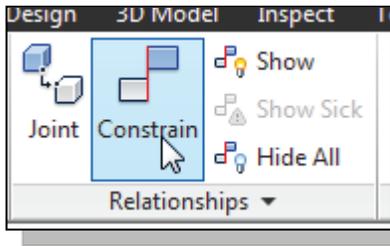
1. In the *Assembly* panel, select the **Place Component** command by left-mouse-clicking once on the icon.
2. Select the **Spacer Thin** part in the list window. Click on the **Open** button to retrieve the model.



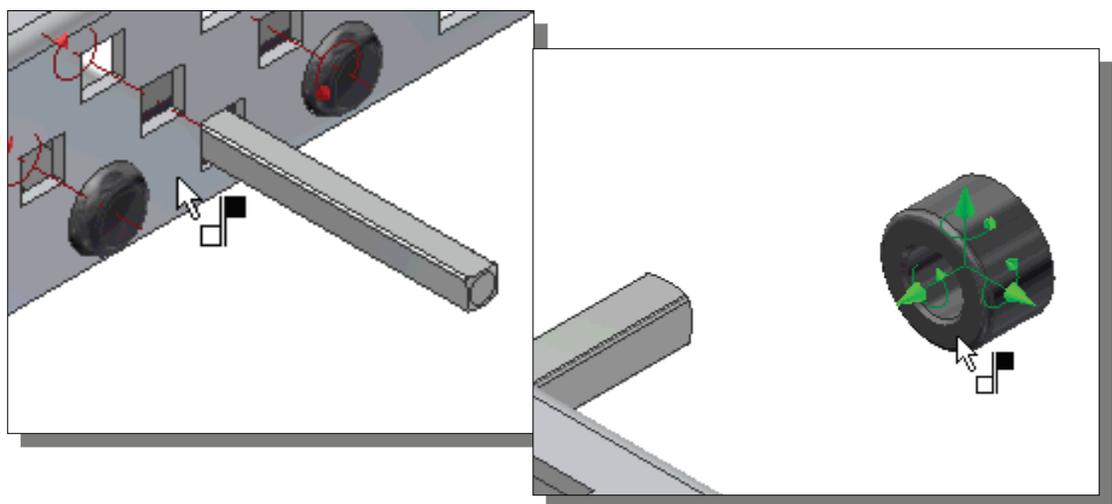
3. Place two copies of the part to the right side of the assembly as shown.



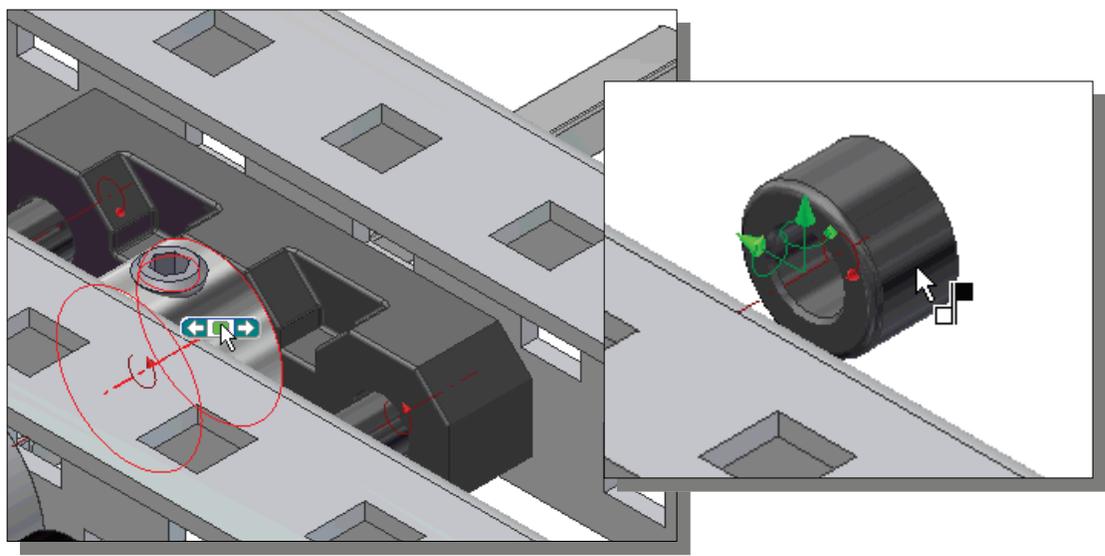
4. Inside the graphics window, right-mouse-click once to bring up the option menu and select **Done** to end the Place Component command.



5. In the *Assembly* panel, select the **Constrain** command by left-mouse-clicking once on the icon.
6. On your own apply the **Mate** constraint to the two surfaces as shown in the figures above.



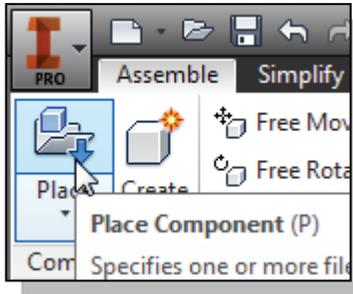
7. Also **Mate** the center axes of the **Spacer Thin** and the **Shaft Collar** as shown.



8. Repeat the above steps and assemble the other **Spacer Thin**.

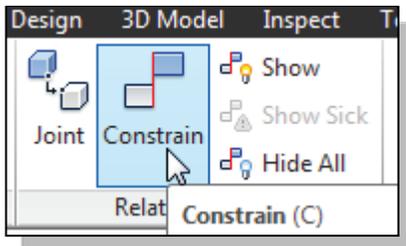
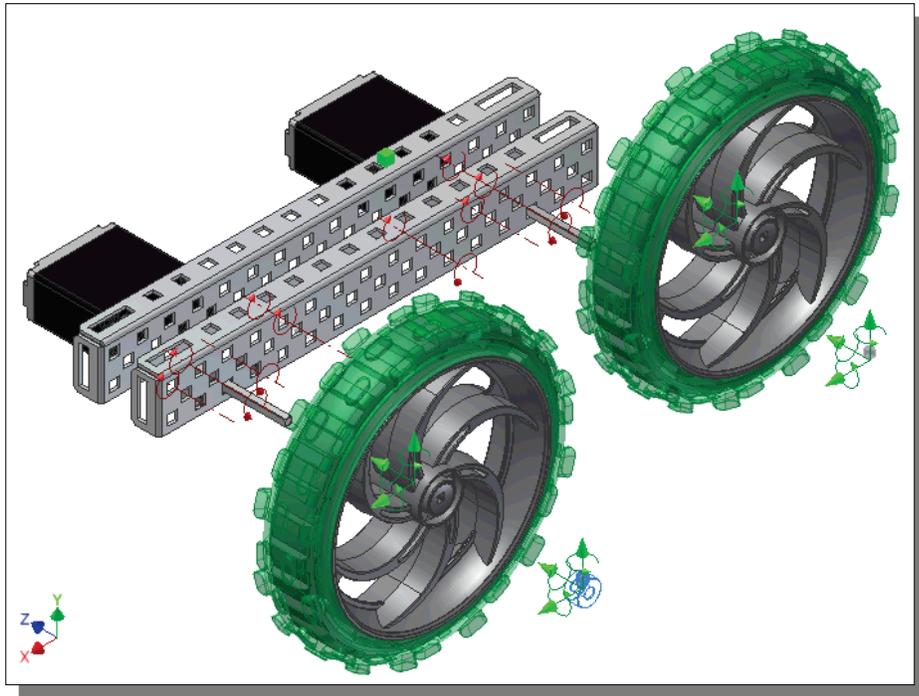


9. Click the **Cancel** button to exit the Constrain command.

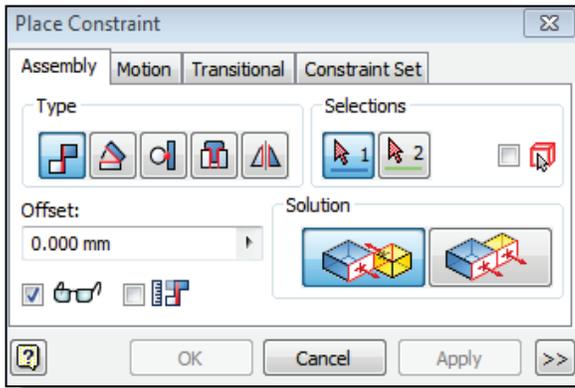


10. In the *Assembly* panel, select the **Place Component** command by left-mouse-clicking once on the icon.

11. Place two copies of the **Shaft Collar** part and two copies of the **Large Wheel** assembly as shown.

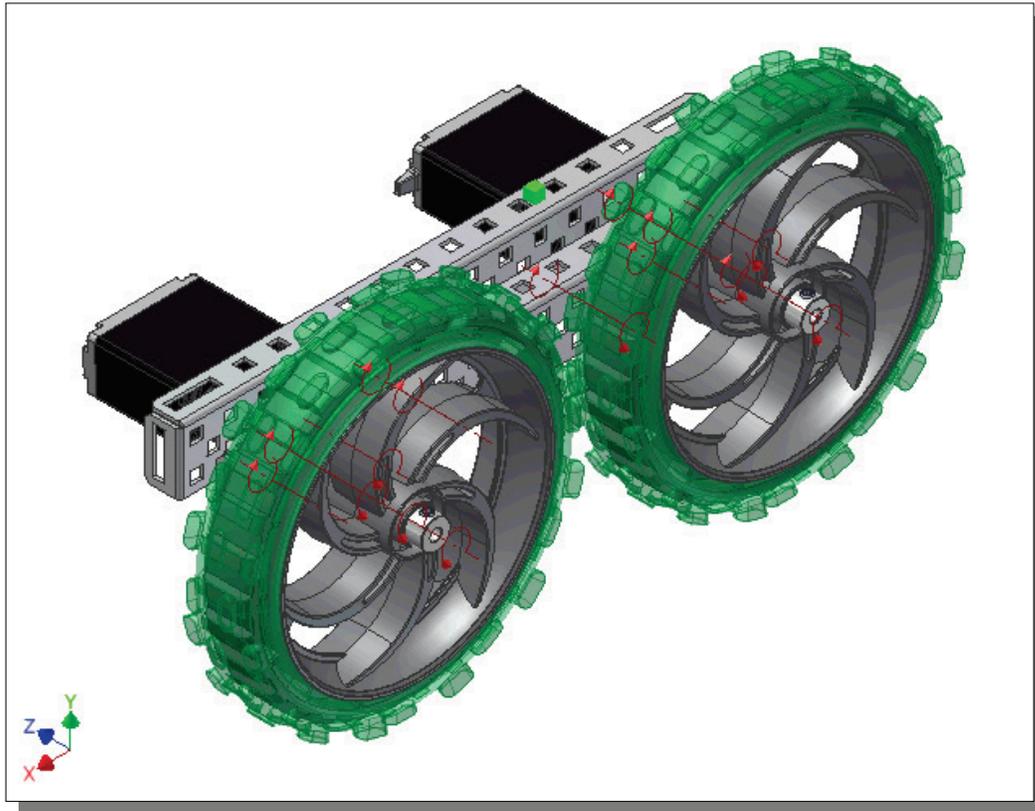


12. In the *Assembly* panel, select the **Constrain** command by left-mouse-clicking once on the icon.

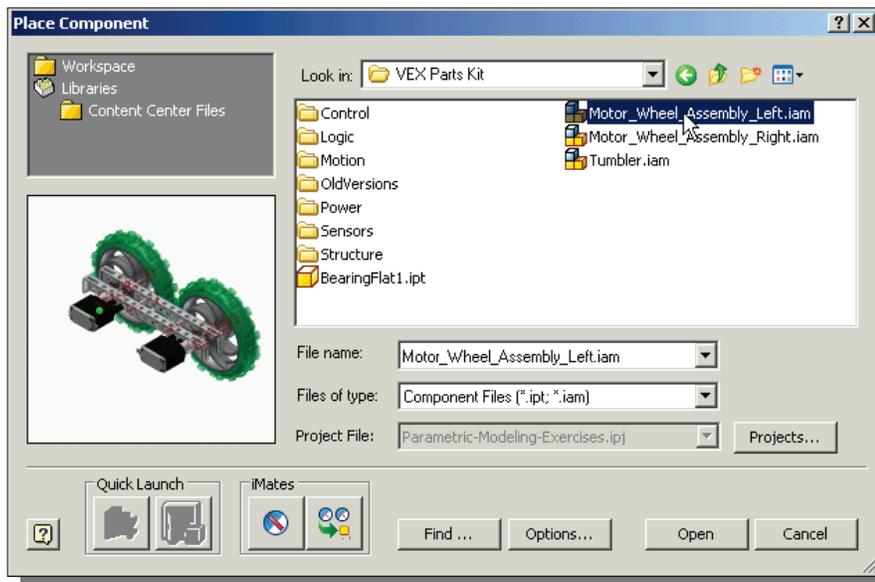


13. In the *Place Constraint* dialog box, use the **Mate** constraint.

14. On your own, assemble the two **Collars** and **Wheels**. Note the direction of the wheels; this will be our left wheel assembly.



