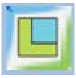
Instructions for exploring and building the PTC robot

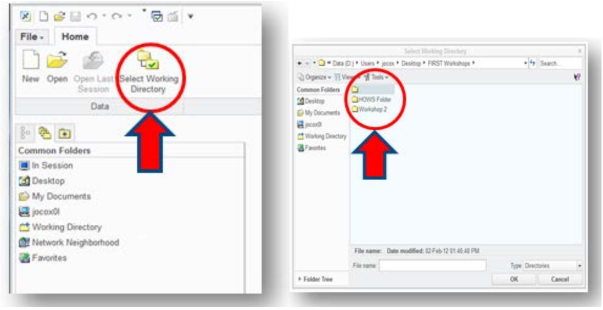
Task 1: Opening the PTC robot model

Objective: In this task you will open **Creo Parametric** and explore the PTC robot.

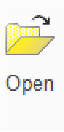
1. Begin by opening **Creo Parametric** by Clicking its icon.



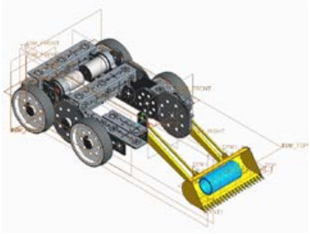
2. Now set your working directory to the workshop folder by selecting the **Select Working Directory** icon and then navigating to the **HOWS Folder 2012/Detailed Design Robot** and clicking **OK**.



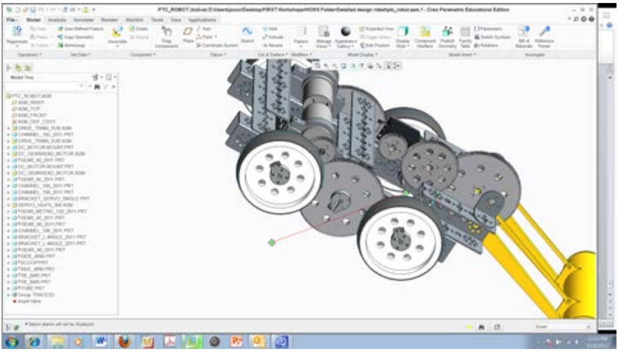
3. Now open the **PTC_Robot.asm** model by clicking the **Open** icon.



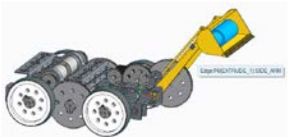
4. Turn off the display of all of the datums using the datum display filter.



Remember how to navigate in **Creo Parametric**, the scroll wheel zooms, Holding the scroll wheel down and moving the mouse spins the model, and holding the shift key while holding the scroll wheel down and moving the mouse pans the model.

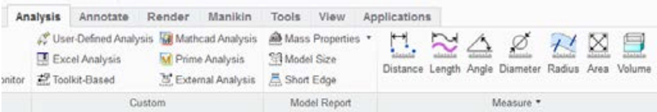


5. Now try exploring the kinematics of this model using the **CTRL-ALT** keys and left mouse clicking and moving the bucket

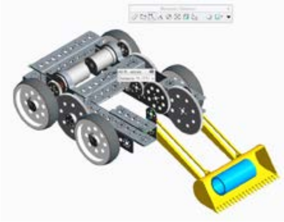


and wheels.

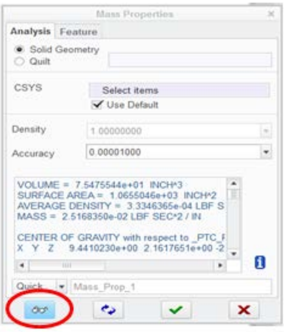
6. Now return the scoop to the bottom and choose the **Analysis** tab in the top level menu.



7. You can use the tools in this tab to measure distances, angles, area, volume, etc. Take a minute to measure some of these on the **PTC_robot**.



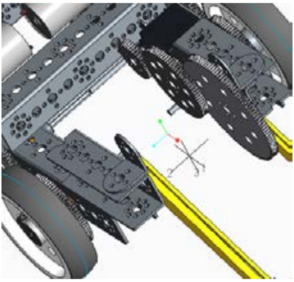
8. Now select the icon for **Mass Properties**. A dialog box will appear. Find the icon at the bottom of the dialog box that looks like glasses and left click on it.



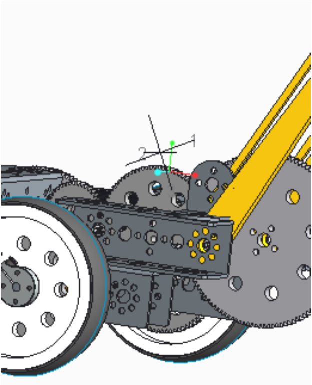
9. The text area will be filled with calculations associated with the mass properties of the assembly.

Note: *Mass properties are values associated with* *a model that characterize it in terms of how it will react to forces and how it will move. For example, volume, mass and center of gravity are all values considered part of the mass properties of a model.*

10. Notice that the location of the center of gravity is displayed on the model using a coordinate system with axes labeled 1,2, and 3.

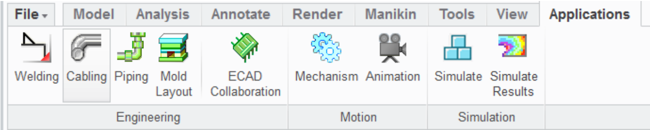


11. Try moving the bucket to its highest position and then recalculate the mass properties by clicking on the eye glasses again. Notice how the center of gravity has changed.



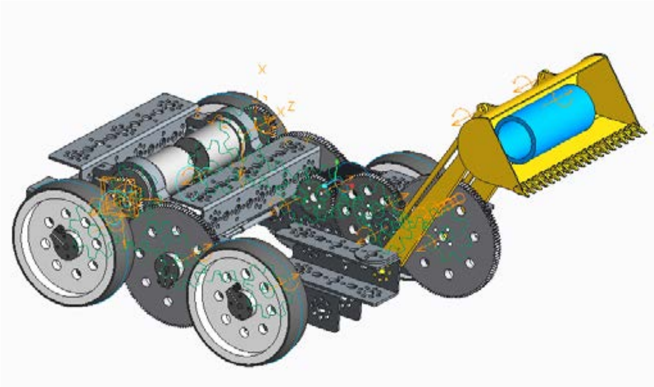
Note: *This calculation is very important for robots. Many times robots fail in their competitions because their center of gravity is too high or off center or in the wrong place. This calculation alone justifies the time it takes to* *build a CAD model of your robot.*

12. Now let's explore the kinematic simulations built into this model. Close the mass properties dialog box. Select the **Applications** tab in the top level menu.

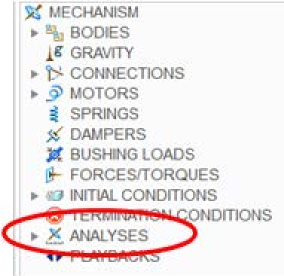


13. Choose the **Mechanism** icon

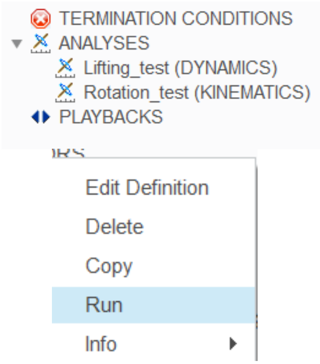
14. Notice that all the kinematic connections are highlighted.



15. Now expand the arrow next to **Analyses** in the Mechanism Tree.



16. There will be two analyses, one called **Lifting-test (DYNAMICS),** and **Rotation-test (KINEMATICS)**. Right click on the **Lifting-test** and select Run.



