Phases

3 & 4

HOW TO DEVELOP A PRODUCT

Production & Field Support

PRODUCT DEVELOPMENT MANUAL

How to Develop a Product

WRITTEN BY JORDAN COX

ACKNOWLEDGEMENTS

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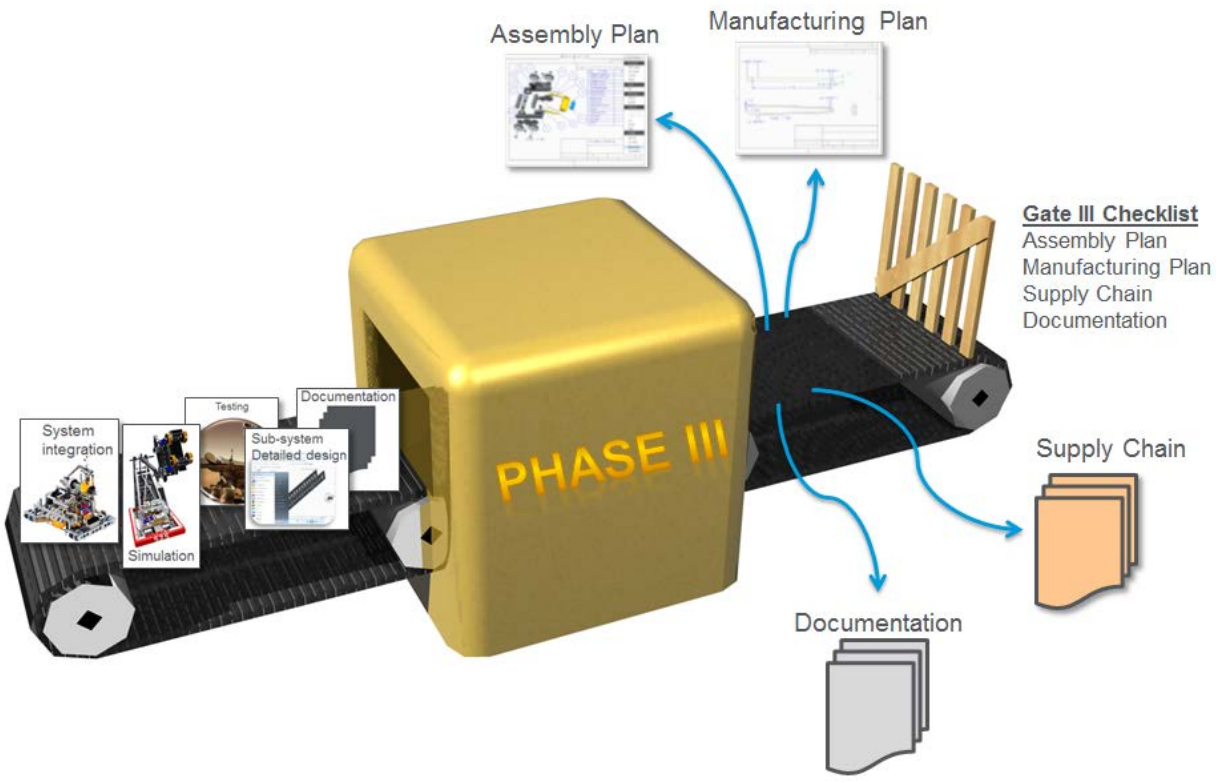
Phase

3

PREPARING A MANUFACTURING PLAN TO PRODUCE YOUR DESIGN

Phase III: Manufacturing Planning & Production



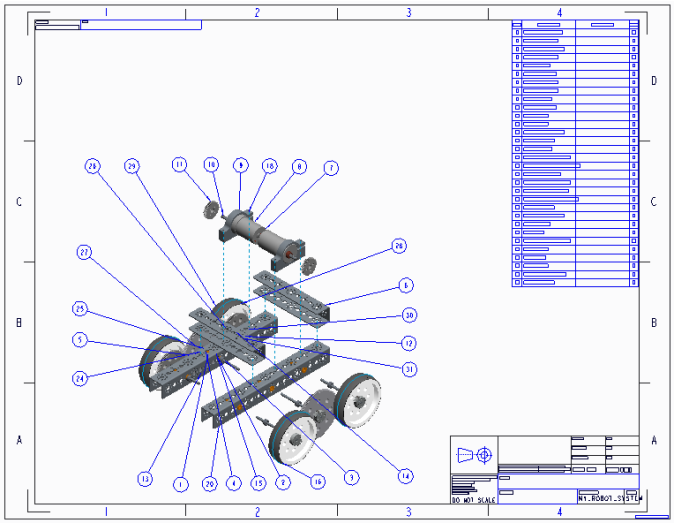
Once you have completed the first two phases of the product development process, you have a detailed design of your product. The third phase in the product development process focuses on how to make the product. This can involve making parts, acquiring parts from suppliers and developing an assembly plan for how you will assemble all of the parts into the final product. You will need to use all of the deliverables that were

created in the second phase to create manufacturing plans or supply chain plans to procure all of your parts and an assembly plan to build the final product.

CREATING AN ASSEMBLY PLAN

It actually helps to put together an assembly plan to begin with so that you can identify all of the parts in the product design and create a bill of materials. An easy way of creating an assembly plan is to create an exploded drawing with a bill of materials. The creation of an exploded drawing and the bill of materials is very straight forward once you have completed the modeling of your product.

Exercise 16: Refer to the Appendix for the exercise *Exploded Drawing* and follow the instructions to create an exploded drawing and bill of materials.



Once you have created all of the assembly drawings that you will need to document your assembly procedures, make sure to print them in hard copy format so that you can refer to them during fabrication and assembly.

DOCUMENTING CUSTOM PARTS

Most of the parts that you will use in designing your system may be standard parts, either parts from a kit of parts or standard use parts from a distributor. However, there may be custom parts required. These custom parts can be documented by creating a regular drawing with dimensions. This will be necessary for fabricating the custom

part, whether you will fabricate it or you will contract with someone else to fabricate it. Make sure you have documented all of your custom parts with drawings.

CREATING A PRODUCTION PLAN

Now that you have an assembly drawing with a bill of materials as well as drawings for all custom parts, you can create a production and procurement plan. The easiest way to do this is to create a spreadsheet with all of the parts listed from the bill of materials. Then create columns associated with whether the parts will be fabricated in-house, externally or procured from a supplier. This will help you keep track of all of your parts.

Part	In-house fabrication	External fabrication	Supplier	Received
Axle Bronze Bushing			Pitsco	Jan 6, 2013
Bucket arm	NC Machined			Feb 1, 2013
Bucket		3D print shop		Due Mar3, 2013
Channel 288mm			Pitsco	Jan 6, 2013

Once your parts have been procured, fabricated and received, you can then use your assembly plans to insure correct assembly of your design.

ASSEMBLING ALL THE DOCUMENTATION

One of the most important parts of your product development is documenting the decisions that are made. Keep a notebook and document each of the production decisions that you make. You can certainly print the drawings and keep them as part of your documentation. You should also be using PTC Windchill to store all of your models. This repository is part of your documentation.