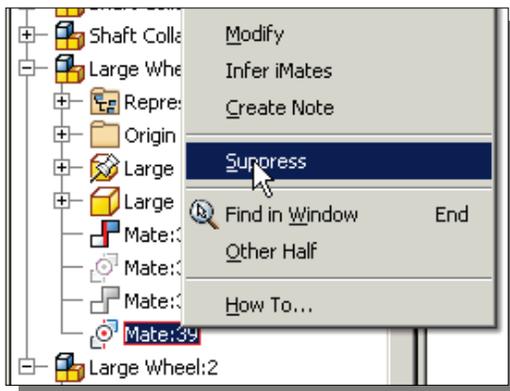
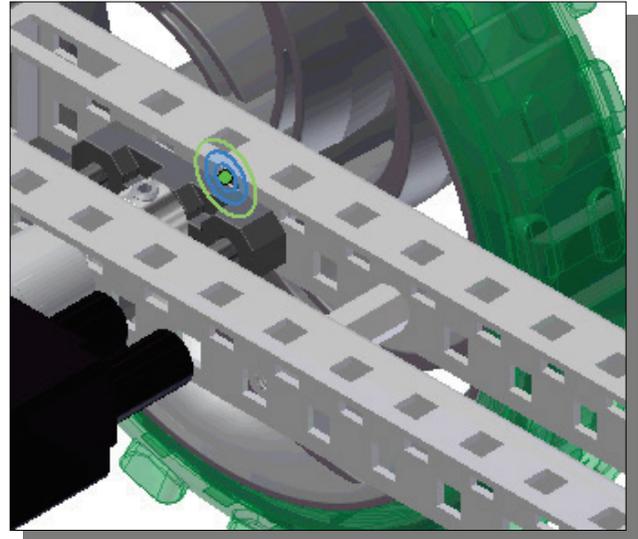
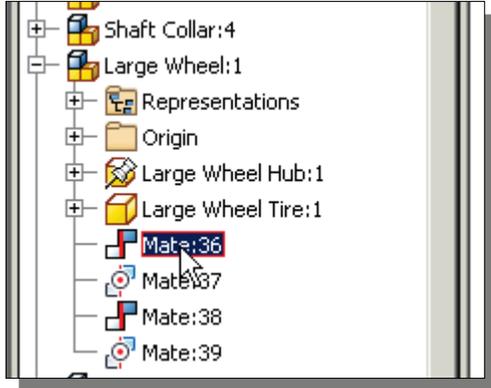
15. On your own, save the completed model as a subassembly, using the name: **Motor\_Wheel\_Assembly-Left.iam**.



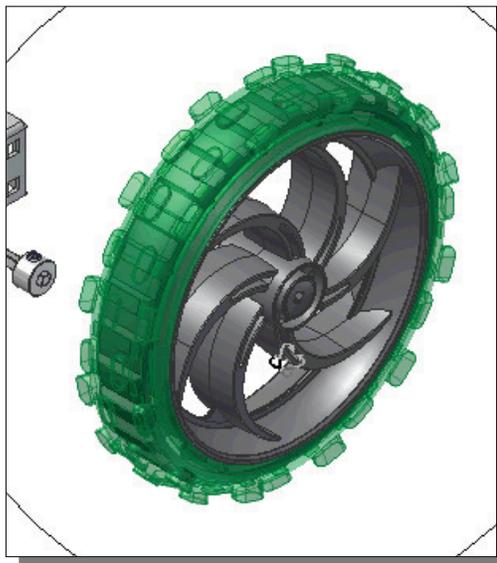
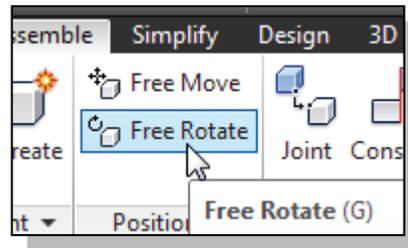
- We will next edit the current assembly and create the right side motor-wheel assembly.

## Modifying the Wheel Directions

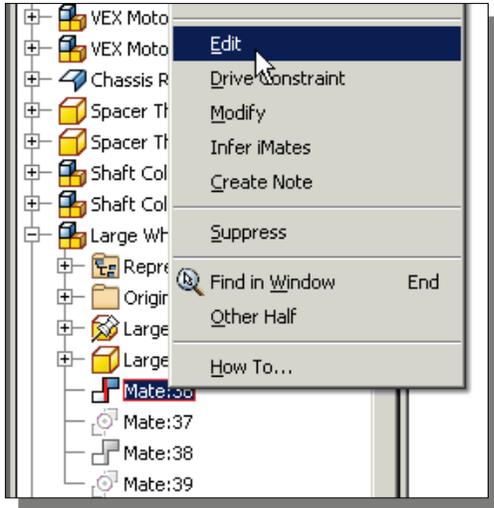
1. In the *browser* window, expand the first *Wheel* item list and locate the *Mate* constraint used to control the direction.



2. On your own, **Suppress** all the other constraints for the *Wheel*.
3. Select the **Rotate Component** command by left-mouse-clicking once on the icon.

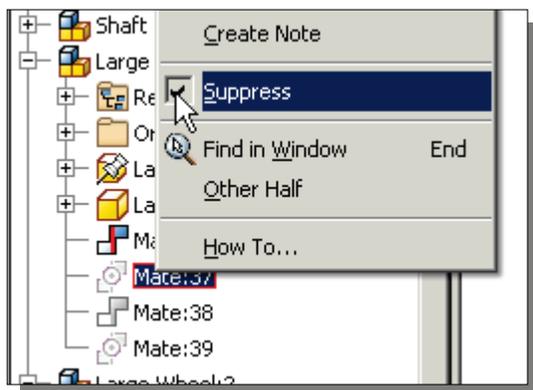
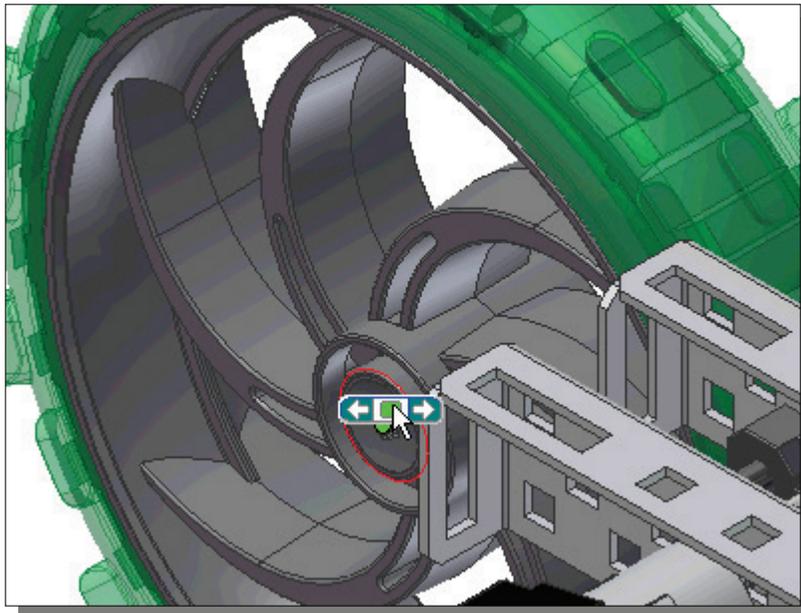


4. On your own, rotate the *Wheel* 180 degrees.



5. **Right-mouse-click** on the identified *Mate* constraint to bring up the option list. Choose **Edit** to modify the constraint settings.

6. Examine the geometry selected for the constraint and select the corresponding geometry on the *Wheel* as shown.

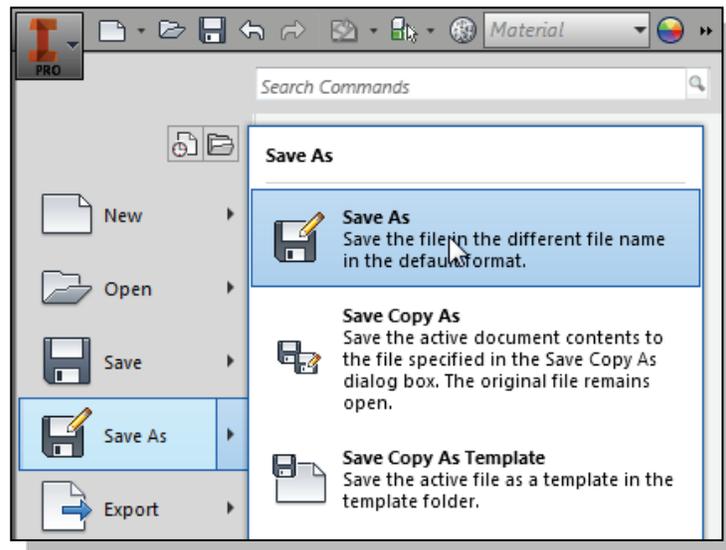


7. In the *browser* window, reactivate the next suppressed item in the list.
8. Examine and modify the constraint settings if necessary.

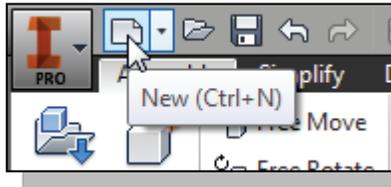
9. Repeat the above steps and also adjust the aligned *Shaft Collar*.
10. Repeat the above steps and adjust the direction of the other *Wheel*.



11. On your own, use the **Save As** command and save the assembly as a new subassembly, using the name: ***Motor\_Wheel\_Assembly-right.iam***.

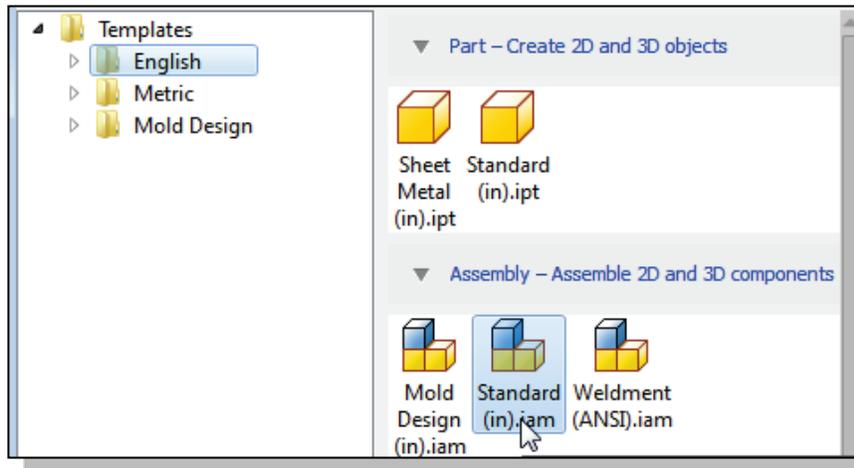


## Starting the Tumbler Assembly

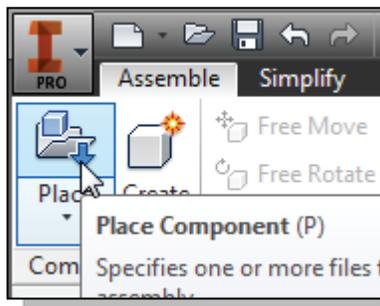


1. Select the **New File** icon with a single click of the left-mouse-button in the *quick access* toolbar as shown.

2. Select the **English** units set and in the *Template* list; select **Standard(in).iam** (*Standard Inventor Assembly Model* template file).