17. This analysis turns on the lifting motor to see how the bucket will be lifted in terms of speed and impulse.

18. You can try the same with the Rotation analysis. It turns on the motors that turn the wheels.

19. Once you have run both analyses, you can expand the arrow next to the

PLAYBACKS and watch the analyses again or save them as video files.

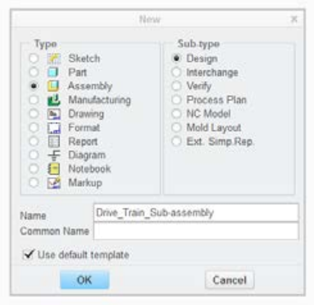
Congratulations! You have completed exploring the PTC Robot.

Task 2: Assembling the Drive Train Sub-assembly

Objective: Learn how to assemble models of robots from the kit of parts.

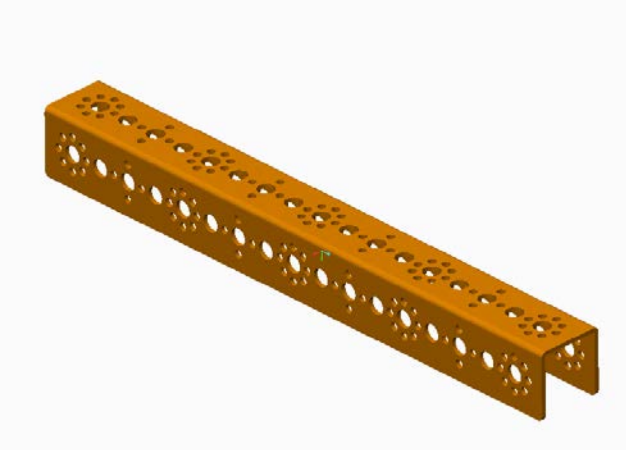
1. Open **Creo Parametric** and set the working directory to the **HOWS FOLDER 2012** and **Detailed design robot.**

2. Now select to create a **New** file and select **Assembly** and name it "**Drive_Train_Sub-assembly**".

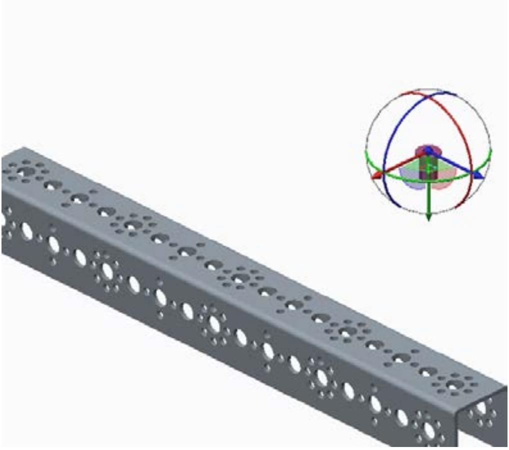


3. Once the assembly file opens, select **Assemble** from the icons on the dashboard at the top of the screen.

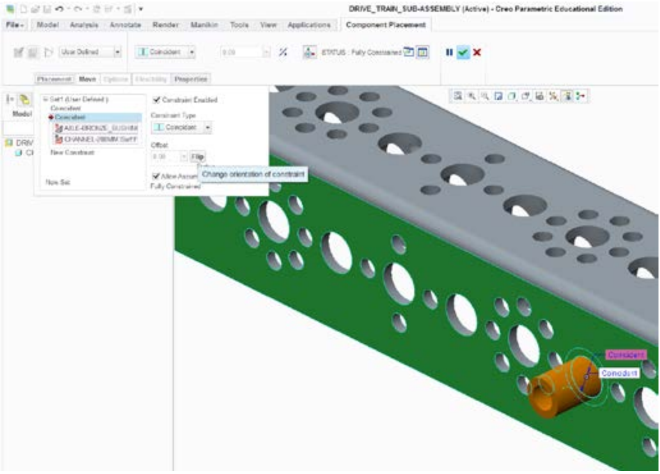
4. Assemble the first part by opening it and then applying the default constraints to ground it. The first part is the "**channel-288mm.prt**".



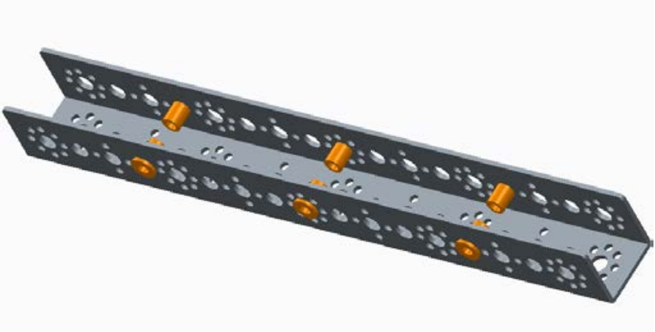
5. Once it has been grounded, bring in the next part which is a bronze bushing. The file name is “**axle-bronze_bushing.prt**”. You will want to insert the bushing into the appropriate holes on both sides of the channel.



6. Begin by inserting the peg into the middle hole on one side of the channel. If the bushing needs to be flipped, there is a "**flip**" option under the **Placement** tab.



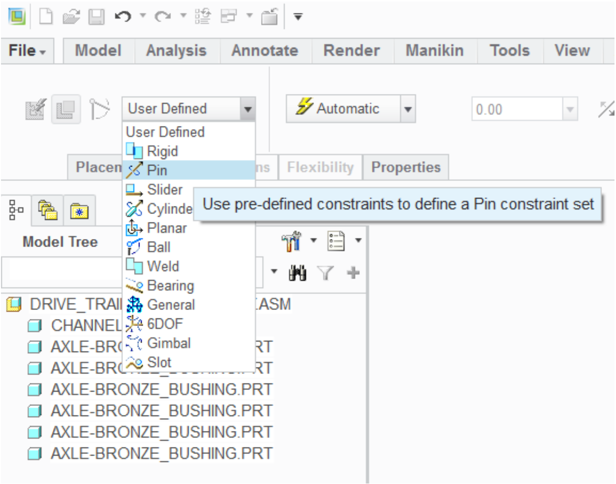
7. Now place two more bushings on either side of the first one with 4 holes spacing between them. Repeat this procedure on the opposite side of the channel until there are six bushings placed in the appropriate locations.

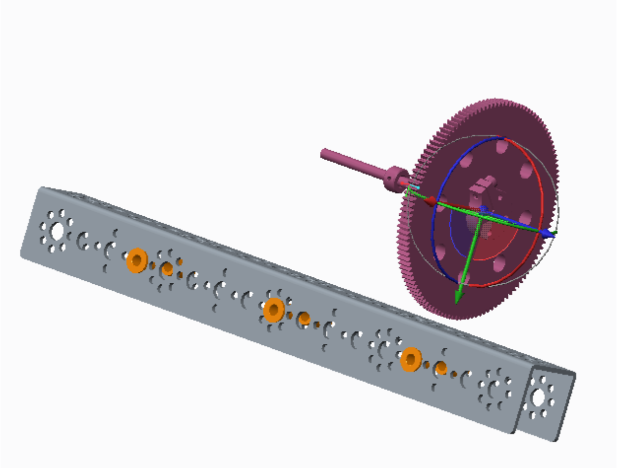


Add gears and wheels using kinematic constraints

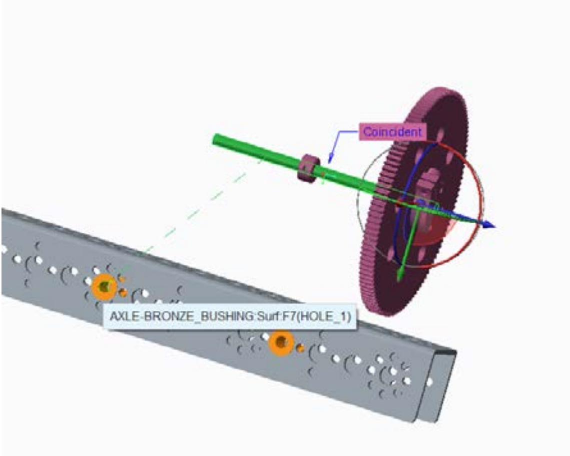
***Note**: This has all been done using static constraints. Now we will assemble a large gear and two wheels into this assembly using kinematic constraints that allow the gears and wheels to spin even after they have been assembled.*

1. Assemble the large gear by Selecting **Assemble** and then selecting the "**large_gear_sub.asm**" file. Orient it using the orientation handles so that it is near the middle bushing. Now find the "**User Defined**" tab on the assembly dashboard and then find the "**Pin**" constraint and select it.