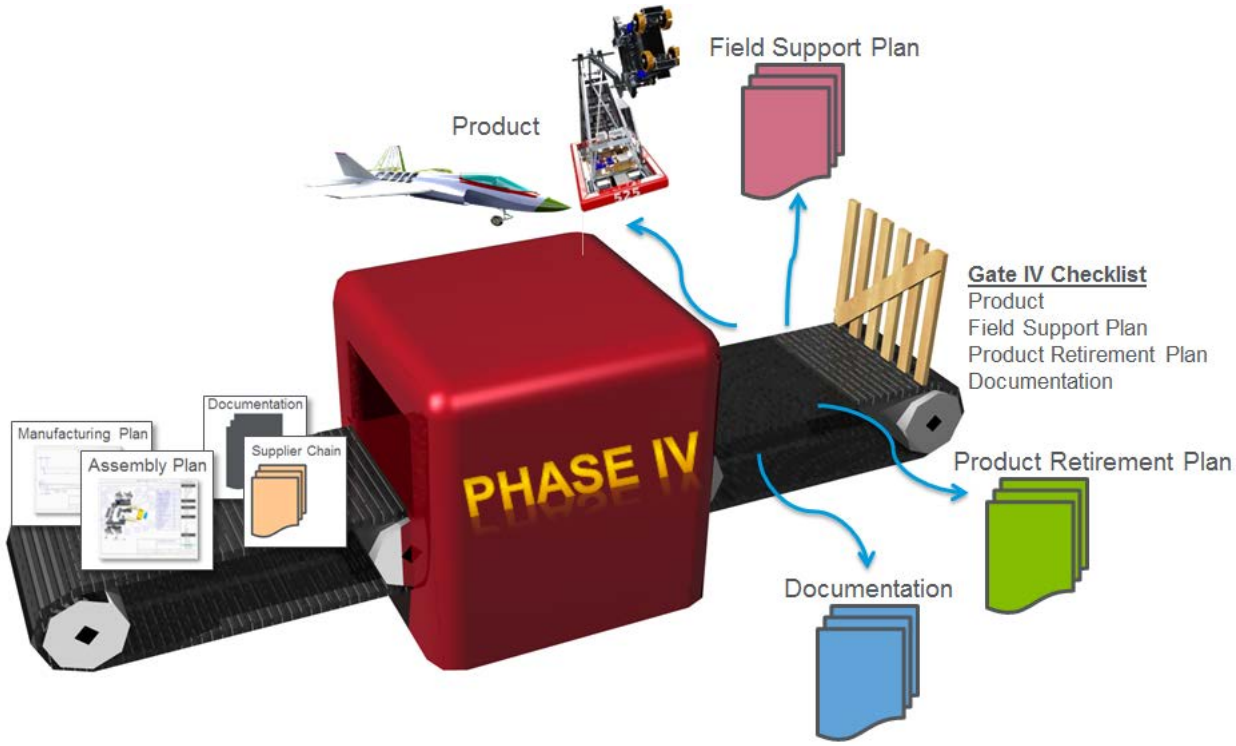
CONDUCTING A DESIGN REVIEW – PHASE III GATE CHECK

Congratulations, you have completed the first three phases of the product development process. Now you need to do a gate check to make sure everything is ready to move on to the next phase in the product development process. A gate check is best conducted as a design review. Assemble a group of mentors and then go through each of the aspects of your design to date. This is your chance to present the production and assembly plans of your system. Use all of the artifacts you created especially the drawings and production plans. Review each of the parts and do a final review on your documentation. Record the design review in your notebook along with recommended changes and have the mentors sign and date it.

Phase

4

FIELD SUPPORT & PRODUCT RETIREMENT

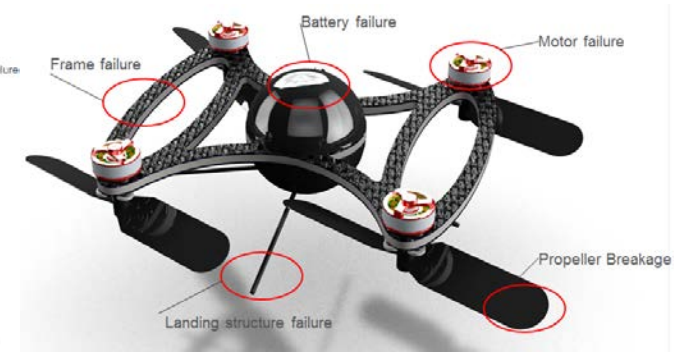


It is important to anticipate the problems you may experience with your product when it is in its field of operation. For your robot or aircraft, this means on the field of competition or in transit. All products fail and experience less than perfect behavior while operating in whatever field they were designed to operate in. Sometimes, products end up being used in ways they weren't designed to operate. However it happens, products need support in the field. An effective way to anticipate these needs in the field is to perform a failure modes and effects analysis (FMEA). This analysis is a way of predicting how parts might fail in the field.

CONDUCTING A FAILURE MODES AND EFFECTS ANALYSIS

The FMEA analysis involves determining why things might fail (Failure Mechanisms), how things fail (Failure Modes), as well as what probability there will be that they will fail. Failure modes are defects in the design, the process of making the parts, the inspection process or how the parts are being used. These defects end up causing the failure of the product or system.

Step 1: The first step in performing a FMEA is to identify all the ways that your robot could fail. This involves a brainstorming session where you and your team members brainstorm all of the ways that your system could possibly fail during competition or transit.



Step 2: is to rank each of these failures in terms of how likely they are to occur and what effect the failure would have on the overall system. Some engineering companies have created worksheets to help them document this brainstorming session.

Step 3: is to discuss a plan for addressing all of the failure modes that you and your team feel have the potential to happen and will be catastrophic to the robot during competition.

Exercise 17: Refer to the Appendix for the exercise *FMEA* and complete the worksheet.

Creating a Field Support Plan

A field support plan begins with performing a failure modes and effects analysis where all possible failure modes are identified and are classified as to their severity and potential to happen. Once this is completed, a plan is made to procure spare parts or redesign subsystems so that failures won't happen or if they do, there will be back up parts and systems available during competition. Prepare a field support plan using the information you identified during your FMEA exercise.

Once your plan is in place, execute it. Procure the parts and be prepared so that your system can perform at its finest.

Exercise 18: Refer to the Appendix for the exercise *Field Support Plan* and complete the worksheet.

Creating a Product Retirement Plan

Product retirement is as important as product creation. Most companies are now required to provide plans for appropriate product retirement including retreival of the products and disassembly and recycling of parts and materials. Brainstorm with your team to identify and develop a retirement plan for your system.

Conducting a Design Review – Phase IV Gate Check

Congratulations, you have completed all of the phases of the product development process. Now you need to do a gate check to make sure everything is complete. A gate check is best conducted as a design review. Assemble a group of mentors and then go through each of the aspects of your design to date. This is your chance to present the FMEA, field support plans, and retirement plans for your system. Use all of the artifacts you created especially the worksheets. Review each of the parts and do a final review on your documentation. Record the design review in your notebook along with recommended changes and have the mentors sign and date it.

Congratulations You Have Completed the Product Development Process Curriculum!

Phases

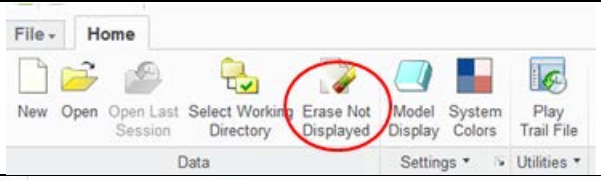
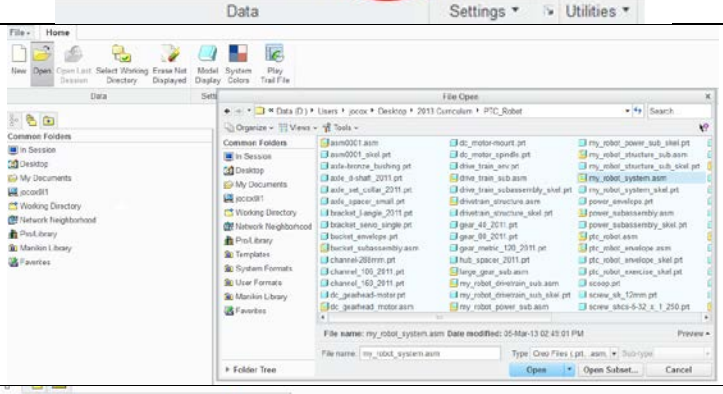
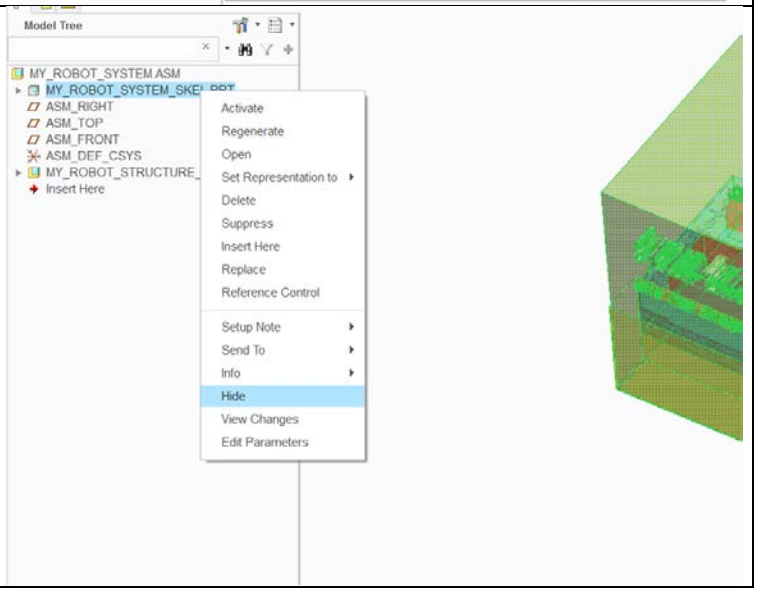
3 & 4