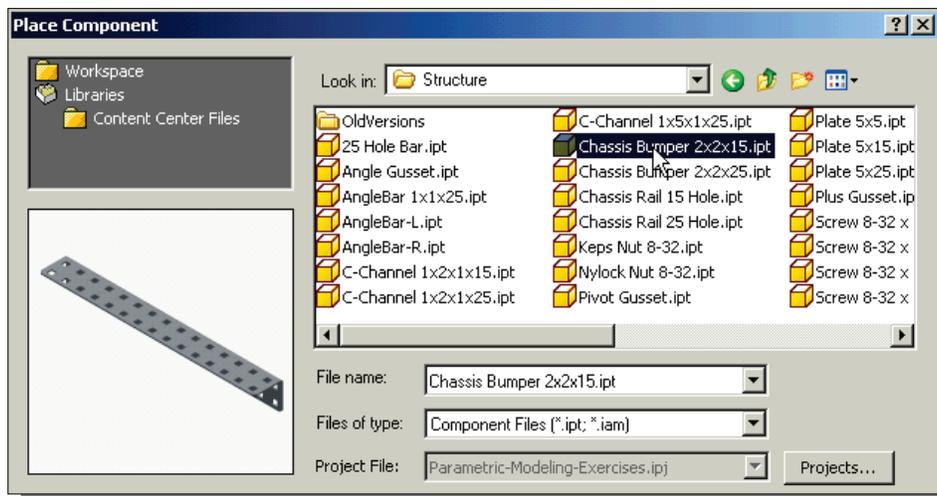


3. Click on the **OK** button in the *New File* dialog box to accept the selected settings.

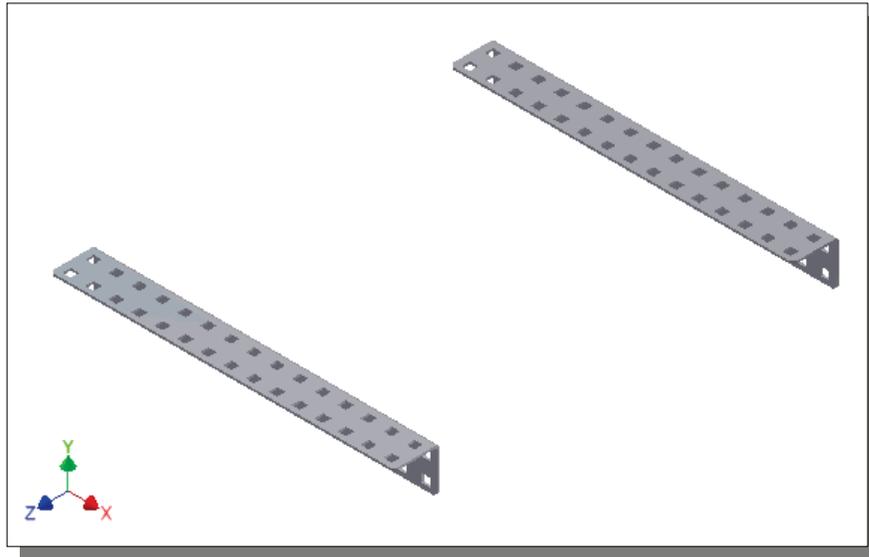


4. In the *Assembly* panel, select the **Place Component** command by left-mouse-clicking once on the icon.

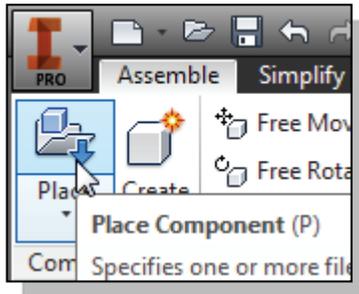
5. Select the **Chassis Bumper 2x2x15** part in the list window. Click on the **Open** button to retrieve the model.



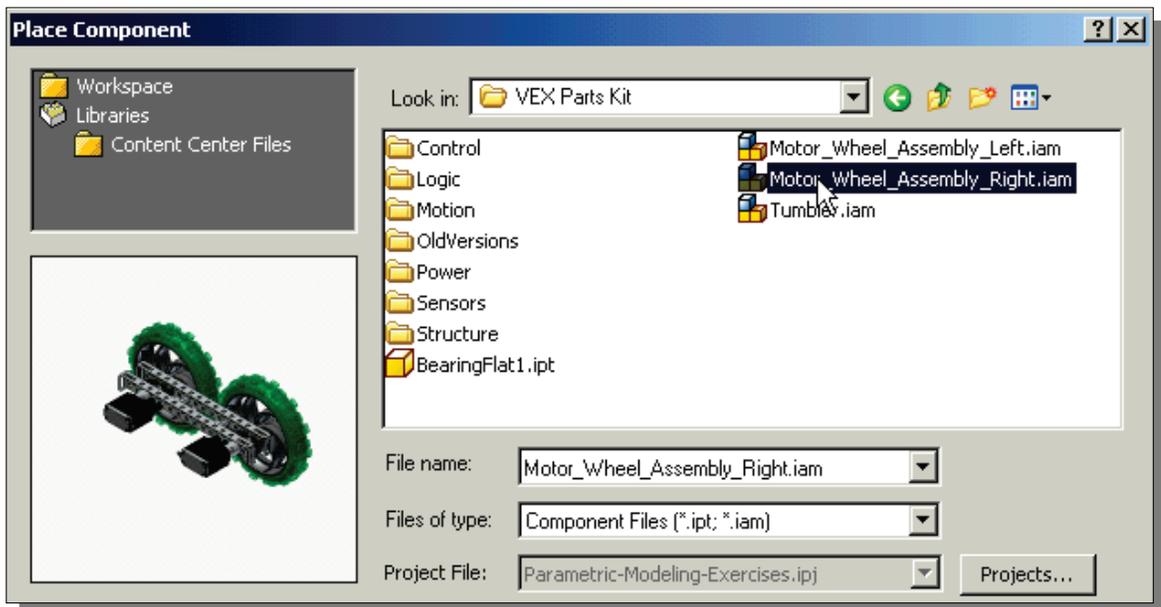
- In the graphics area, place two copies of the part, with the first copy to the right side, as shown in the figure.



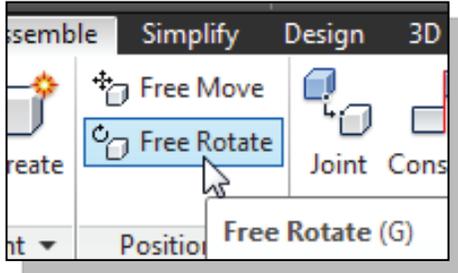
- Inside the graphics window, right-mouse-click once to bring up the option menu and select **OK** to end the placement of the **Chassis Bumper** parts.



- In the *Assembly* panel, select the **Place Component** command by left-mouse-clicking once on the icon.
- Select the **Motor\_Wheel\_Assembly-right** assembly in the list window. Click on the **Open** button to retrieve the model.

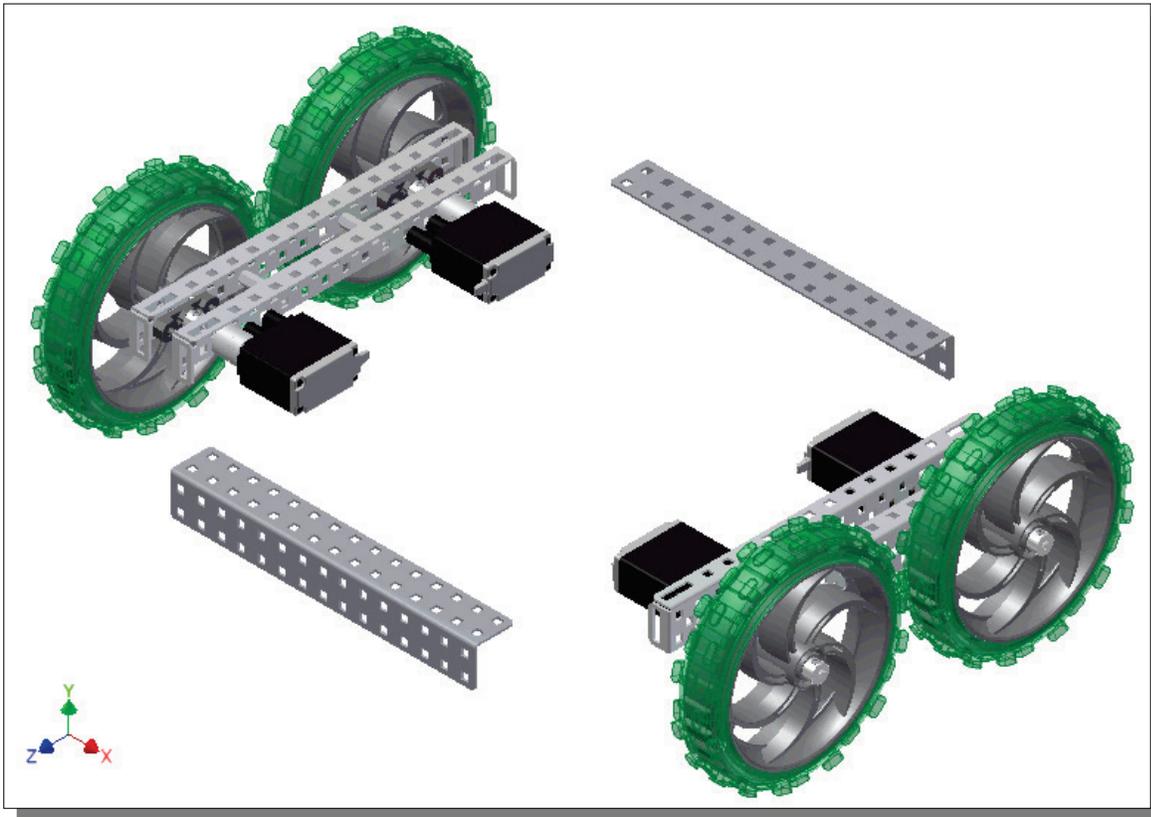


10. In the graphics area, place a copy of the **Motor\_Wheel\_Right** subassembly to the left side of the other pieces.
11. On your own, repeat the above steps and place a copy of the **Motor\_Wheel\_Left** subassembly to the right side of the screen.



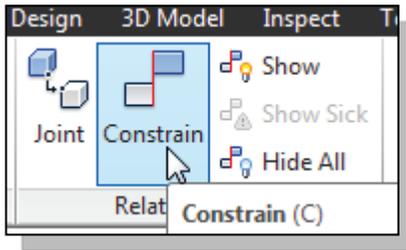
12. Select the **Free Rotate** command by left-mouse-clicking once on the icon.

13. On your own, adjust the orientation of the pieces as shown.



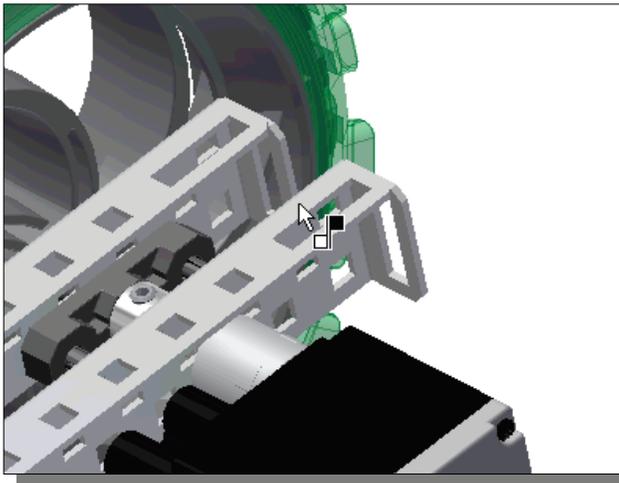
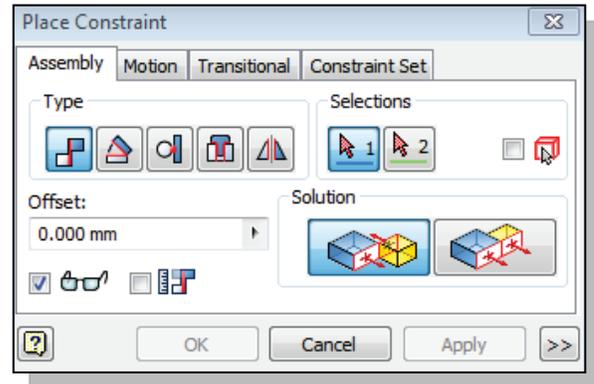
14. On your own, save the current model as an assembly, using the name: **Tumbler.iam**.