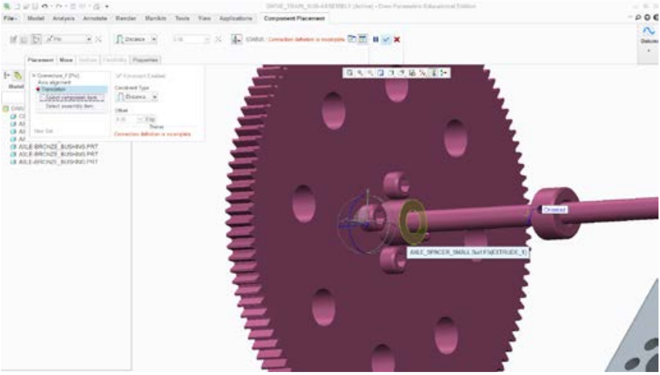


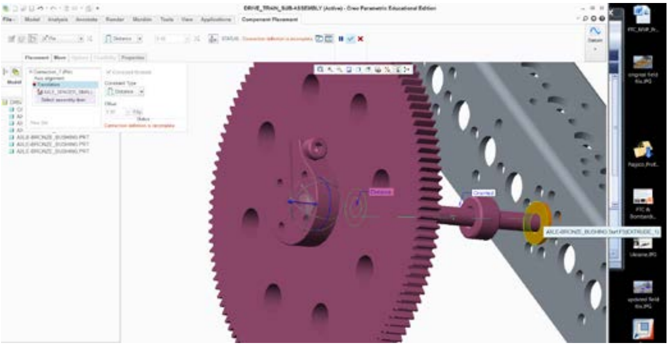


2. A **Pin** constraint automatically requires a minimum of two sets of constraints to be specified. First the axes must be aligned. In this case the cylindrical surface of the shaft of the gear must be selected (Make sure you select the cylindrical surface and not the flat key surface of the shaft). Then the cylindrical surface of the bronze bushing in the middle of the channel.

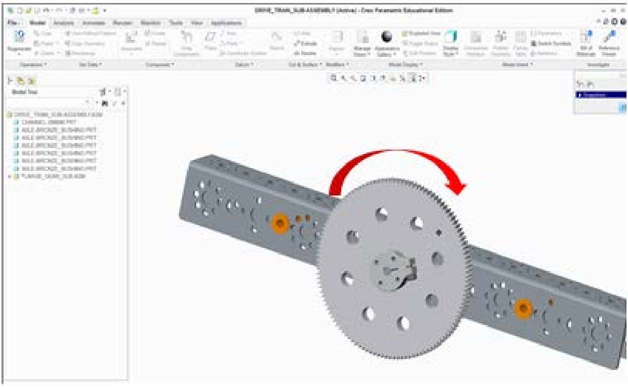


3. Next, the flat shoulder of the gear and the flat face of the bushing must be coincident. Selct these two surfaces and the gear will align itself. Again you may need to "**flip**" the alignement. Also, if the gear is obstructing the face of the bushing, you can move the gear in the middle of specifying constraint surfaces by pressing simultaneously the **CTRL-ALT** buttons on the keyboard and then **left mouse button** selecting the part to be moved and moving the gear until the face of the bushing appears.

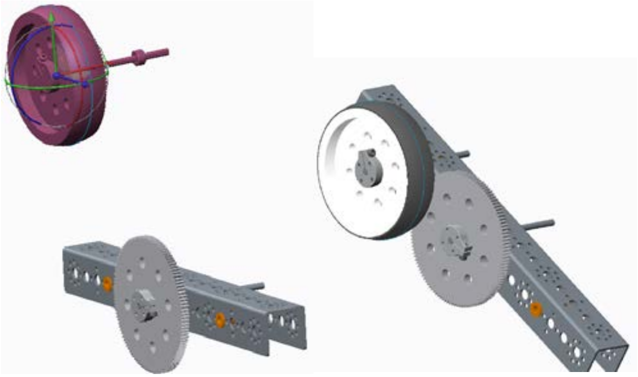




4. Once the assembly of the gear is completed by checking the green check mark in the dashboard, check to make sure the kinematic constraint has been applied correctly. Press **CTRL** and **ALT** and then **left mouse button** select the gear and spin it to make sure it is working correctly. You can also use the **Drag Components** tab in the top dashboard and then select the gear to spin it.

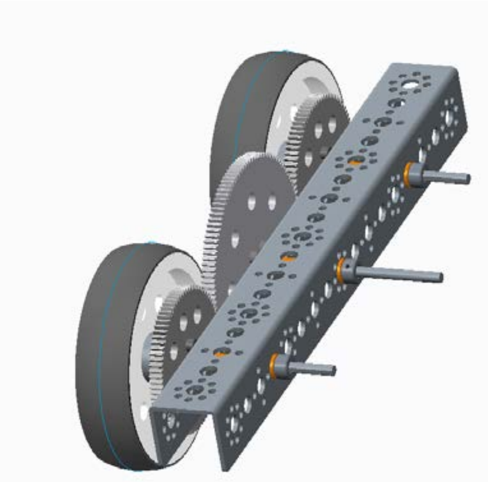


5. Now continue the assembly by assembling the “**wheel_large-sub.asm**” on either side of the gear using the same kinematic “**Pin**” constraints.



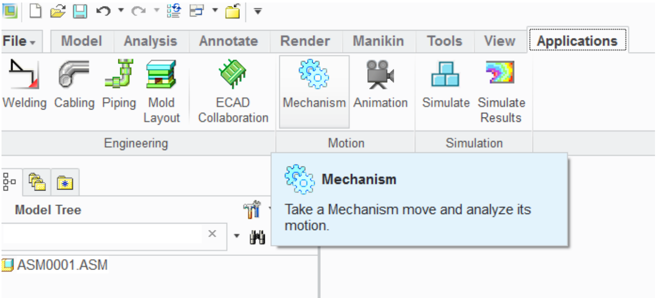
6. Once you have finished assembling the wheels on both sides of the gear, check to make sure both of the wheels spin properly. Notice that the gear and wheels all spin independently regardless of the gears’ meshing. To connect the gears, a

gear connection will need to be defined.