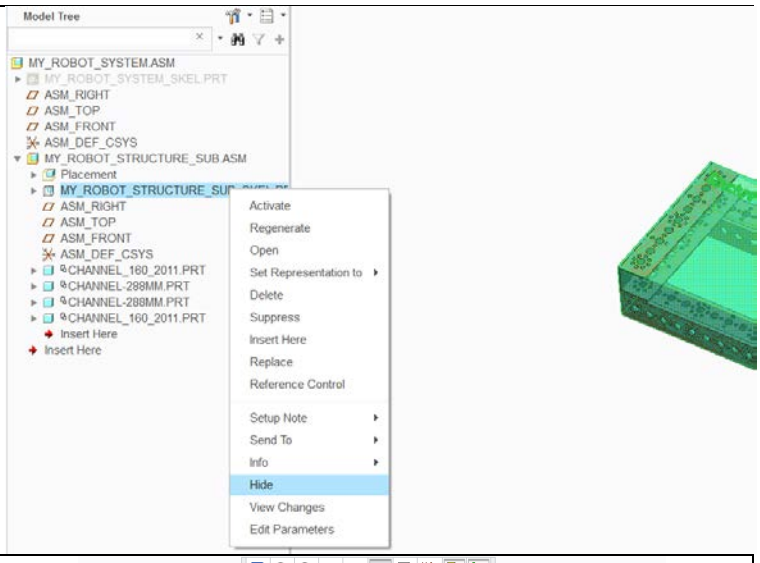
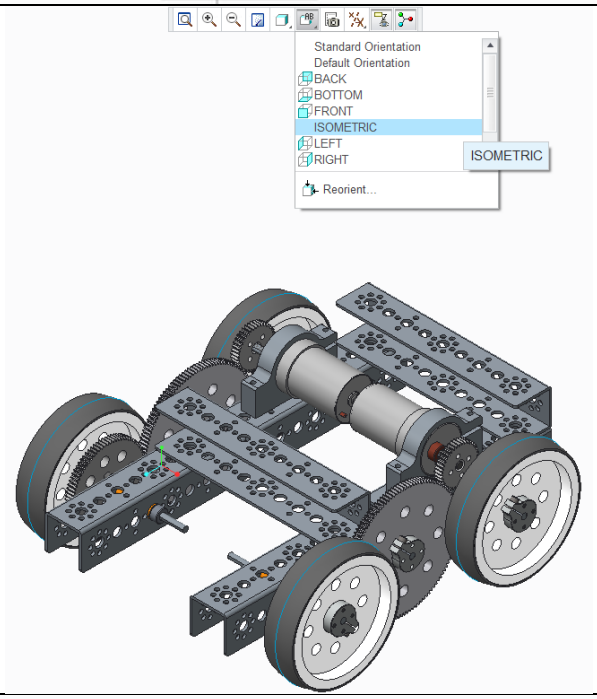
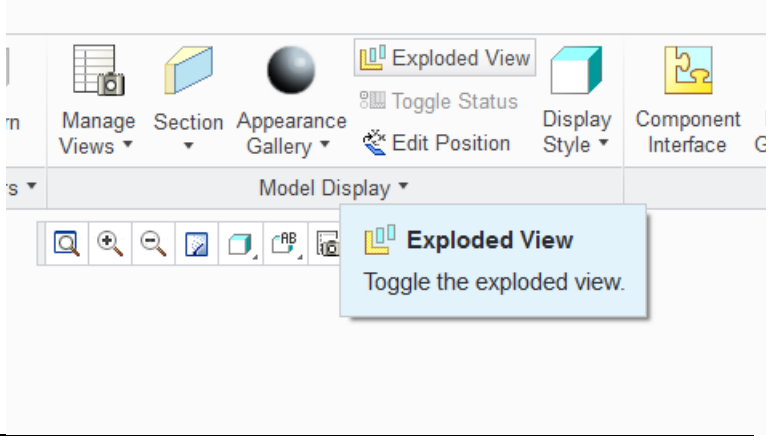
HOW TO DEVELOP A PRODUCT

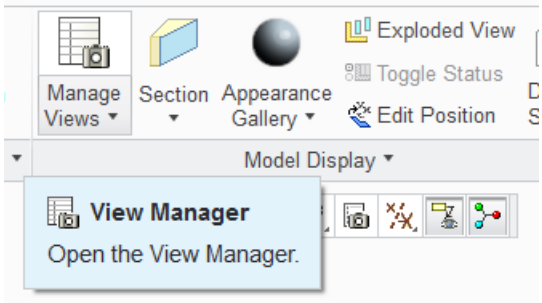
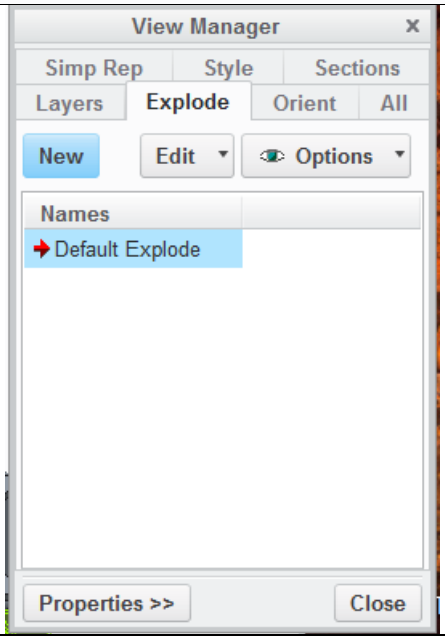
APPENDIX

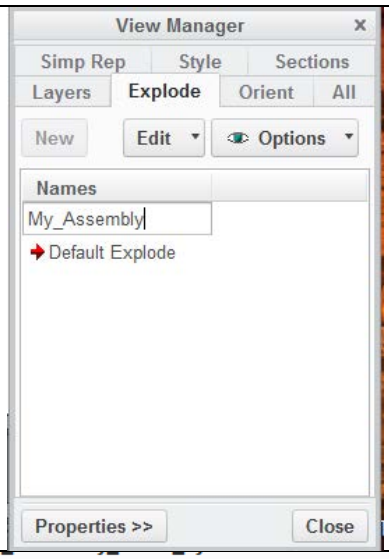
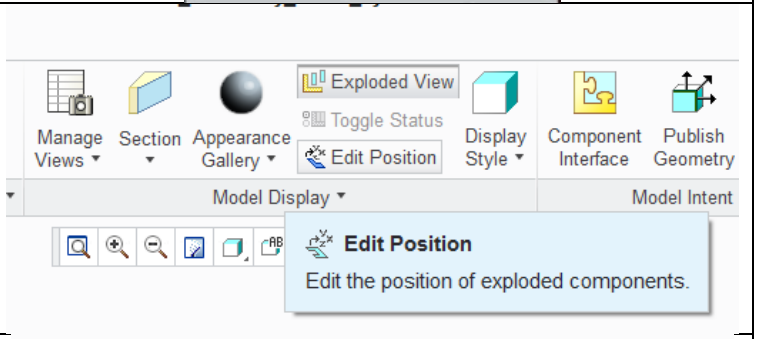
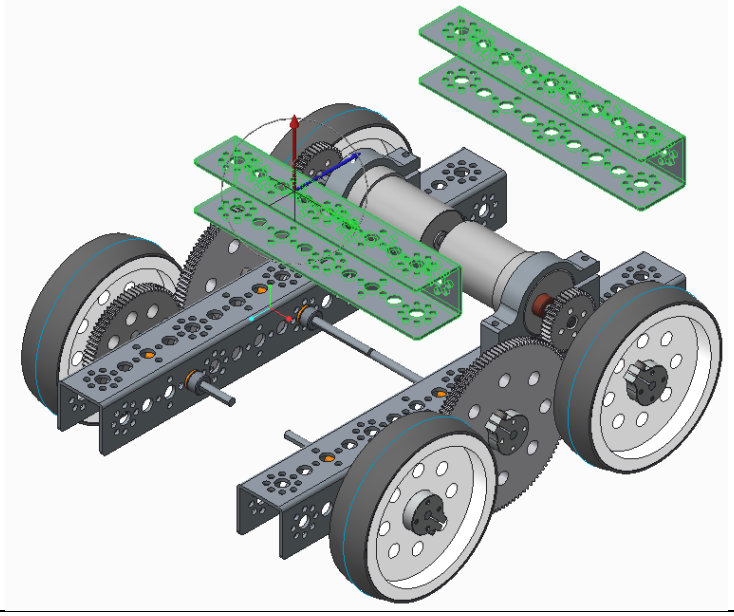
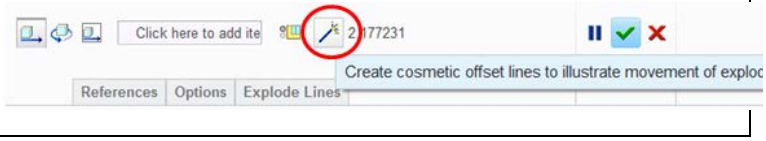
EXERCISE 16.0: EXPLODED DRAWING