## Assemble the Chassis



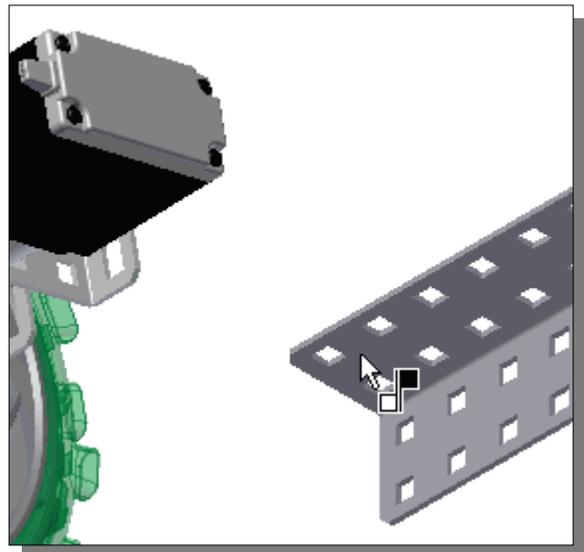
1. In the *Assembly* panel, select the **Constrain** command by left-mouse-clicking once on the icon.

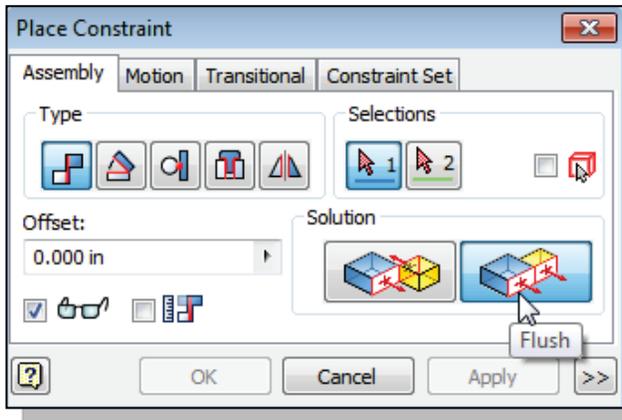
2. In the *Place Constraint* dialog box, confirm the **Mate** constraint option is activated.



3. Select the top face of the inside **Chassis Rail** of the *Motor\_Wheel\_Right* assembly as shown.

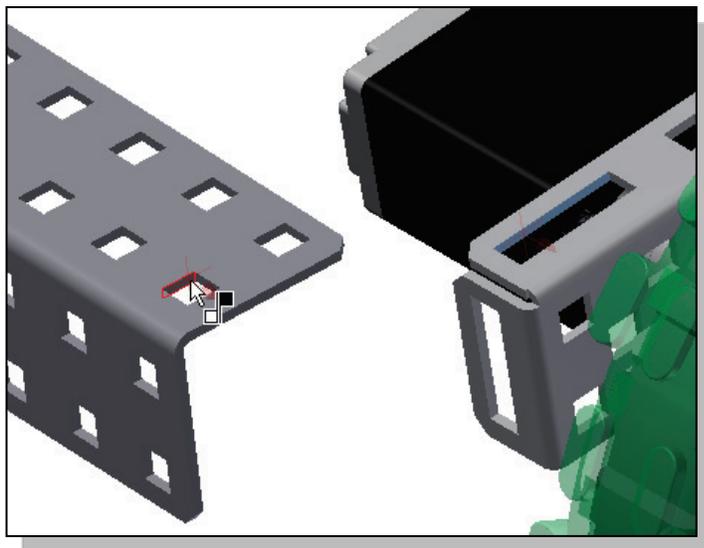
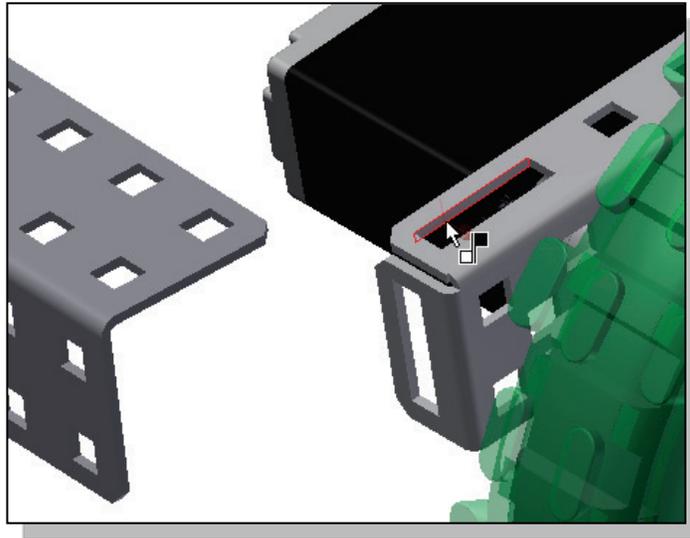
4. Select the bottom face of the first **Chassis Bumper** part as the second item for the **Constraint** command.
5. Click on the **Apply** button to accept the selection and apply the **Insert** constraint.





6. In the *Place Constraint* dialog box, switch to the **Flush** constraint.

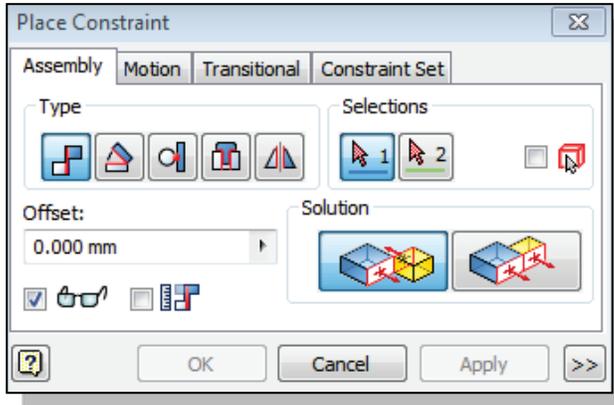
7. Select the vertical face of the first **Chassis Rail** part on the **Motor\_Wheel\_Left** subassembly as shown. (see page 36 for the completed ailgnment.)



8. Select the small vertical face of the first **Chassis Bumper** part as the second item for the Constraint command.

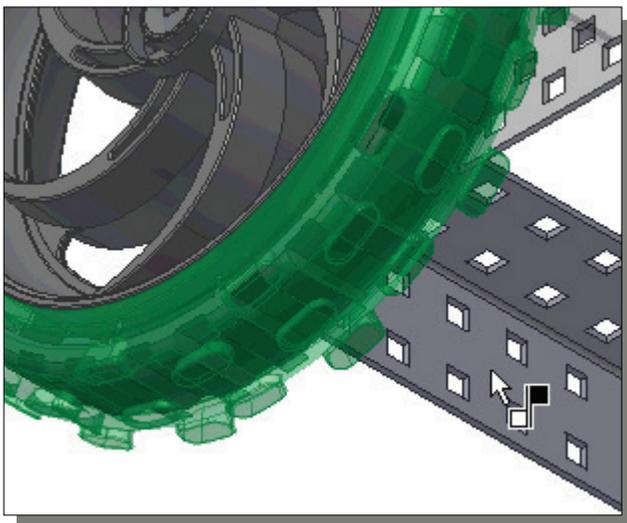
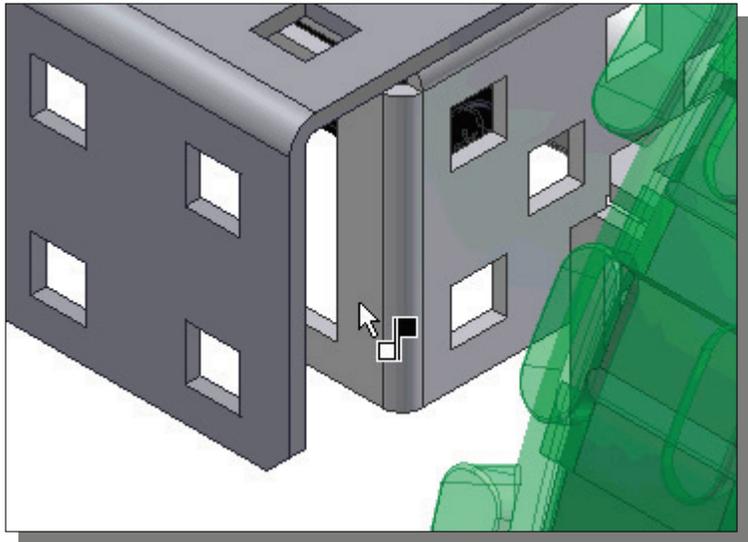


9. Click on the **Apply** button to accept the selection and apply the Flush constraint.



10. In the *Place Constraint* dialog box, switch to the **Mate** constraint.

11. Select the small vertical face of the first **Chassis Rail** part as shown.

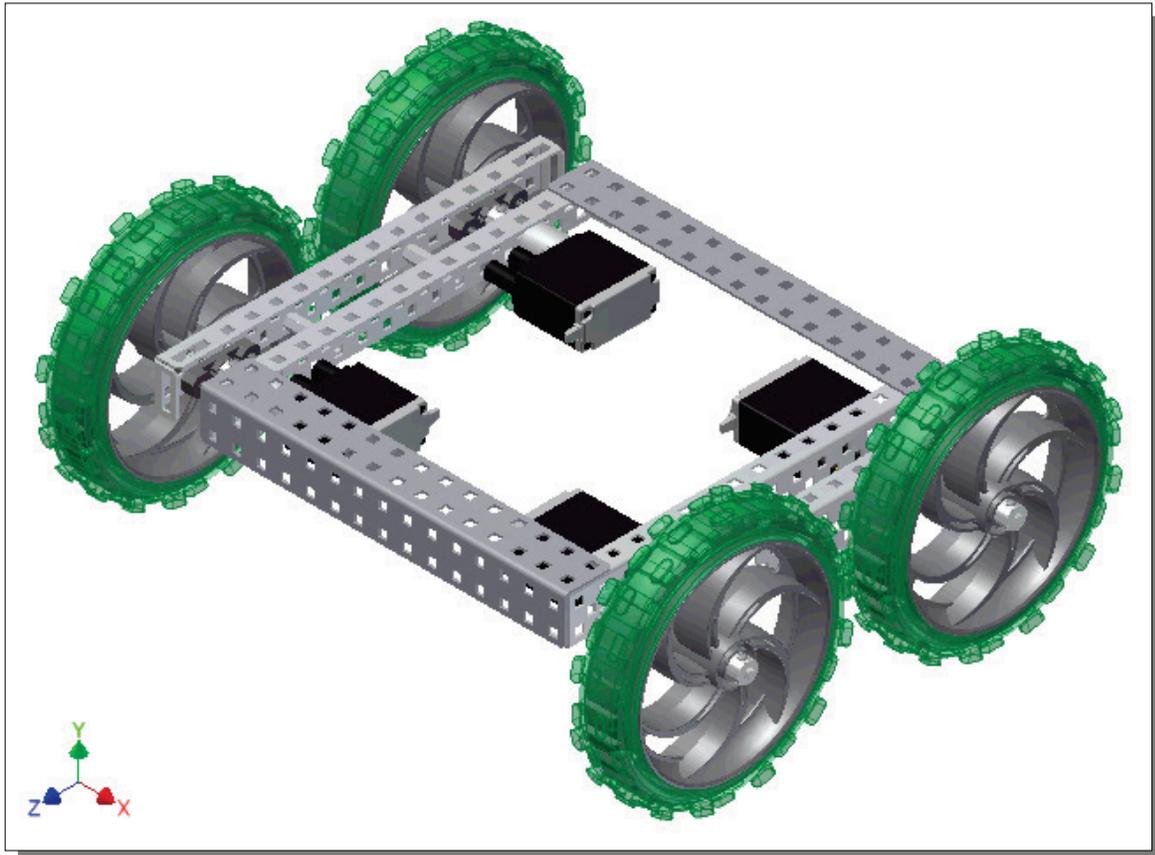


12. Select the inside vertical face of the first **Chassis Bumper** part as the second item for the Constraint command.



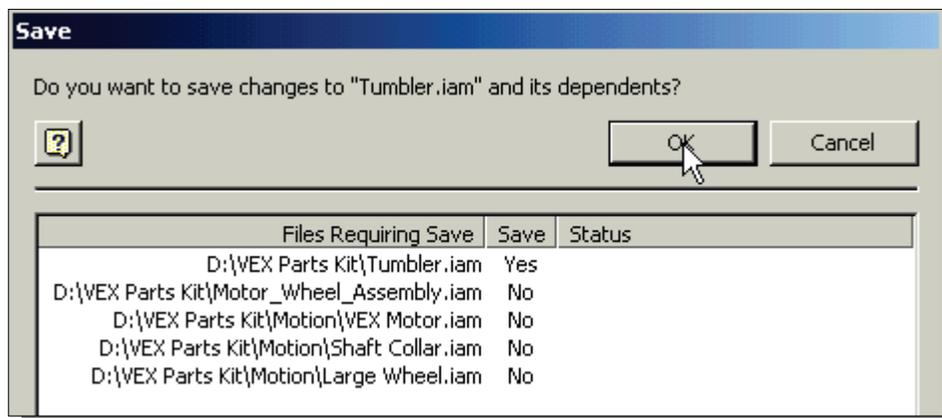
13. Click on the **Apply** button to accept the selection and apply the **Mate** constraint.