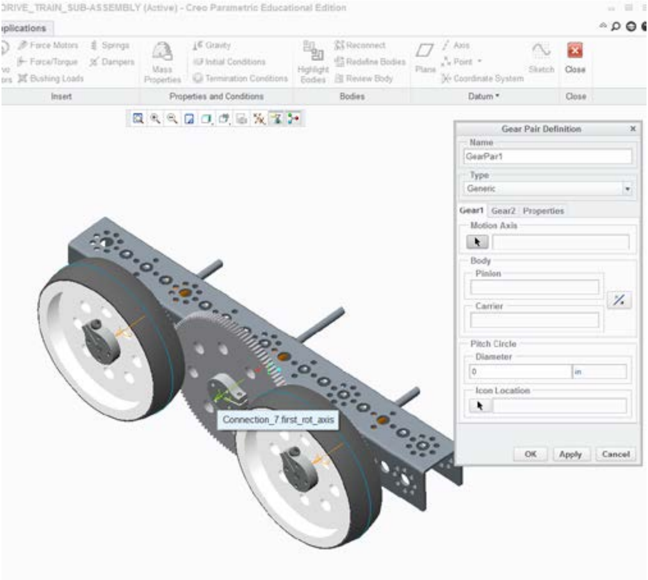


Task 12: Create gear pairs

1. To establish a gear pair connection, it is necessary to move into the **Mechanism** application. Select the **Applications** tab at the top of the screen. Select the **Mechanism** application.

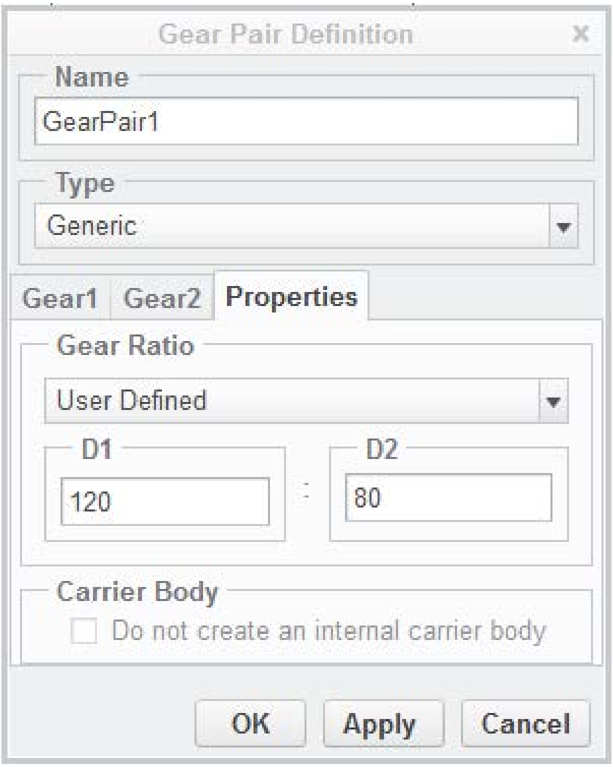


2. To define a gear pair, select the "**Gears**" option in the top dashboard and a dialog box will appear allowing you to create a gear pair. A gear pair can only be defined between two **Pin** connections. There doesn't even need to be any gear teeth for a gear pair connection to be defined.

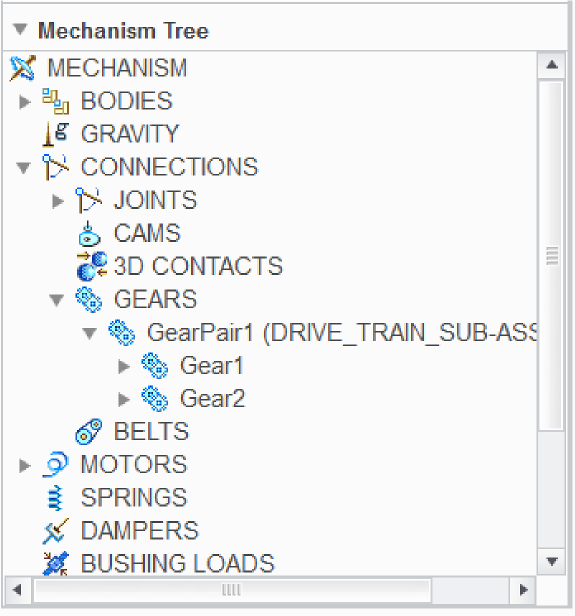


3. First select the pin joint icon  of the large gear in the middle of the assembly and then change to the **Gear2** tab and select one of the wheel pin connection icons. Now that both gears have been identified, select the **Properties** tab in the dialog box. This is where the properties of the gear connection can be specified. The rate at which the two pin joints rotate with respect to each other can be set by the pitch circle diameters or by a ratio defined by the user. In this case the ratio can be determined by specifying the number of teeth of each gear. Pull down the menu under **Gear Ratio** and change it to **User Defined**. Enter the number of teeth of the

large gear (120) and then the number of teeth of the gear on the wheel (80).



4. Use the same proceedure to set up the gear pair connection between the middle gear and the other wheel. You can always redefine the gear connections by navigating to the **Mechanism Tree** and finding the **Gears** under the **Connections** node in the tree.

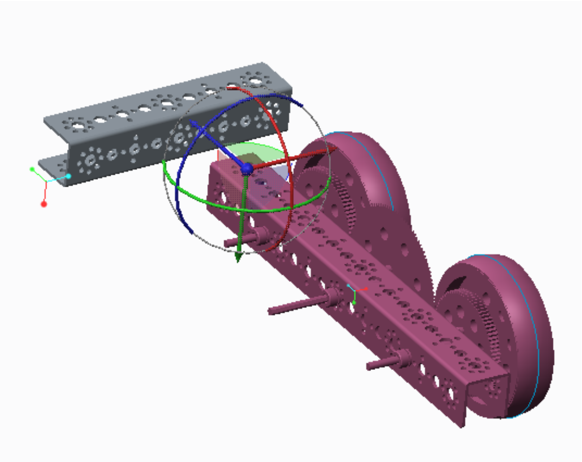


5. **Right mouse button** on **GearPair1** to reopen the gear connection dialog box. Once the connections have been defined, close the applications dashboard using the **Close** icon and then save the **Drive_Train_Sub-assembly**.

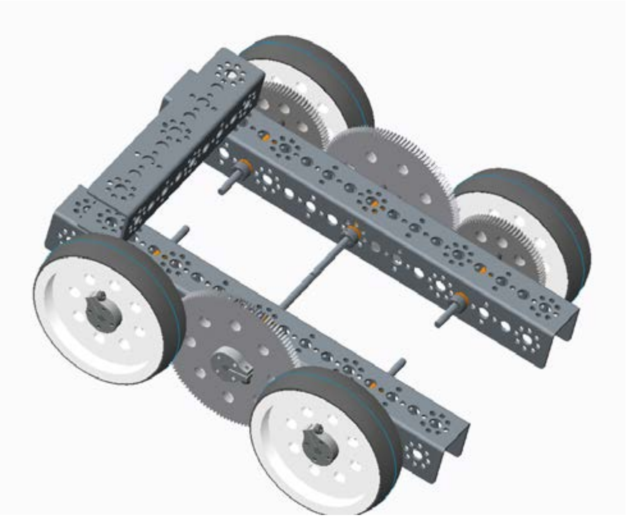
Congratulations! You have completed the assembly of the drive train components.

Task 3: Assembling the robot

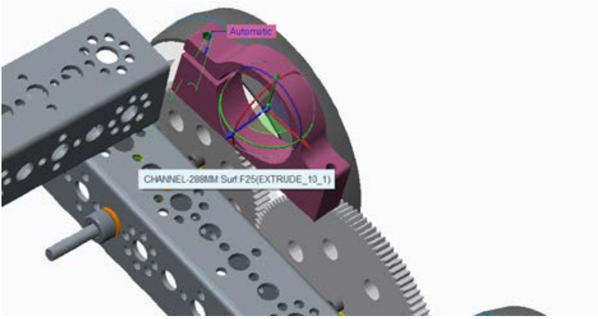
1. The assembly of the robot can now begin. Create a new assembly file named "**My_Robot**". Begin the assembly by assembling the part "**channel_160_2011**" and constraining it to the ground using the default constraint. Now assemble the **Drive_Train_Sub-assembly** to the channel. Select two holes to align and then the flat faces of the two channels. A third constraint will need to be applied specifying an angle of 90 degrees between two faces. Remember it always helps to orient the parts close to the final orientation before you start applying constraints. It helps **Creo Parametric** "guess" what the appropriate constraints are.