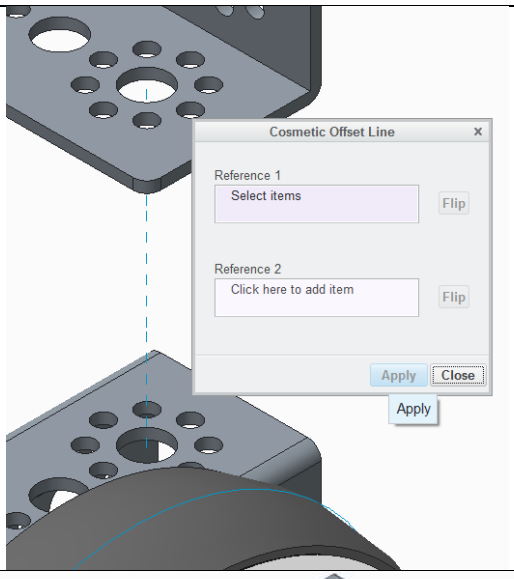
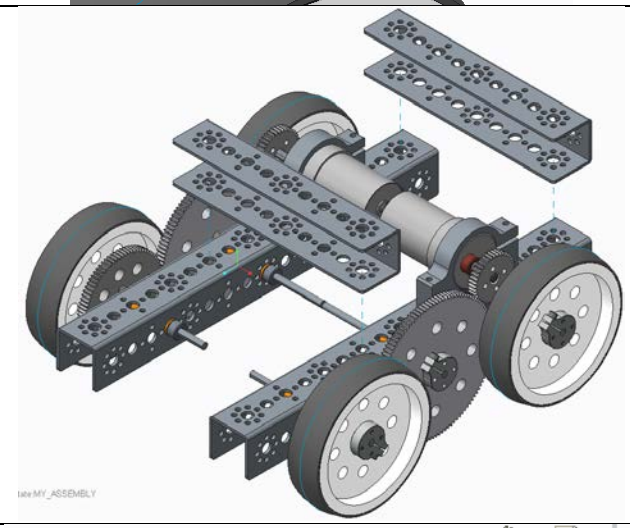
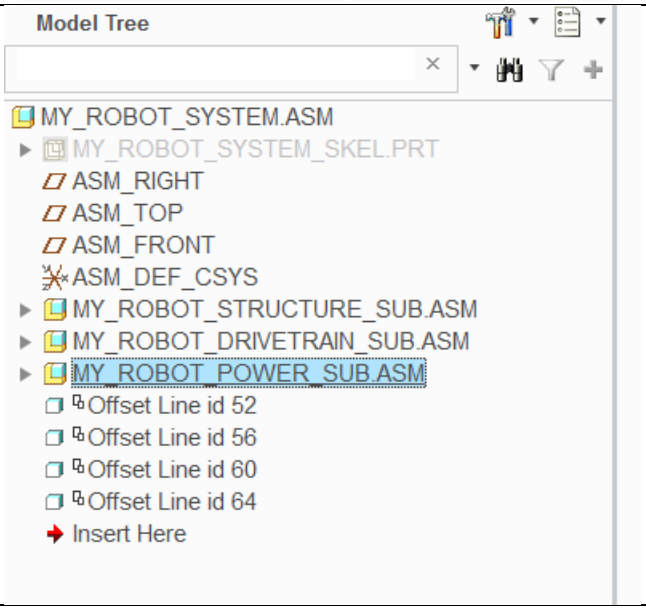
Now that there is a detailed design of our robot we can create an exploded drawing and bill of materials very quickly.

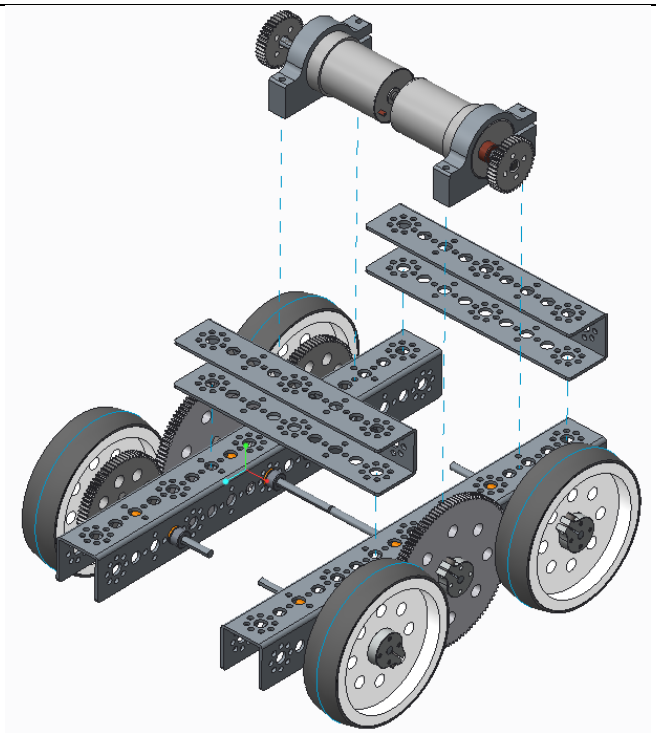
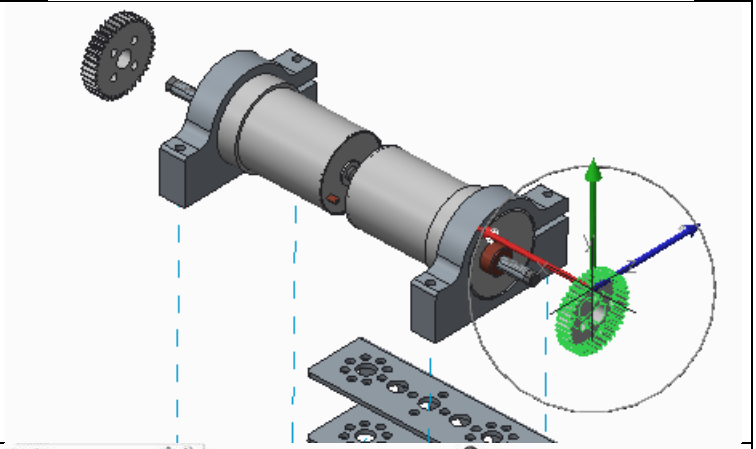
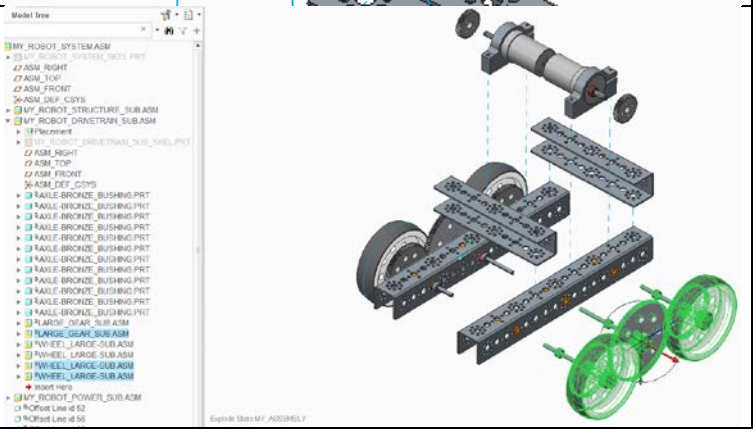
Close all of your model files and erase from memory by selecting **Erase Not Displayed** and clicking **OK.**	
Open the system model "**my_robot_system.asm**".	
Right click on the skeleton file in the model tree and select **Hide** so that all the reference geometry is hidden.	