14. On your own, repeat the above steps and assemble the other pieces. Your assembly should appear as shown.

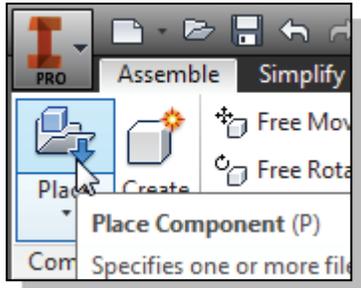


15. **Save** the completed model.

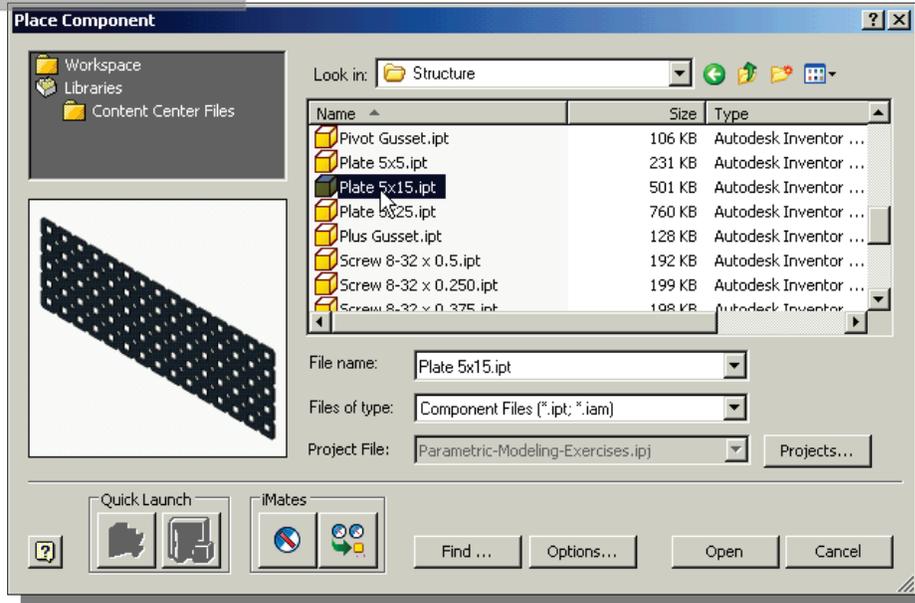
16. Click the **OK** button to accept the changes to the model.



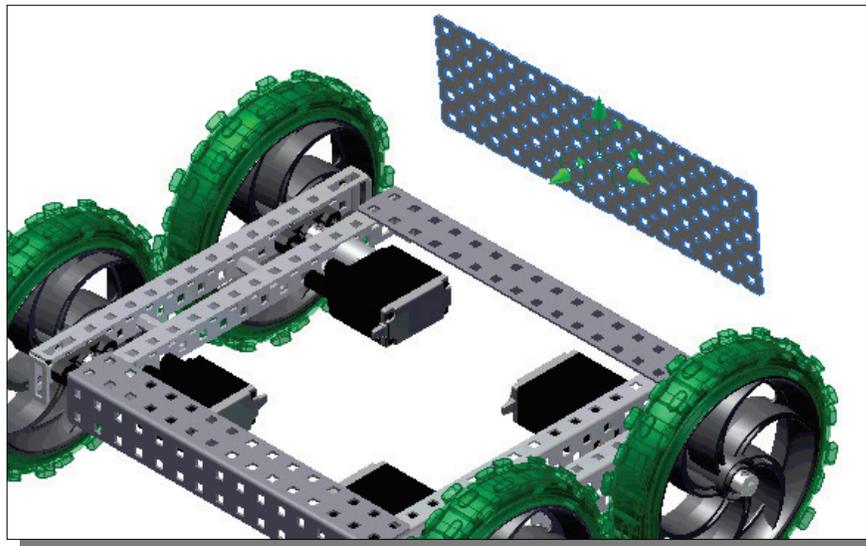
## Assemble the Chassis Plate



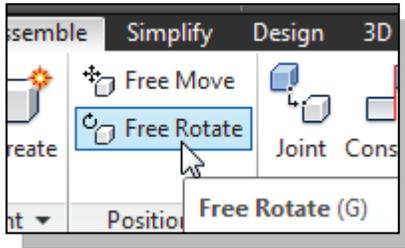
1. In the *Assembly* panel, select the **Place Component** command by left-mouse-clicking the icon.
2. Select the **Plate 5x15** part in the list window. Click on the **Open** button to retrieve the model.



3. Place a copy of the **Plate** in the graphics area.

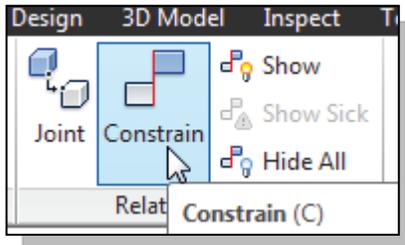
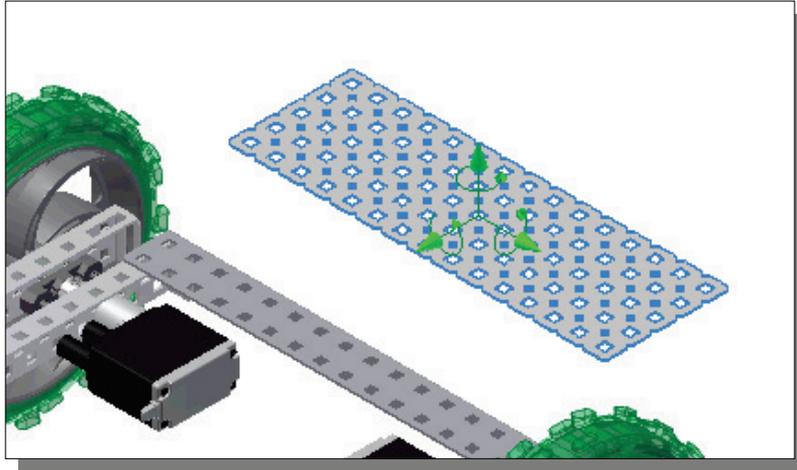


4. Inside the graphics window, right-mouse-click once to bring up the option menu and select **OK** to end the Place Component command.



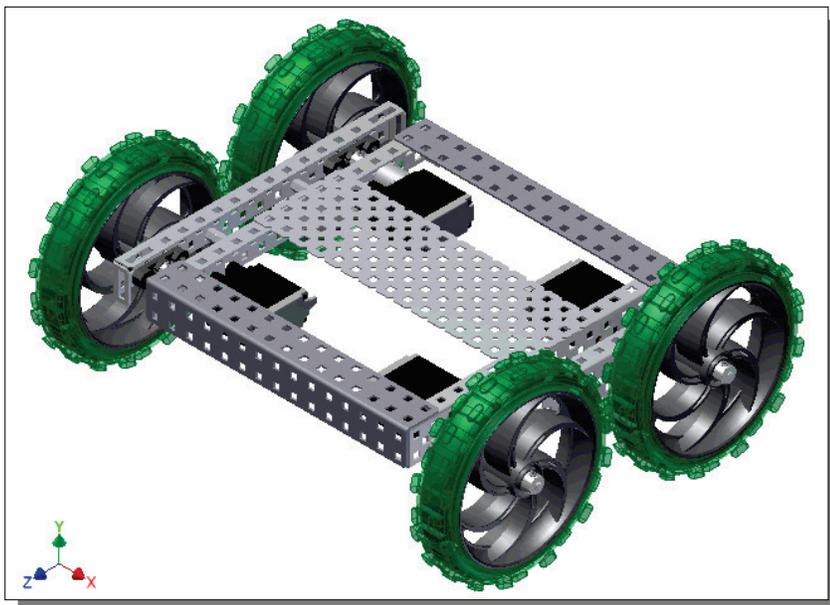
5. Select the **Rotate Component** command by left-mouse-clicking once on the icon.

6. On your own, use the left-mouse-button and rotate the **Plate** to the horizontal assembly orientation as shown.

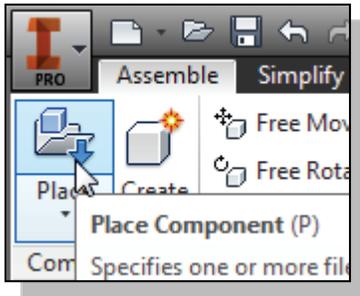


7. In the *Assembly* panel, select the **Constrain** command by left-mouse-clicking once on the icon.

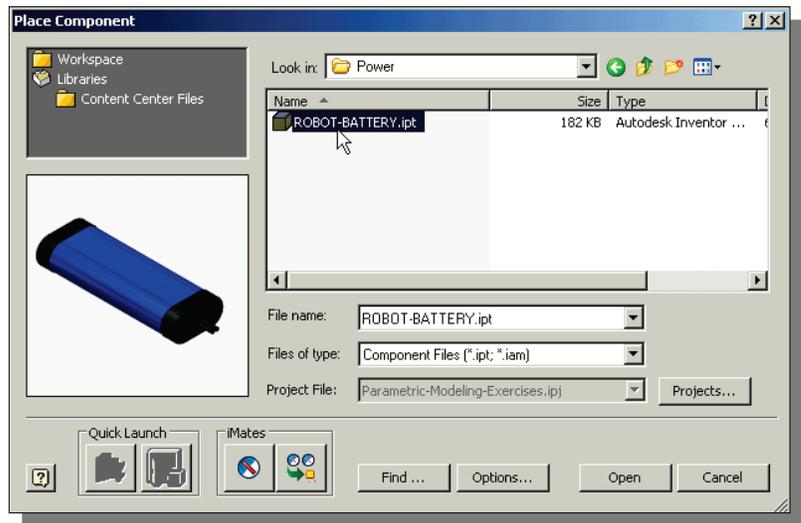
8. On your own, assemble the **Plate** to the top of the **Chassis** and align the square holes as shown.



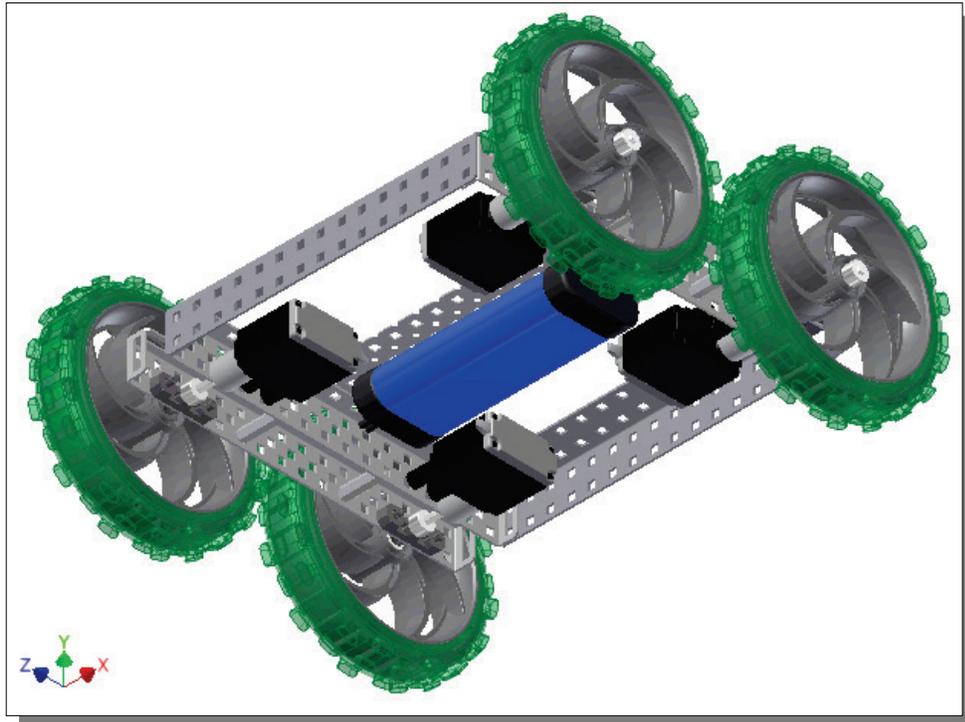
## Adding the Battery Pack under the Chassis Plate



1. In the *Assembly* panel, select the **Place Component** command by left-mouse-clicking the icon.
2. Select the **Robot Battery** part in the list window. Click on the **Open** button to retrieve the model.