2. Now assemble another instance of the **Drive_Train_Sub-assembly** on the other side to complete the robot drive train.

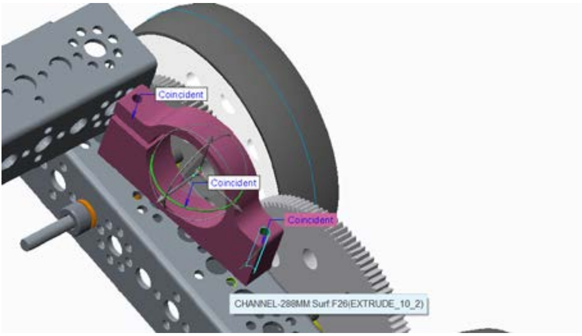


3. Continue the assembly of the robot by adding the **DC_Motor_Mount.prt** aligning the small holes and the flat bottom of the mount to the top of the channel.



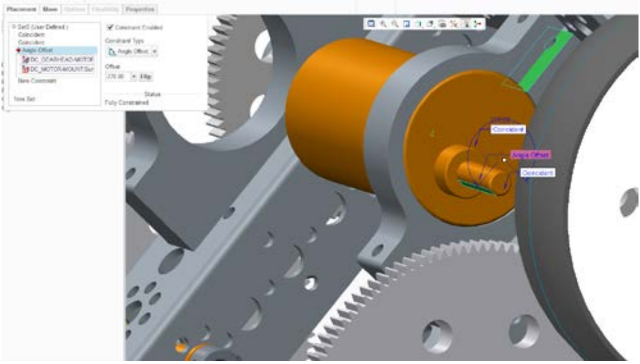
4. You will need to apply a third constraint

to insure proper alignement. Make the axes of the other small hole on the mount coincident with the corresponding small hole in the channel. Assemble another instance of the **DC_Motor_Mount.prt** on the other side of the robot drive train as well.



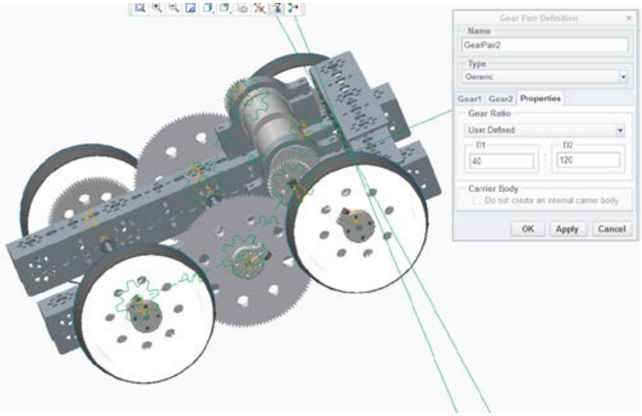
5. Now assemble the **DC-gearhead-motor.prt** into the mounts. This is done by aligning the cylindrical surfaces and then aligning the flat surface of the face of the DC motor with the flat side of the mount. A third constraint is applied to orient the shaft of the motor so that the small gear which will be assembled on the shaft will mesh appropriately with the large middle gear of the drive train. Use an **Angle Offset** constraint and select the flat surface of the shaft and the flat surface of the mount. Then change the angle to **270 degrees** so that the shaft is closest to the

large gear in the middle.

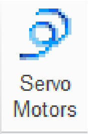


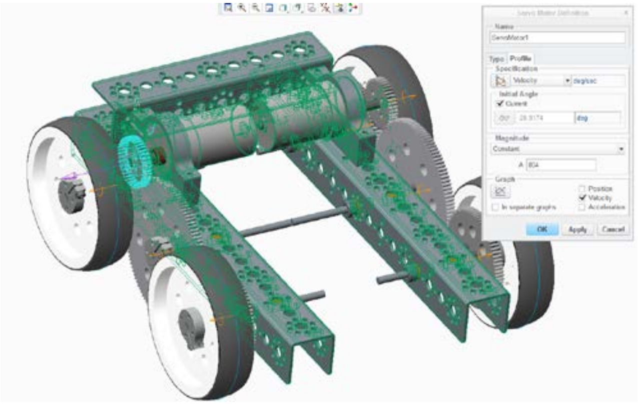
6. Do the same for the other motor in the opposite motor mount. Depending on the orientation of the mounts and motors, the angles specified may be 270 degrees and 90 degrees or vice versa.

7. Now assemble the small gears (**gear_40_2011.prt**) onto the shafts of the motors with kinematic **Pin** constraints so that the gears will turn and then make gear pair connections between the small gears and the large gears remembering that the small gear has (40) teeth and the large gear (120) teeth.



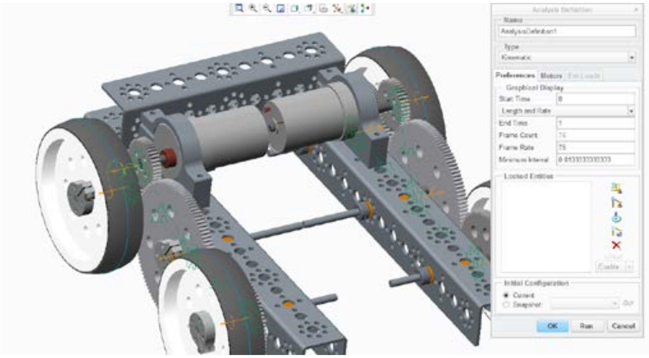
8. While we are in the **Mechanism** application, let's also define the servo motors that will drive the gears and wheels. Select the **Servo Motors** tab at the top of the dashboard. A dialog box will appear. The first thing to define is the **Pin** connection which will act like a servo motor. Pick the axis icon associated with the small gear at the end of the shaft of one of the motors.





9. Now select the **Profile** tab in the dialog box and change the **Specification** to **Velocity** and the **Magnitude** to 924 degrees/second, (this comes from the standard DC motor provided in the FTC kit which runs at a constant 154 RPM, which converts into degrees/second by multiplying by 360 degrees/revolution and dividing by 60 seconds/ minute). Check the motor definition by selecting the **Mechanism Analysis** tab in the top dashboard. Change the **Type** to **Kinematic**, the end time to **1 second** and the frame rate to **75 frames/ second**, then click **Run**. The

analysis will be performed and the gears and wheels will turn. Now close the dialog box by selecting **OK**.



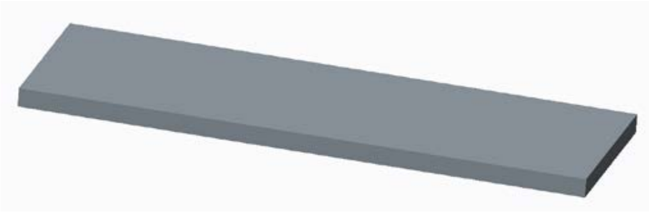
10. To play back the analysis, use the **Playback** tab in the top dashboard. If the motor does not spin in the right direction, you can flip the direction by reopening the servo motor dialog box for the defined servo motor. This is done using the **RMB** on the servo motor in the mechanism tree on the left of the screen.