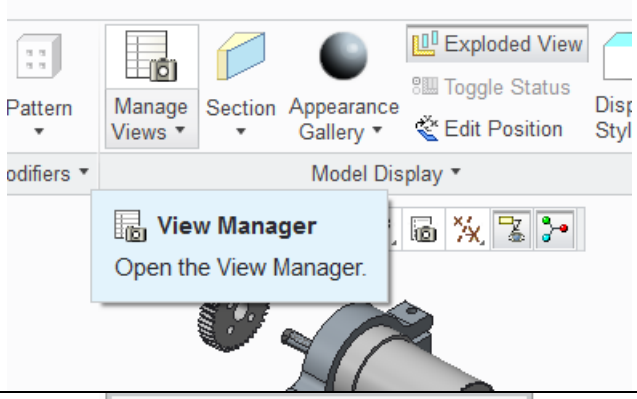
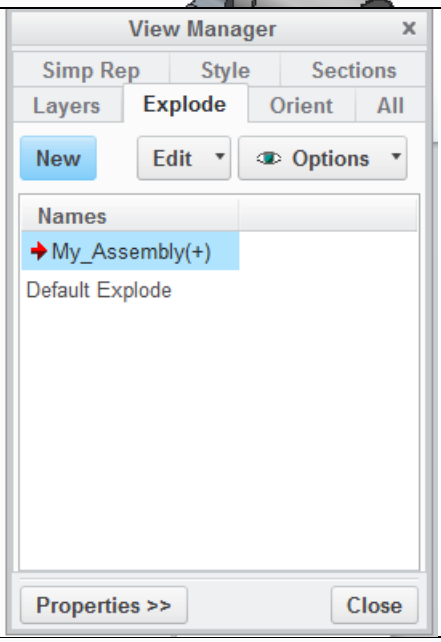
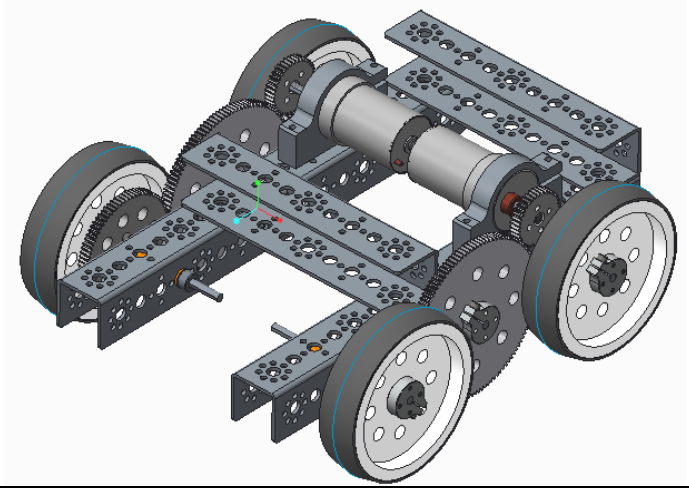
That will only hide the system reference geometry so you will need to hide the reference geometry in all of the subassemblies as well.	
Now select the **Saved Views** tool and pick **Isometric** view to orient your robot as shown.	
Find the **Exploded View** icon in the upper menu and click on it to explode your model.	

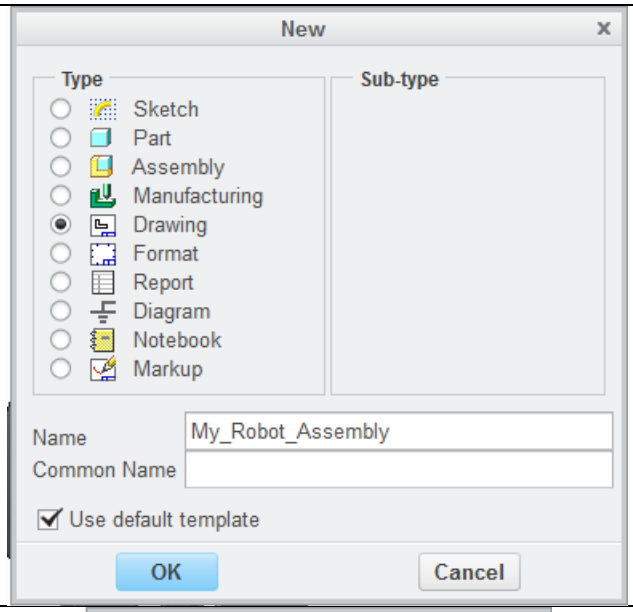
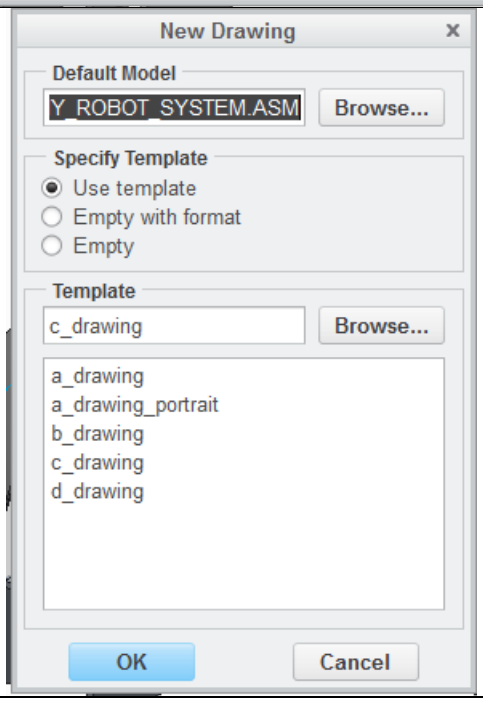
The default explode state is rarely what you will need to document your design or for assembly procedures, so we will learn how to create our own custom explode states. Click on the **Explode View** icon again to unexploded your model.	
Now select the **Manage Views** icon to create a new exploded view.	
Select the **Explode** tab and then click the **New** button to create a new explode state.	