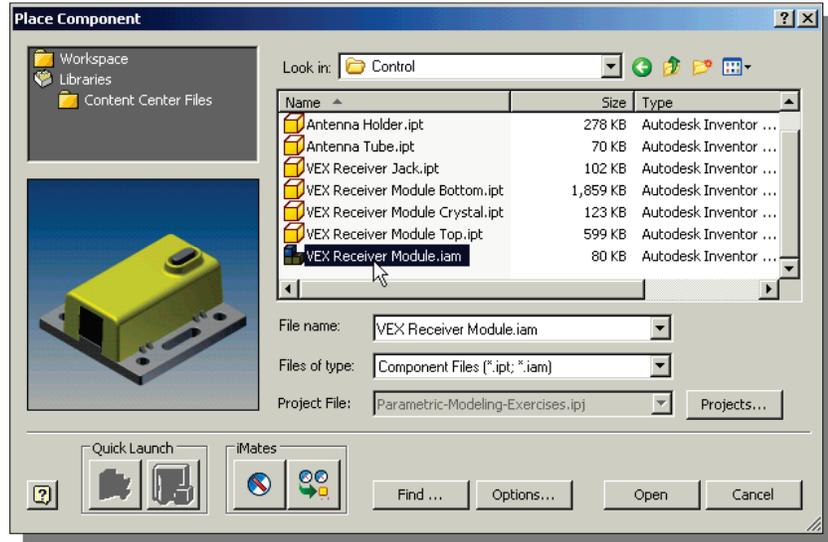
3. Place one copy of the **Battery** toward the right side of the graphics window.
4. On your own, assemble the **Battery** pack under the **Chassis Plate** as shown.



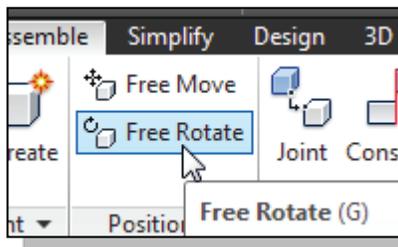
## Adding the RF Receiver on the Rear Chassis Bumper



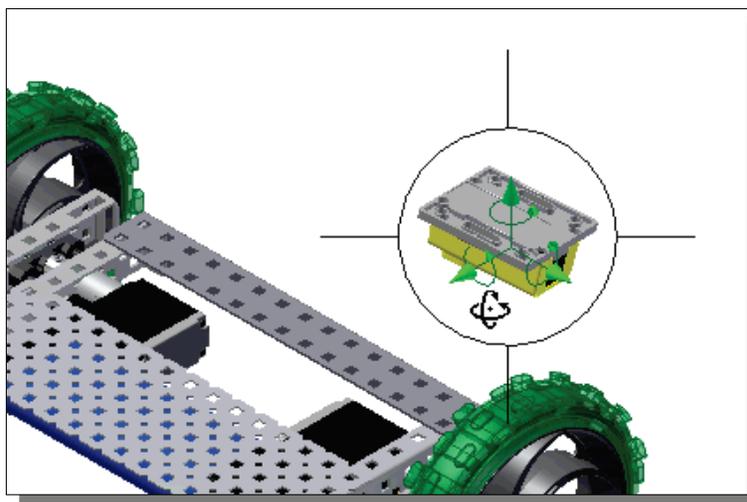
1. In the *Assembly* panel, select the **Place Component** command by left-mouse-clicking the icon.
2. Select the **VEX Receiver Module** assembly in the list window. Click on the **Open** button to retrieve the model.

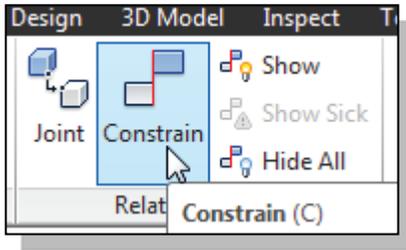


3. Place one copy of the RF **Receiver** toward the right side of the graphics window.



4. Select the **Free Rotate** command by left-mouse-clicking once on the icon.
5. Rotate the RF **Receiver** so that it is facing upside-down.

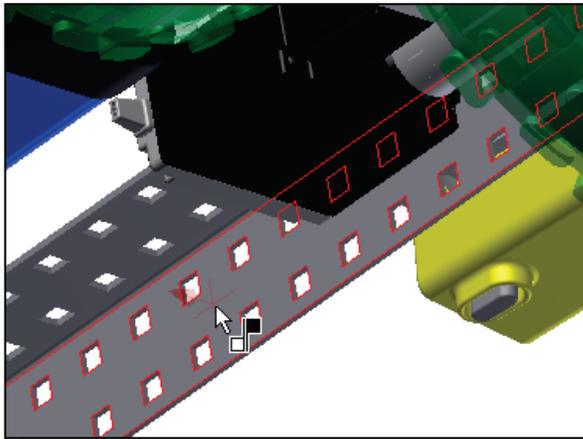
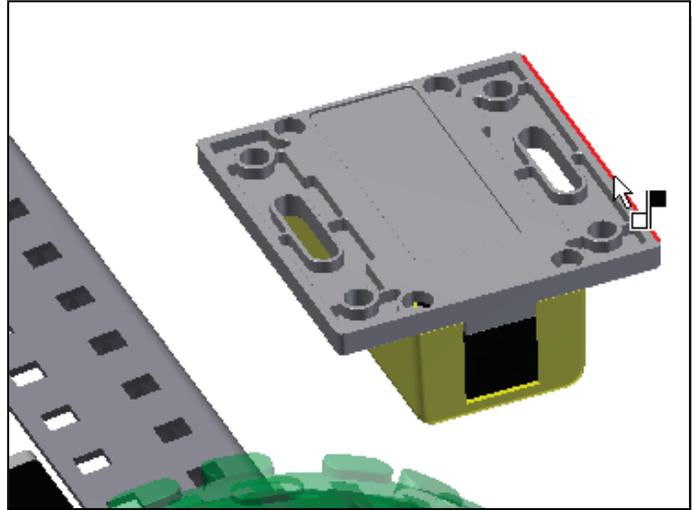




6. In the *Assembly* panel, select the **Constrain** command by left-mouse-clicking once on the icon.

7. Using the **Mate** constraint option, select the back edge of the RF **Receiver** as shown.

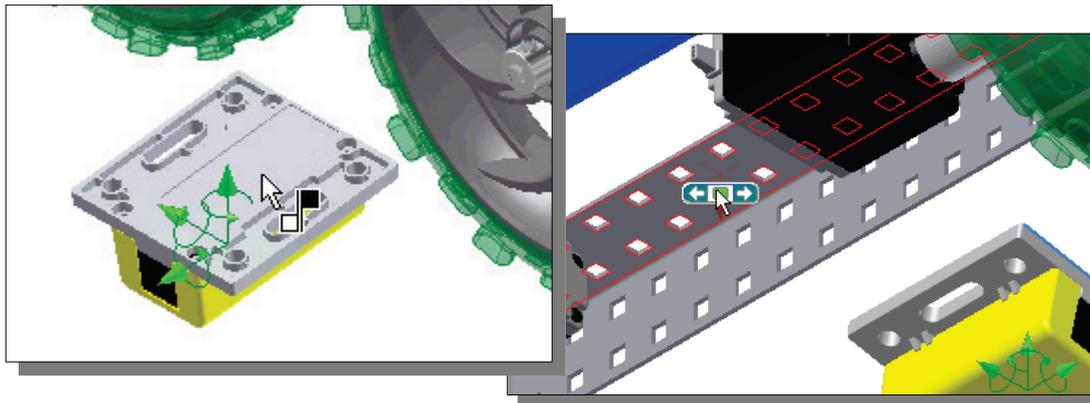
- The base of the RF **Receiver** has a tapered shape; we will use the edge to align.



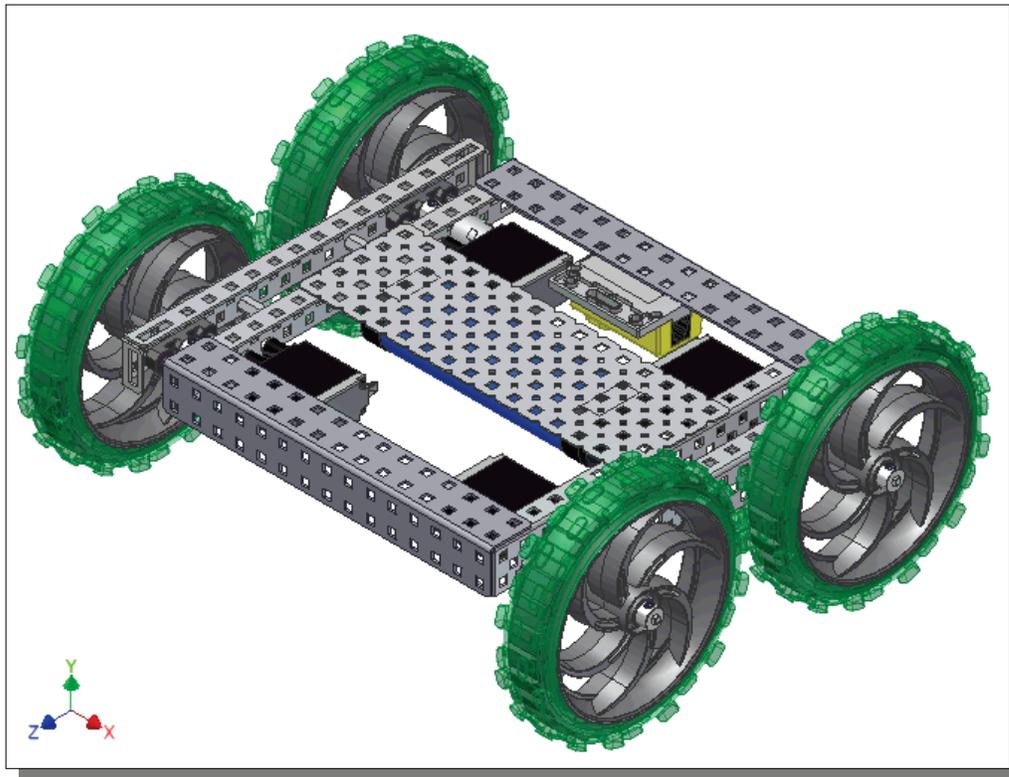
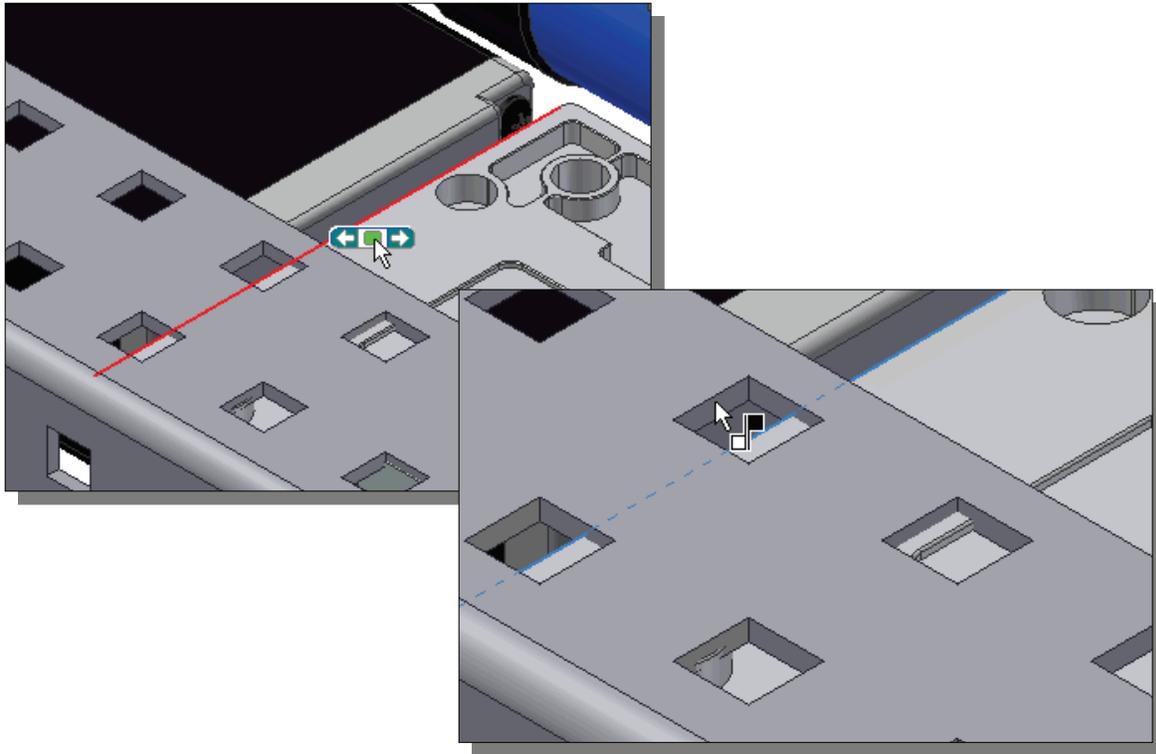
8. Select inside vertical face of the rear **Chassis Bumper** part as the second item for the Constraint command.
9. Click on the **Apply** button to accept the selection and apply the **Mate** constraint.