11. Now save your robot and close the file.

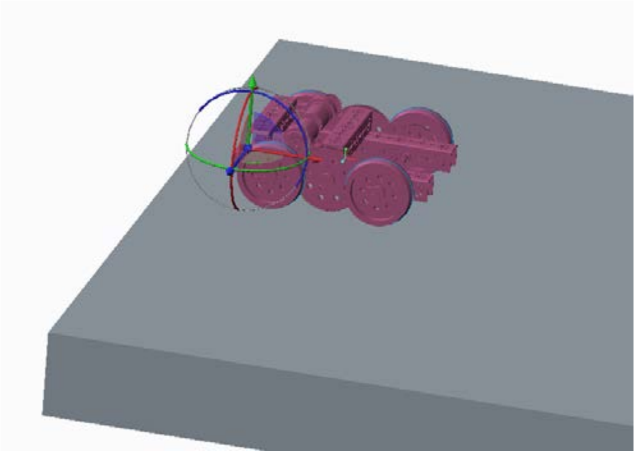
Congratulations! You have completed building the robot. Now let's turn the motors on.

Objective: to simulate the motors driving the robot on a surface.

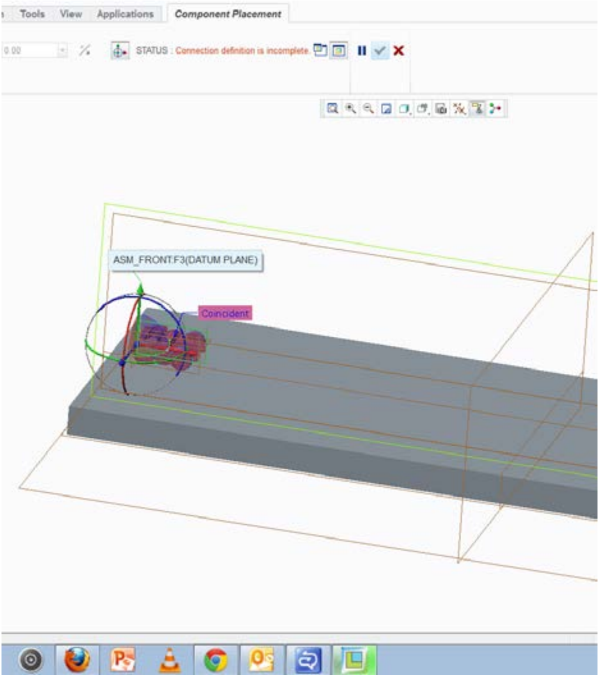
1. Create a new assembly file called: "**Robot_test**" and start the assembly by bringing "**flat_path.prt**" and grounding it using the **Default** constraint.



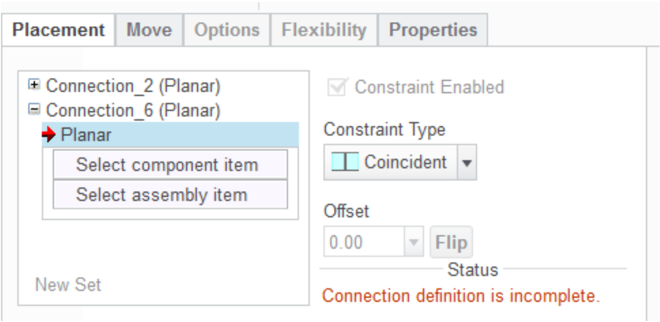
2. Then bring in your robot: "My_Robot.asm" and position it near the left end of the flat path.



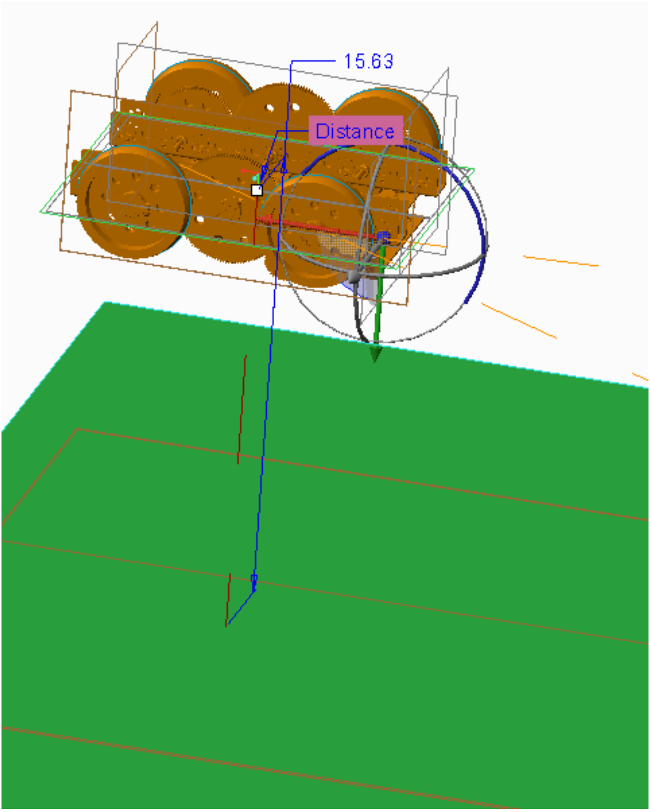
3. Now select a **User Defined** constraint called "**Planar**." This constraint keeps flat faces parallel. Turn on all the datum planes using the **Datum Display Filter** and then select one of the vertical planes bisecting the robot and the vertical plane bisecting the flat path.



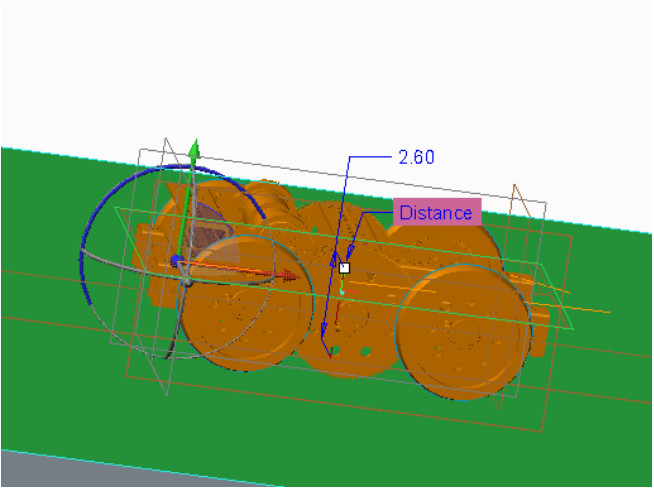
4. Now open the Placement tab in the assembly dashboard and select a **New Set** to open a new **Planar** constraint set.



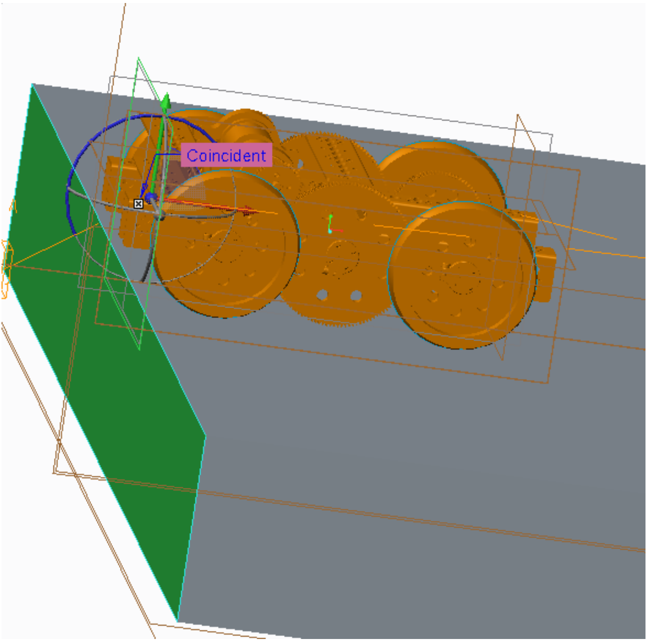
5. Select the plane of the robot that should remain parallel to the top of the flat path. Change the constraint type to **Distance** and then select the top of the flat path. (You may have to select **Distance** a couple of times)