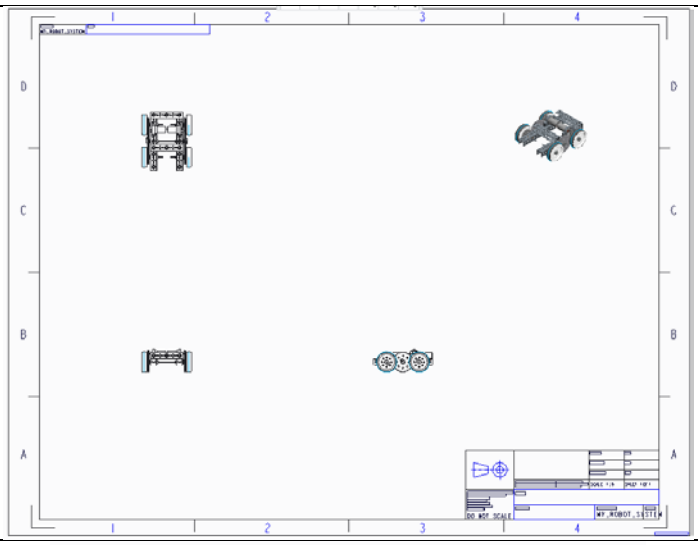
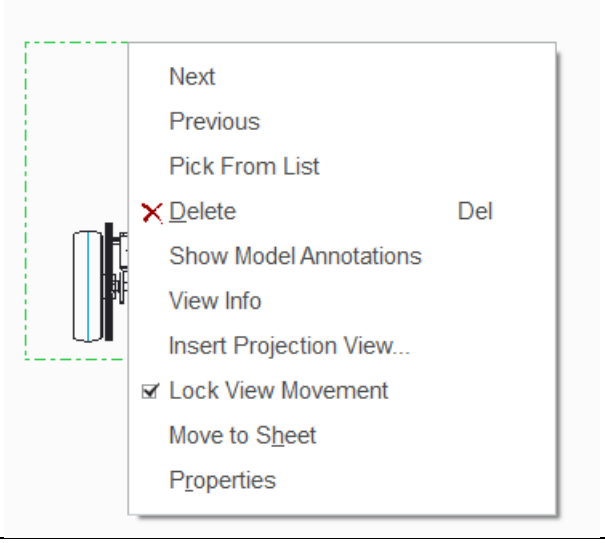
Type in the name "**My_Assembly**" and then hit the **Return** key. Then click on the **Close** button.	
Now select the **Edit Position** tool in the upper menu to begin placing each of the parts in your assembly.	
Begin by left click selecting the two 160mm channels, (remember to use the **CTRL** key to select more than one part), an orientation sphere appears. Use the sphere to edit the position of these channels as shown.	
Now select the offset line tool in the upper dashboard so that you can create offset lines showing where the parts assemble.	

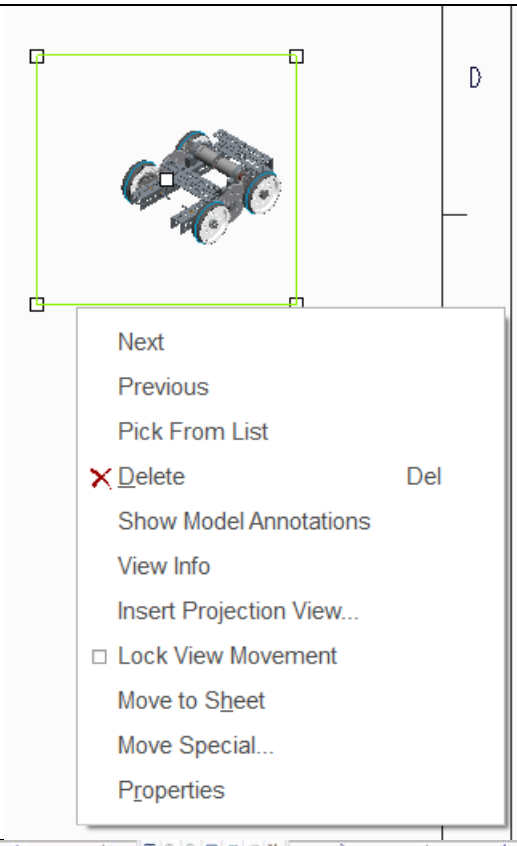
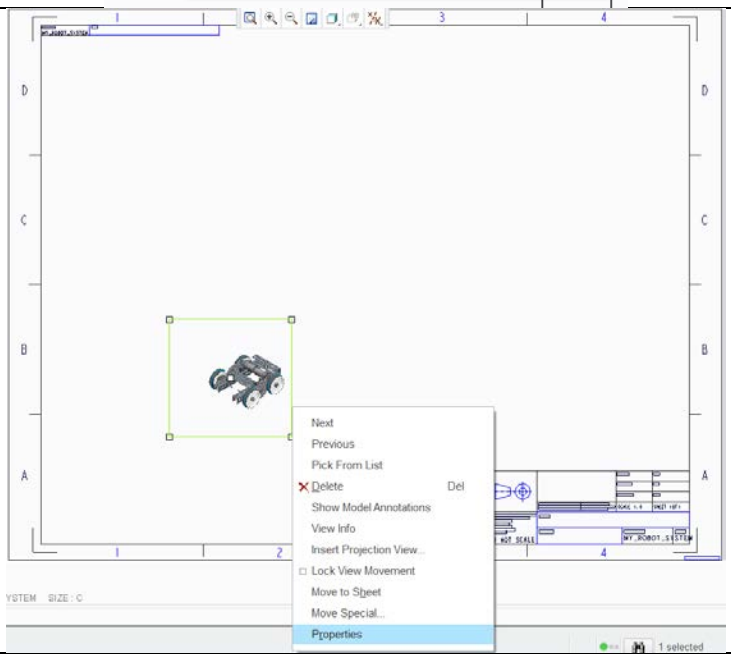
Now select the two cylindrical surfaces of two of the holes and then click **Apply** to create an offset line. Do this for all four of the holes.	
Now click **Close** to finish making the offset lines.	
Next left click on **MY_ROBOT_POWER_SUB.ASM** in the **Model Tree** to select the entire power subassembly then use the orientation sphere to move it up above the channels.	

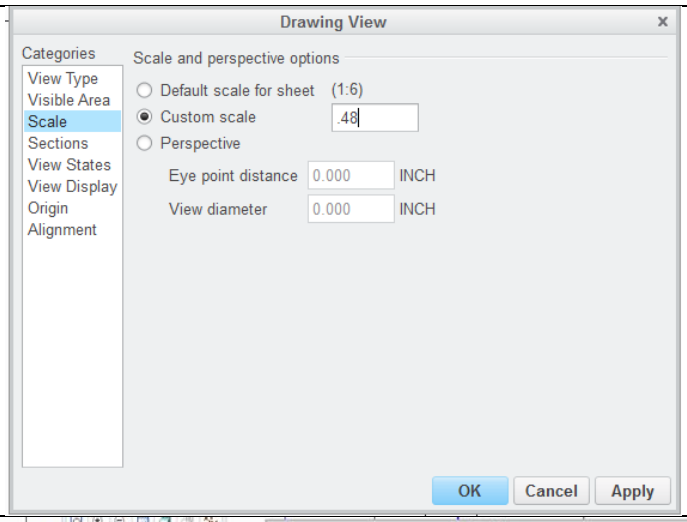
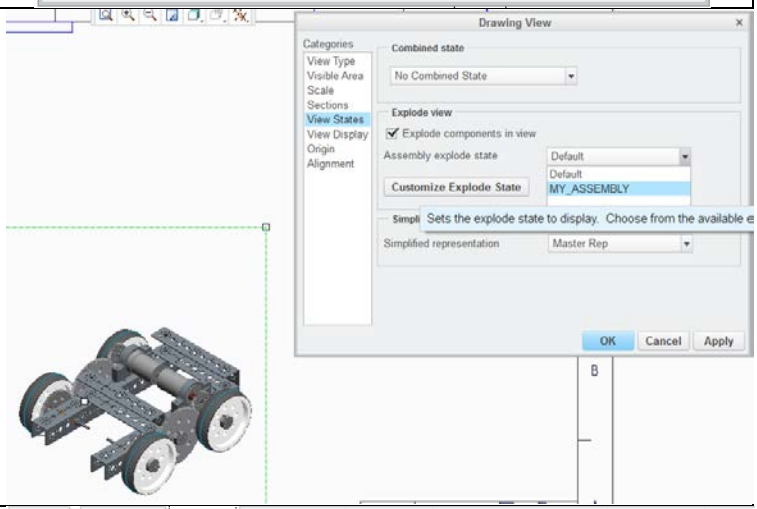
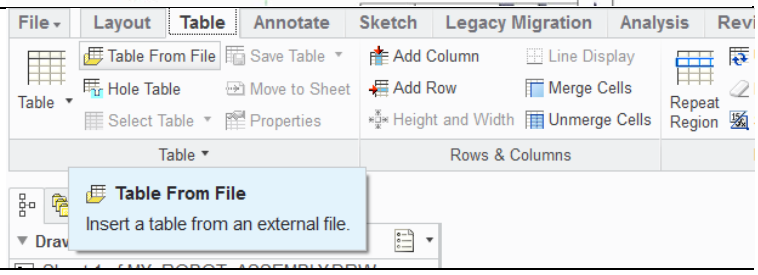
Use the offset line tool to show where the motor mounts connect to the channels.	
Left click to select each of the gears and then use the orientation sphere to explode them from the motor shafts.	
Expand the **MY_ROBOT_DRIVETRAIN_SUB.ASM** entry in the **Model Tree** and then select the wheels and large gear on one side of the robot (remember the **CTRL** key) and then explode them away from the channel.	