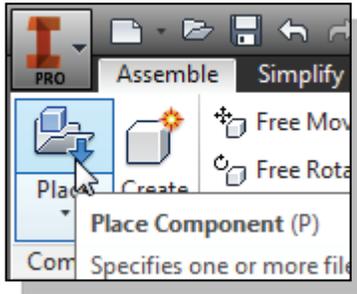
10. On your own, **Mate** the bottom face of the RF **Receiver** to the inside bottom surface of the rear **Chassis Bumper** part.



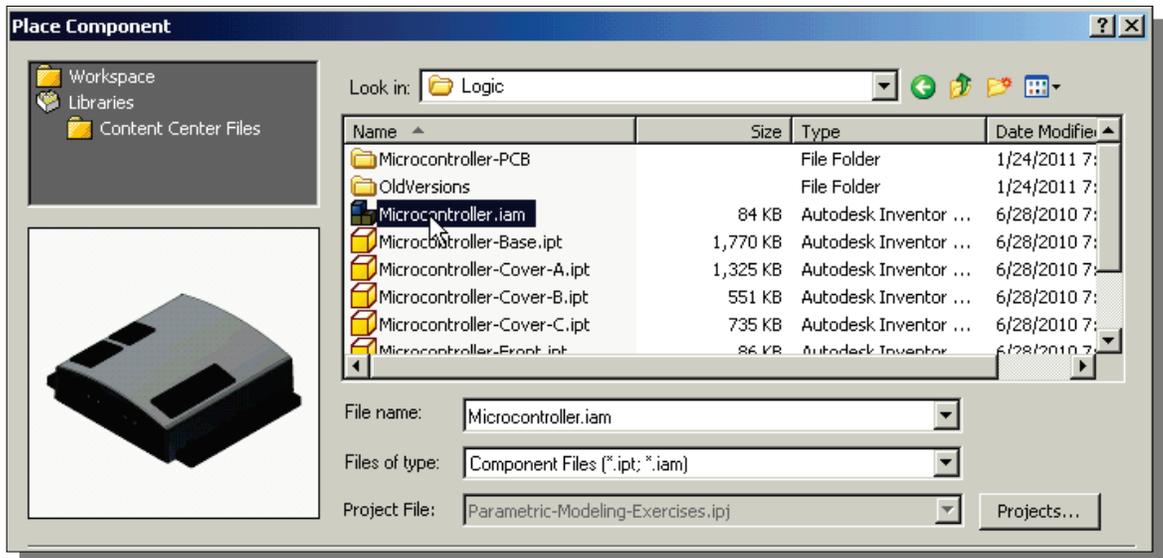
11. On your own, remove the last degree of freedom of the RF **Receiver** by aligning the bottom edge of the RF **Receiver** to the one of the small square hole surfaces of the rear **Chassis Bumper** part.



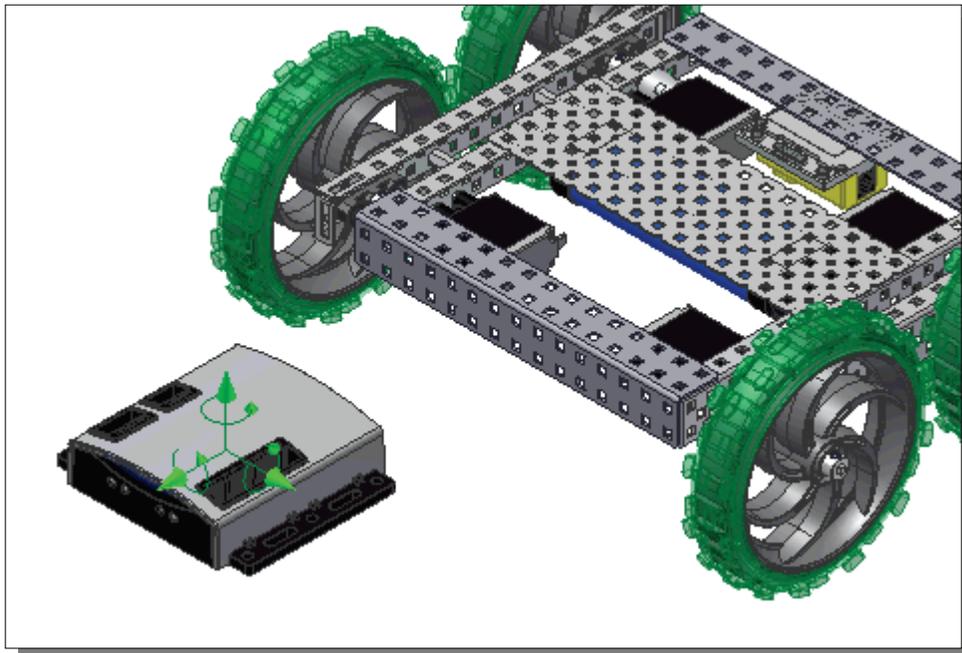
## Assemble the VEX Microcontroller



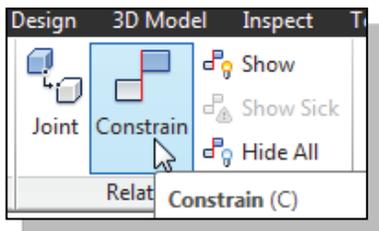
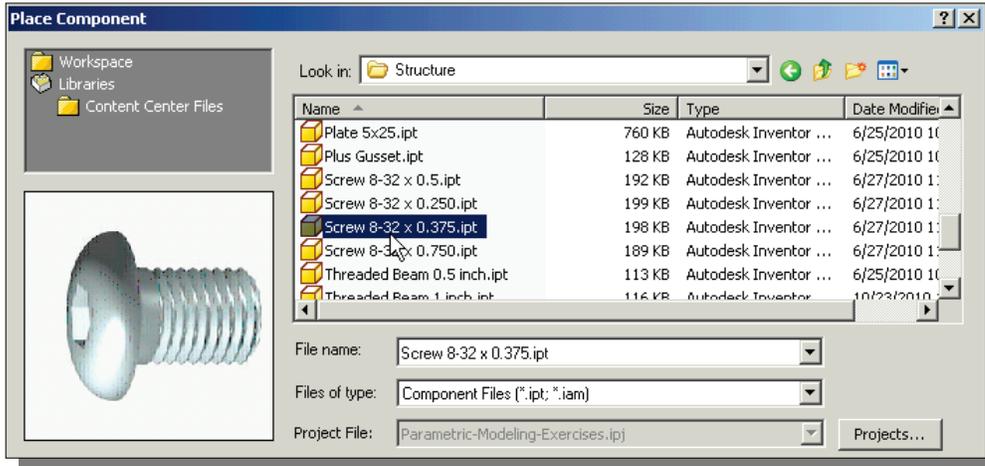
1. In the *Assembly* panel, select the **Place Component** command by left-mouse-clicking the icon.
2. Select the **VEX Microcontroller** assembly in the list window. Click on the **Open** button to retrieve the model.



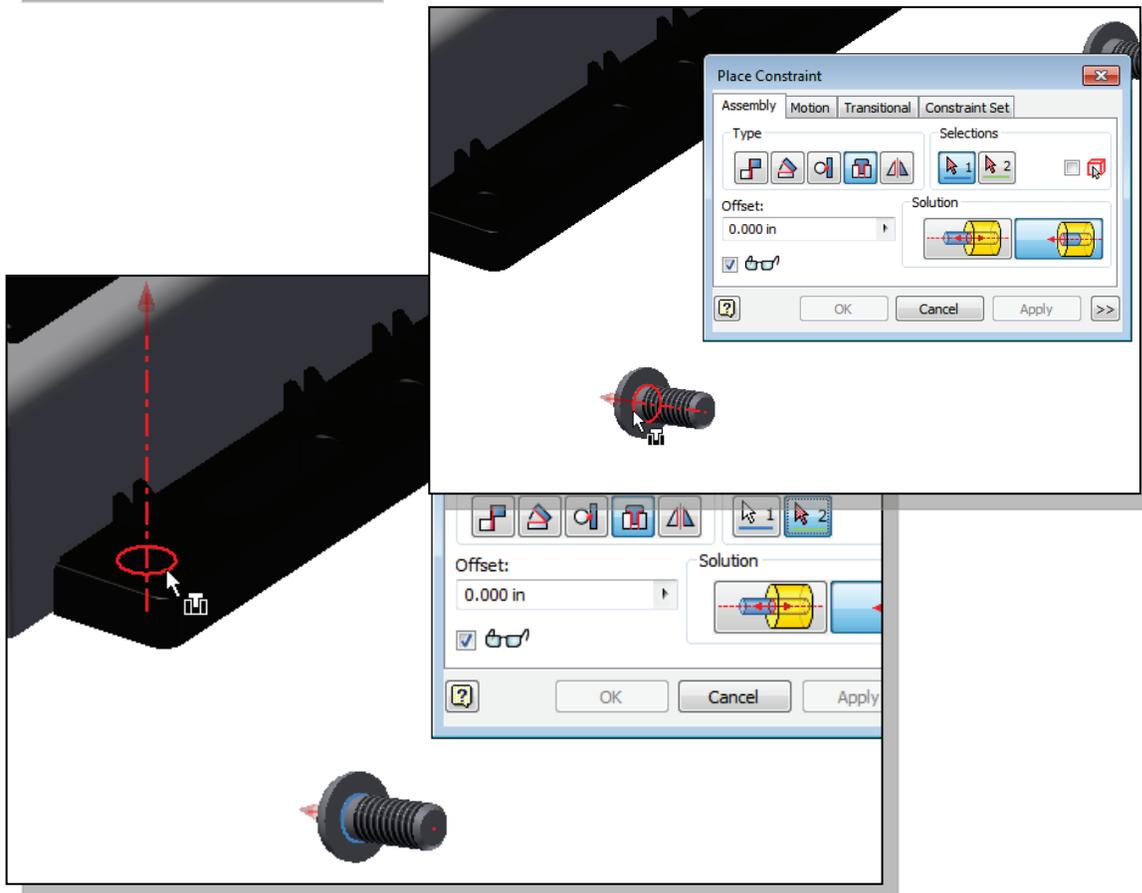
3. Place one copy of the **Microcontroller** towards the left side of the graphics window.