6. Set the distance to **2.6** units so that the wheels are just touching the top surface of the flat path. (Make sure that the robot is right-side up. If not click on **Flip** in the Placement tab of the assembly dashboard)

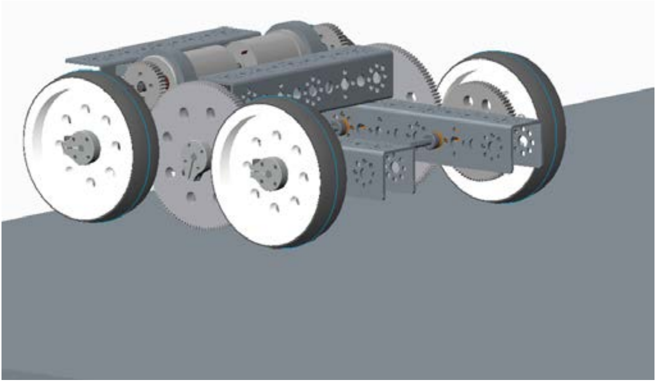


7. Now select a **New Set** of **Planar** constraints and choose the plane at the back of the robot and then the end of the flat path.



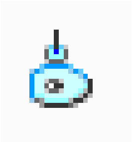
8. Finish the assembly by clicking the green checkmark.

9. Turn the datum plane display off and rotate your assembly so that the robot is oriented as shown.



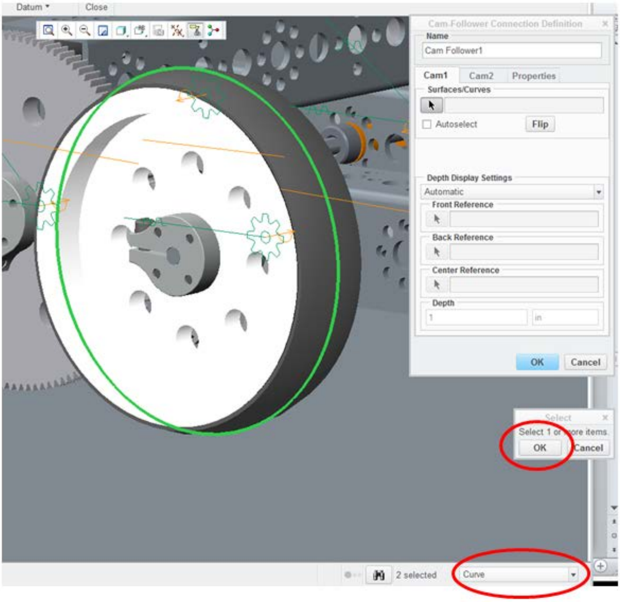
10. Nowchoose Applications from the tabs in the upper menu and then choose Mechanism.

11. We will now create a connection between the wheels and the top of the flat path by choosing CAM in the upper menu.

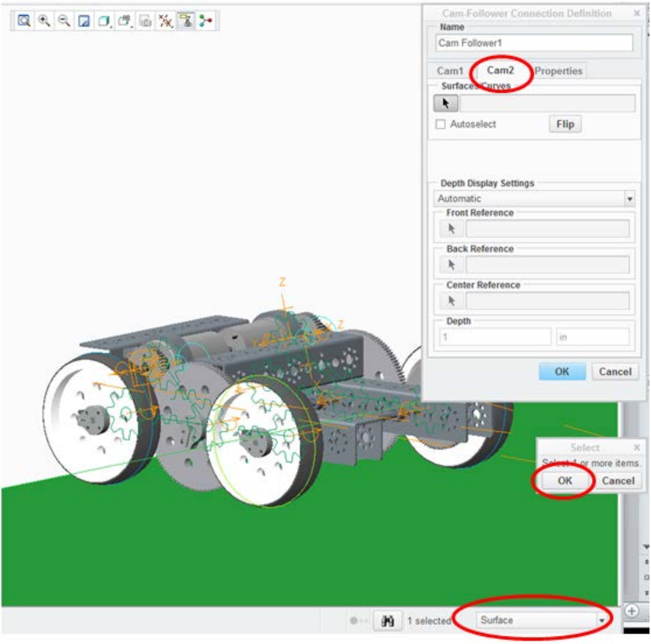


12. A dialog box will appear and the first selection that must be made is to define **Cam1**. This is done by selecting the curve around the front wheel on the left side of the robot.

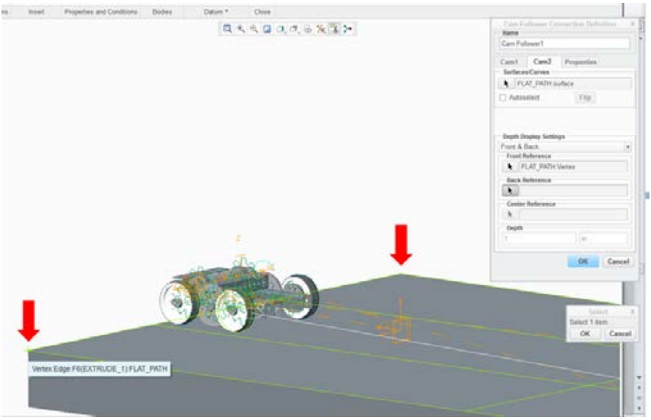
This is done by changing the selection filter in the lower right hand part of the **Creo** window to **Curve** and then selecting the first half of the curve and then holding the **CTRL** key and selecting the other half of the curve. Then click **OK**.



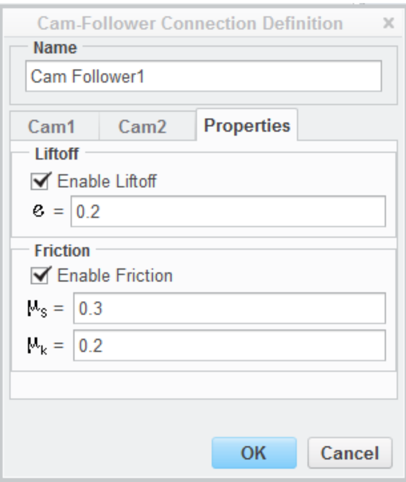
13. Now Select the **Cam2** tab in the dialog box. Change the selection filter to **Surface** and then select the top surface of the flat path and click **OK**.



14. Once you have clicked OK, you will need to select a point on the front edge and back edge of the path.



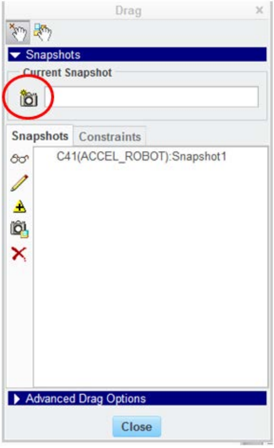
15. Click on the **Properties** tab and check the **Enable Liftoff** box and set the value to **0.2** Then check the **Enable Friction** box and set the top value to **0.3** and the bottom value to **0.2** and then click **OK**.

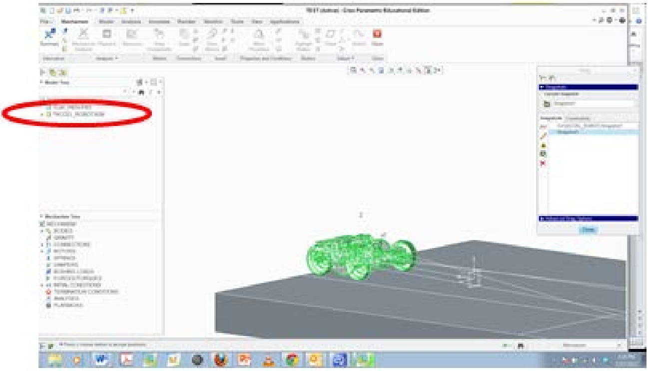


16. You need to create a **Cam** connection with the rear wheel as well in exactly the same manner as you did with the front wheel. you will only need to create these **Cam** connections for one side of the robot.