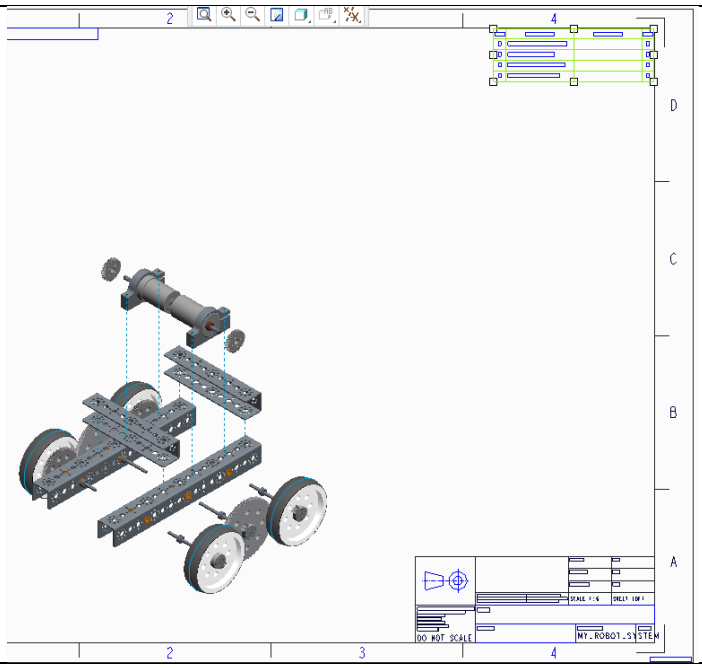
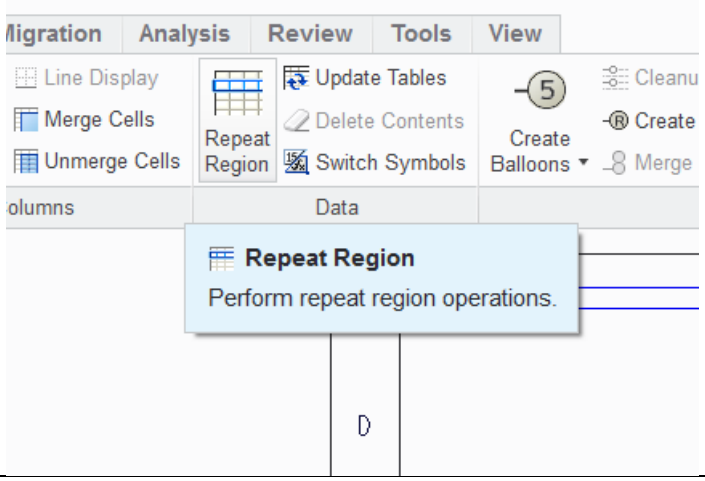
You can continue exploding the parts and subassemblies until you have shown all of the parts and subassemblies and how they fit together. Once you have completed this, click the green check mark to finish positioning the parts and select the **Manage Views** tool in the upper menu.	
You will see that your exploded view has a **(+)** next to it which means that it has been edited and needs to be saved. Right click on **My_Assembly** and select **Save**, then **OK** and then **Close** the view dialog box.	
Now click on the **Exploded View** icon to unexploded your assembly and **Save** your model.	

Now go to the **File** menu and select **New**. Check the **Drawing** button and call this drawing "**My_Robot_Assembly**" and click **OK**.	
You can then select whichever size drawing sheet you would like and can print, (a-size is 8.5X11, b is larger, and so forth). Click **OK** once you have selected the right size format. (Use c size for now).	

You will see a drawing with three views and an isometric view. We will delete all of these except the isometric view which we will change into the exploded view.	
Zoom into the front view and left click on the green dashed border to select it. Once you have selected it then right click on the border and select **Delete**. It will ask if you want to delete all of the highlighted views that are dependent on this one, and you will click on the **Yes** button.	

Select the isometric view and right click and unlock the view movement by unchecking the **Lock View Movement** box.	
Then right click on the border again and select **Properties** to change this view into the exploded view and to scale it larger.	

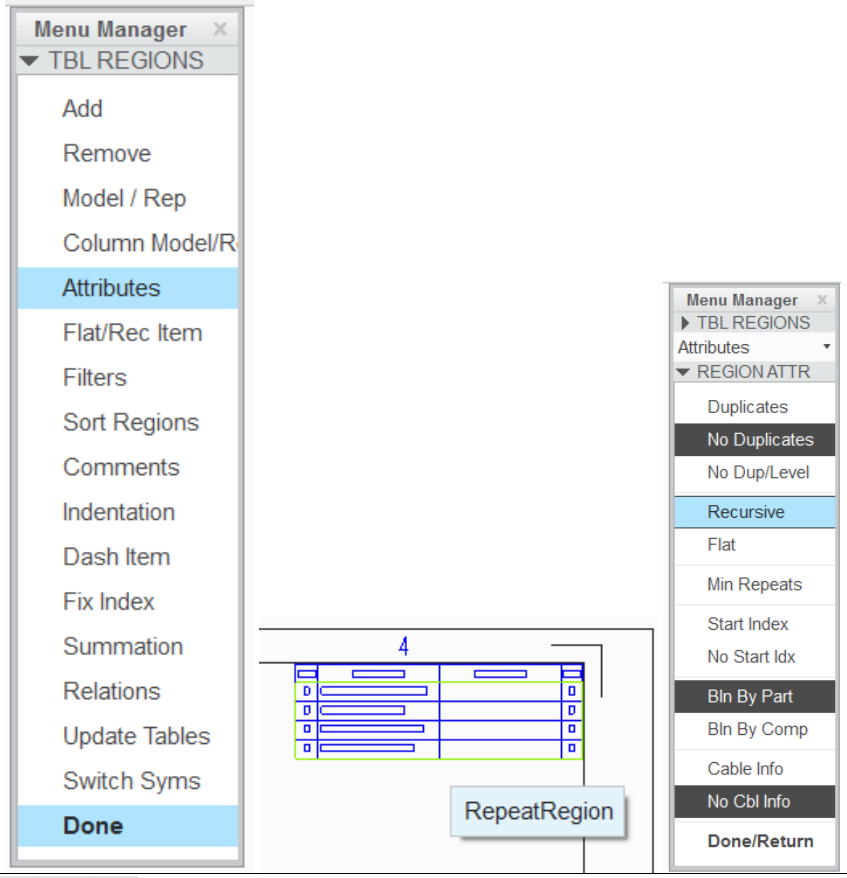
Select **Scale** and then set the value to 3-times the current value. Then click **Apply**.	
Now select **View States**, check the **Explode components in view**, and change the **Default** setting to **MY_ASSEMBLY**, then click **OK**.	
Now let's create a bill of materials. Select the **Table** tab in the upper menu and then select **Table From File**. Select the **bom.tbl** file and click **Open**.	

Place the table in the upper right hand corner of the drawing format by left clicking as shown.	
Now expand the table by selecting **Repeat Region** in the upper menu.	

Select **Attributes** and then left click to select the bill of materials table where the items are listed.