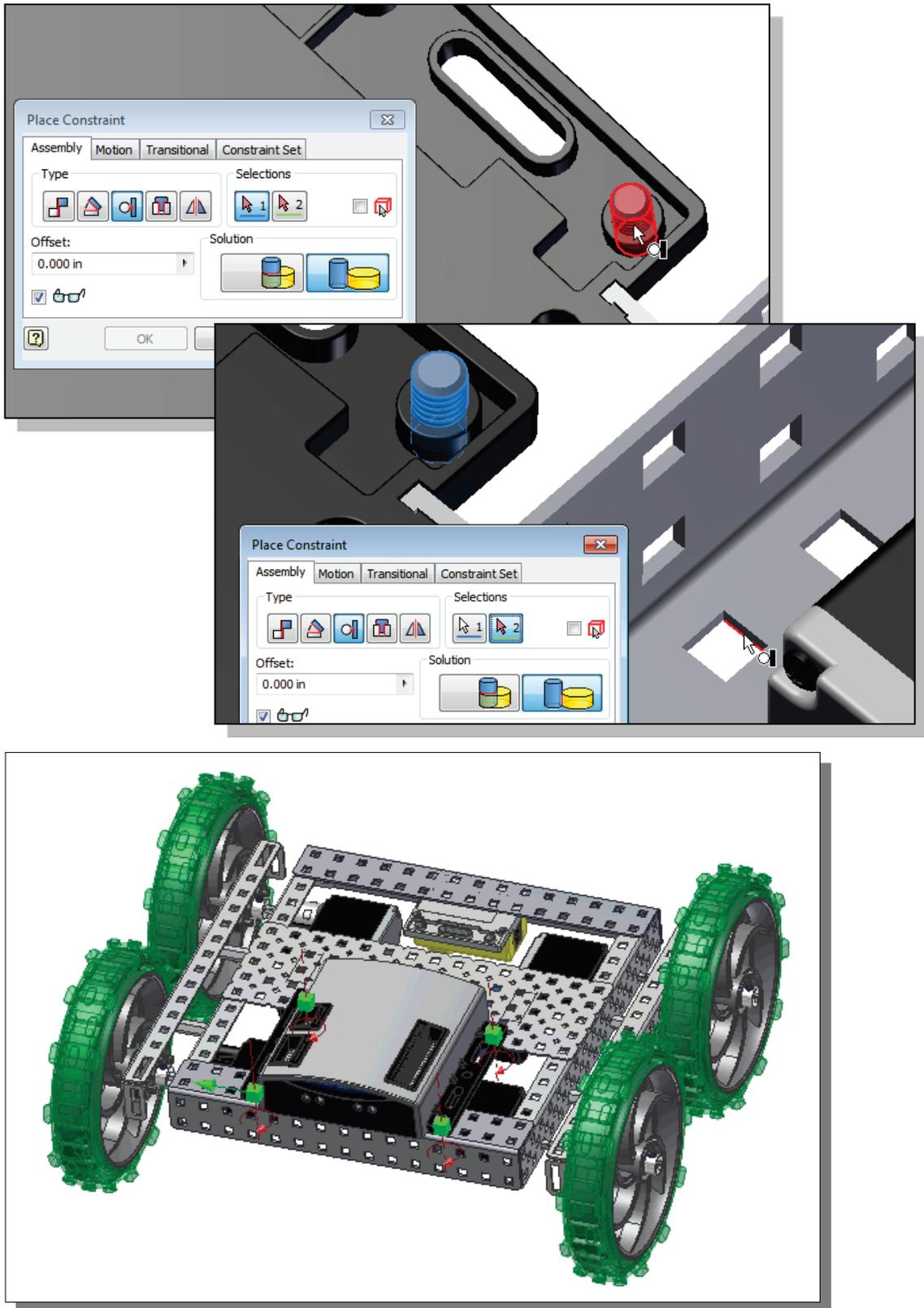
- On your own, place four copies of the **8-32 x 0.375 Screw** part next to the **Microcontroller** part.



- In the *Assembly* panel, select the **Constrain** command by left-mouse-clicking once on the icon.
- On your own, use the **Insert** option to constrain the **Screws** to the **Microcontroller**.



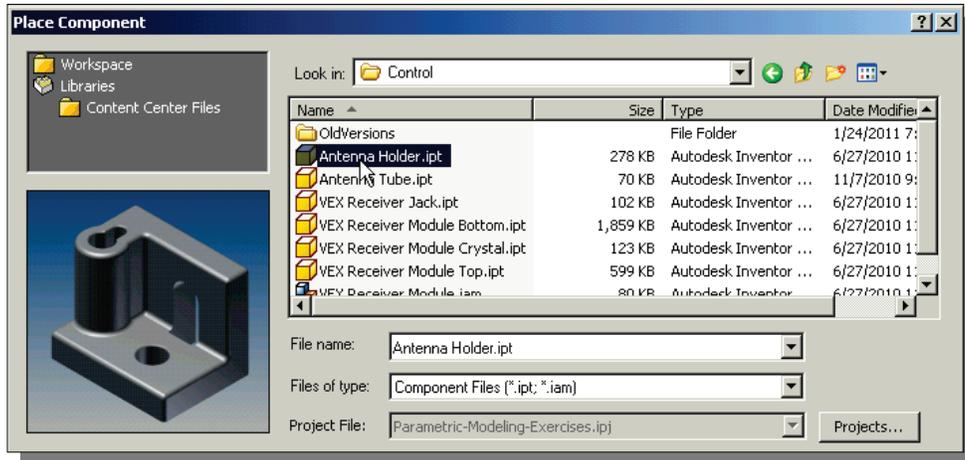
- On your own, use the **Mate** and **Tangent** constraints to assemble the VEX **Microcontroller** on top of the **Chassis Bumper** as shown.



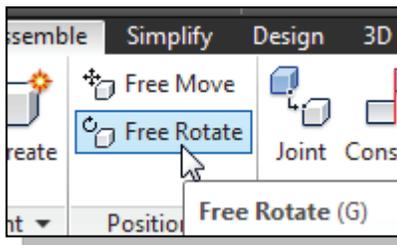
## Assemble the Antenna



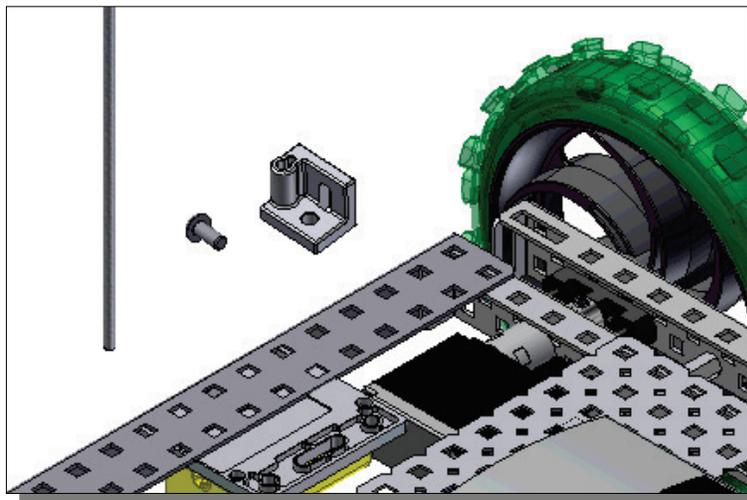
1. In the *Assembly* panel, select the **Place Component** command by left-mouse-clicking the icon.
2. Select the **Antenna Holder** part in the list window. Click on the **Open** button to retrieve the model.



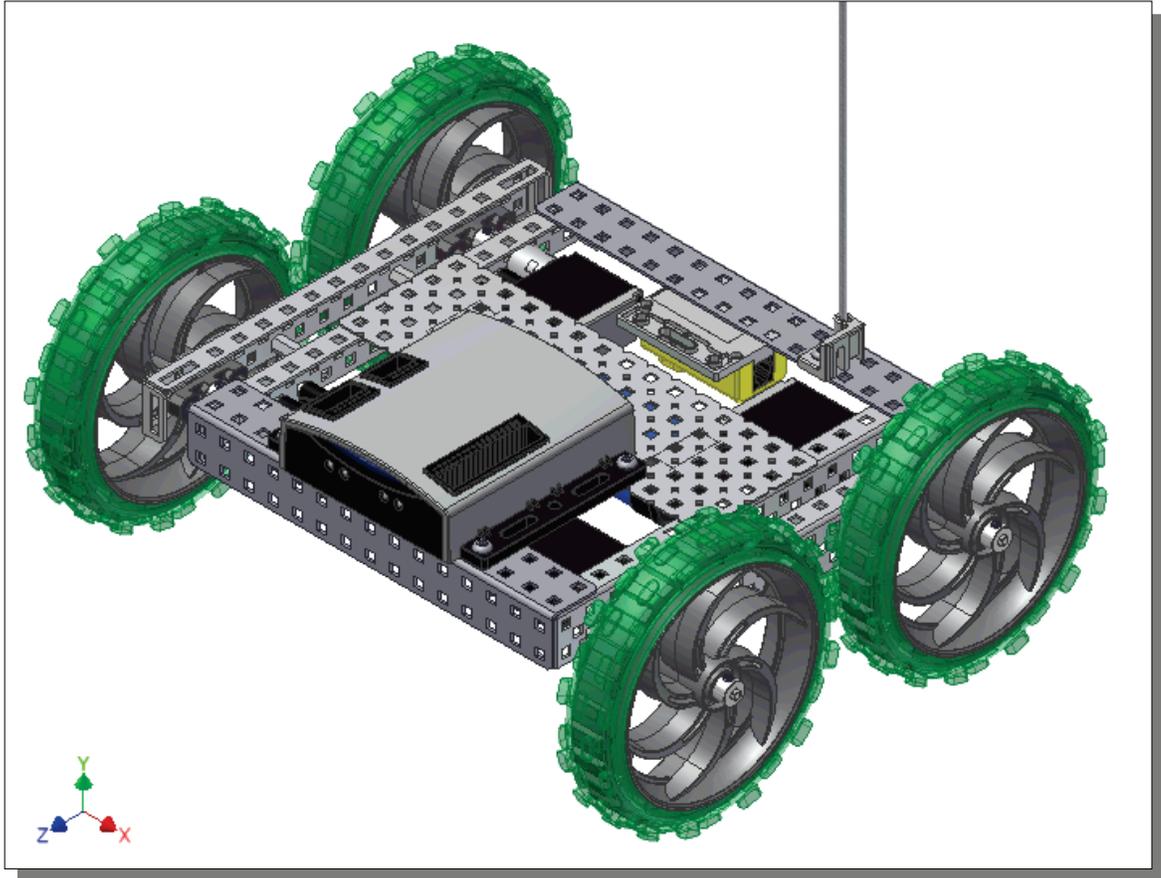
3. Place one copy of the **Antenna Holder** part next to the assembly.
4. On your own, also place one copy of the **Antenna Tube** part and a **3/8 Screw** part next to the **Holder** part.



5. Select the **Rotate Component** command by left-mouse-clicking once on the icon.
6. On your own, use the left-mouse-button and rotate the three parts to the orientation as shown.



7. On your own, apply the proper constraints to the antenna components and complete the assembly as shown in the figure below.



## Conclusion

Design includes all activities involved from the original concept to the finished product. Design is the process by which products are created and modified. For many years designers sought ways to describe and analyze three-dimensional designs without building physical models. With advancements in computer technology, the creation of parametric models on computers offers a wide range of benefits. Parametric models are easier to interpret and can be easily altered. Parametric models can be analyzed using finite element analysis software, and simulation of real-life loads can be applied to the models and the results graphically displayed.

Throughout this text, various modeling techniques have been presented. Mastering these techniques will enable you to create intelligent and flexible solid models. The goal is to make use of the tools provided by AutoCAD and Autodesk Inventor and to successfully capture the **DESIGN INTENT** of the product. In many instances, only a single approach to the modeling tasks was presented; you are encouraged to repeat all of the lessons and develop different ways of thinking in accomplishing the same tasks. We have only scratched the surface of AutoCAD's and Autodesk Inventor's functionality. The more time you spend using the system, the easier it will be to perform computer aided modeling with AutoCAD and Autodesk Inventor.

## Review Questions

1. Is there any difference between a regular part and a sub-assembly when they are placed inside an assembly?
2. How many sub-assemblies were used in the tutorial?
3. How do you access the **Suppress** command?
4. What is the main difference between an **Insert** constraint and a **Mate** constraint when applied to cylindrical surfaces?
5. How do you control the displayed color of the parts in an Autodesk Inventor assembly model?
6. How was the *Motor\_Wheel\_Right* assembly created in the tutorial?

## Exercise

Create the *Probot Model* as described in the Vex-Quick start-guide, which is included on the companion CD. (Refer to the companion CD for design ideas and additional resource information.)