17. Now let's set the initial position so that we can always start over from this position. To do this, click on **Drag Components** in the upper menu.

18. Click on the camera under **Current Snapshot** and then select your robot in the **Model Tree** on the left. This sets the position of your robot. Now close the dialog box.

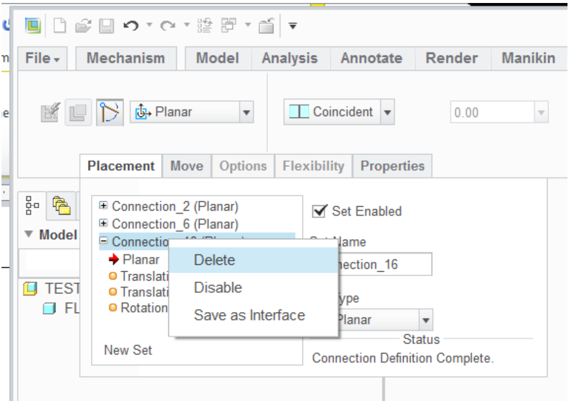




19. Now before we turn on the motors, we need to remove 2 of the assembly constraints or the wheels will just spin and the robot won't go anywhere. Find your robot in the **Model Tree** on the left again and right mouse click and select **Edit**

Definition. Click on the Placement tab to open it.

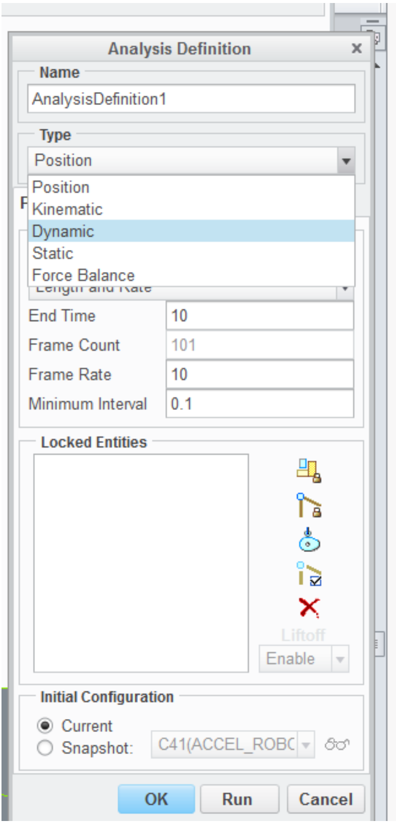
20. You will see 3 assembly constraints that you placed on your robot earlier. You may have to scroll to see all 3. Scroll to the bottom and delete the last two constraints. You will need to select each one and then right mouse click on the **Connection (Planar)** and choose **Delete**. Then click the green checkmark.



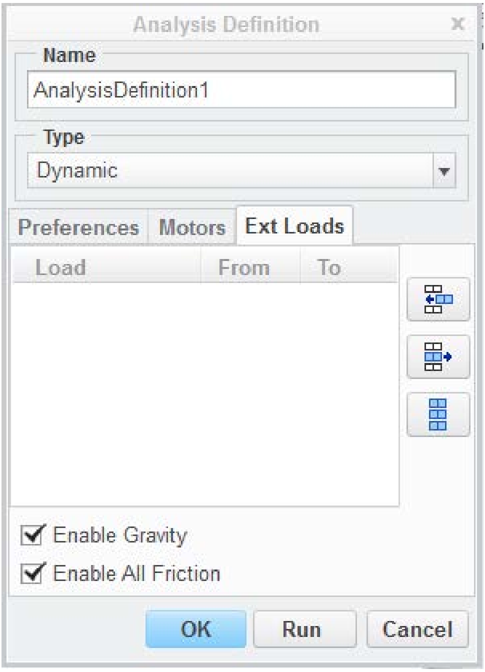
21. Now we are ready to do a simulation. Select **Mechanism Analysis** in the top menu. A dialog box

will appear.

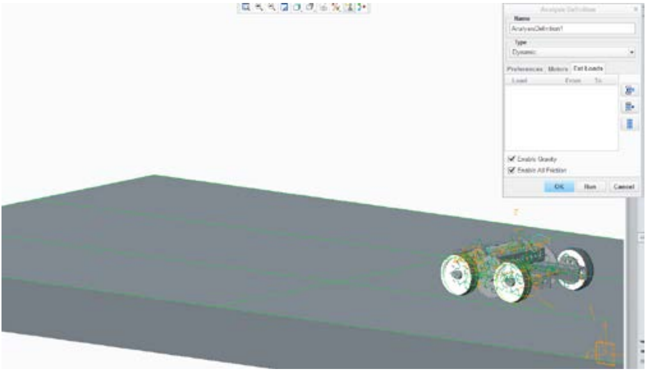
22. Change the **Type** of analysis from Position to **Dynamic**.



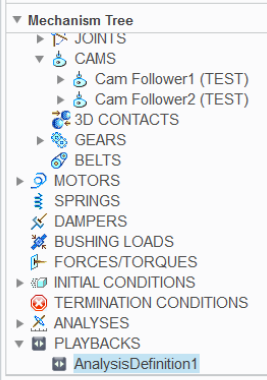
23. Now select the **Ext Loads** tab and check the **Enable Gravity** and **Enable All Friction** boxes.



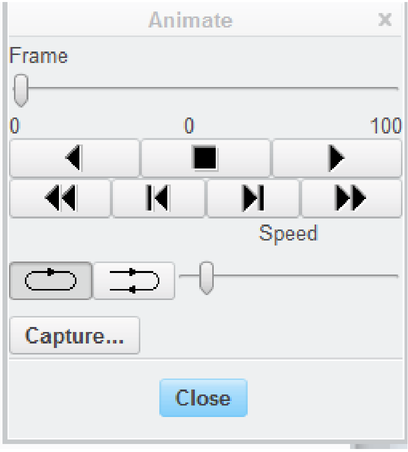
24. Now click on the Run button and wath your robot move. Once the analysis has run, click on the OK button.



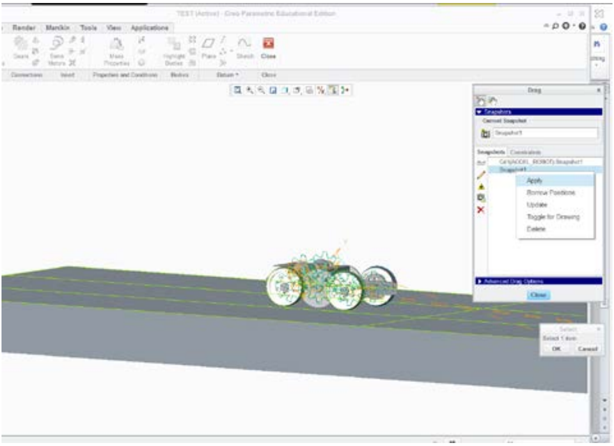
25. You can play this analysis again by looking in the **Mechanism Tree** and finding the element called “**PLAYBACKS**.” Expand it and then right click on your analysis and select **Play**.



26. You can now replay it and spin your model or zoom in and out to better see it move. You can also save it as a video file by selecting capture.



27. If you would like to do other analyses, you can select **Drag Components** in the upper menu and then select the snapshot you took with your robot at its beginning position. Right mouse click on it and select **Apply** and your robot will be returned to its initial position.



Congratualtions! You have successfully simulated your robot in the real world.