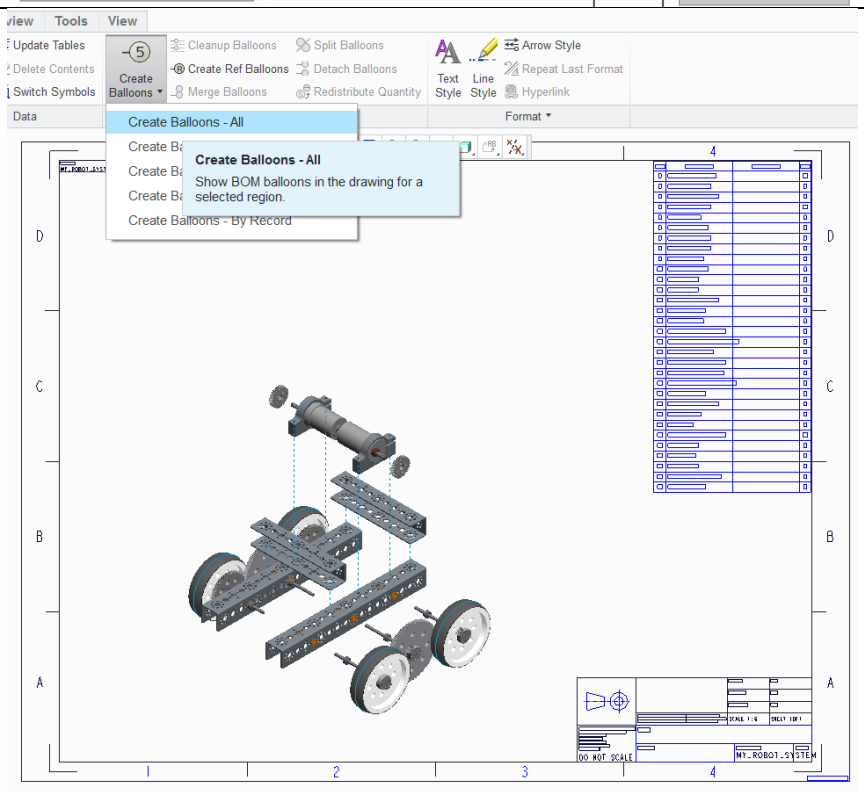
Then in the **Menu Manager**, click **Recursive** and **Done/Return**. And then **Done**.

The table will now be complete with all of the parts in your assembly.

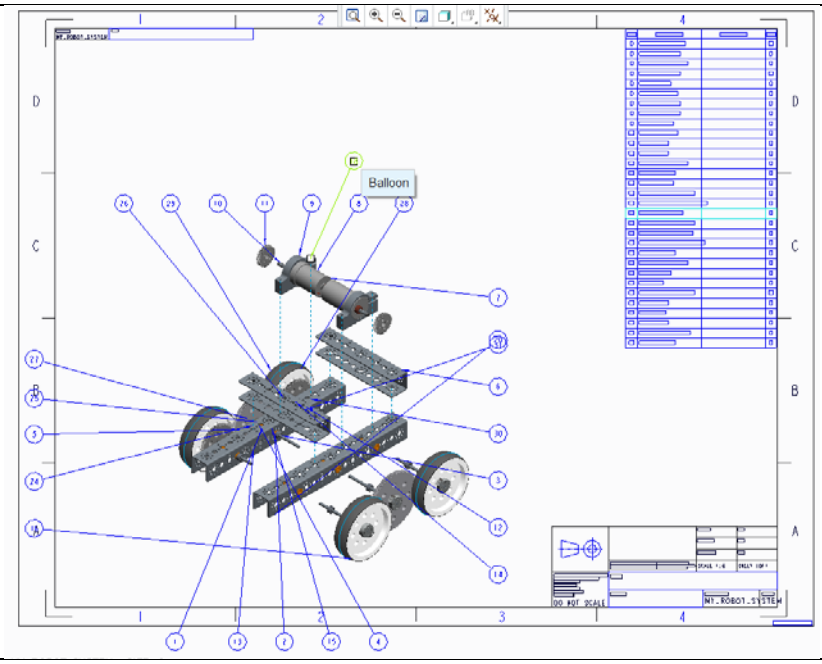


Now select **Create Balloons** in the upper menu and **Create Balloons – All**.

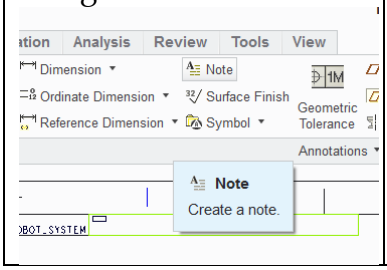
This will create balloons connected to each of the parts listed in the bill of materials.

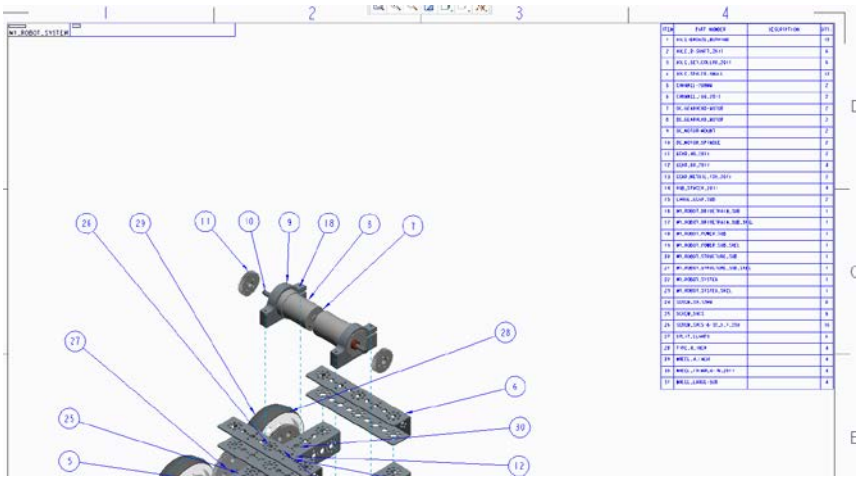


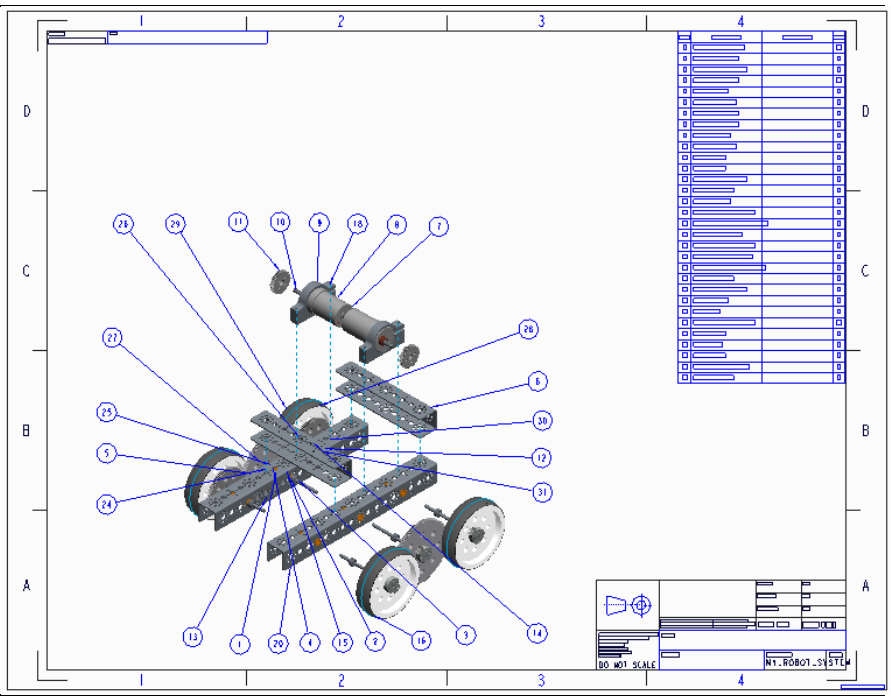
Then by left clicking on each of the balloons you can edit their positions to clean up your drawing.



Your assembly drawing is now annotated with balloons and a bill of materials. You can add notes to your drawing using the **Note** tool.





This drawing provides a visual record of all of your parts and assembly points. You can certainly make several different assembly drawings to document each subassembly as well as your entire system design.	

You have finished the exercise.

EXERCISE 17.0: FAILURE MODES & EFFECTS

Step 1: Select a system you are familiar with and conduct a brainstorming exercise and complete this table for as many failure mechanisms as you can identify. Failure modes are the "why it fails". You can identify the probability that it will occur as (1-not likely, 2-30% chance, 3-60% chance, 4-almost certain). Also you can define the severity as:

1. No degradation in system performance
2. Slight performance degradation
3. Serious performance degradation
4. System failure

Failure Mechanisms	Failure Modes	Probability of Occurance	Severity

EXERCISE 18.0: FIELD SUPPORT PLAN

Using the FMEA spread sheet you completed in the previous exercise, identify each of the failure mechanisms that are serious and identify what you will do to correct the situation.

Failure Mechanisms	Remediation plan	Completed