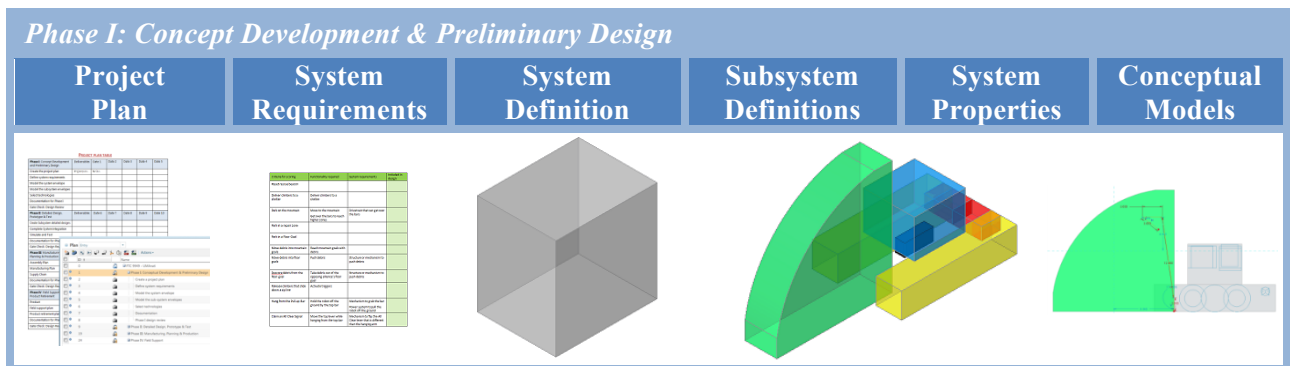Let's break down the complexity of designing and building a robot through a product development process that allows you to engineer solutions to simpler tasks which, when taken together, form an integrated solution. That process has four phases that each contain a collection of deliverables and a gate check – giving you the chance to review and refine.

1. Concept development and preliminary design.
2. Detailed design, prototype, and test.
3. Manufacturing planning and production.
4. Field support and product retirement.

Phase I: Concept Development & Preliminary Design

| Project Plan	System Requirements	System Definition	Subsystem Definitions	System Properties	Conceptual Models

Conceptual Models

The system envelope model includes the subsystems our robot requires, as well as, the size and position of each subsystem. The next step in the product development process is selecting the technology solutions that will allow the subsystems to perform their functions.

Use brainstorming and research to begin developing ideas about how a robot could carry out each of the required functions.
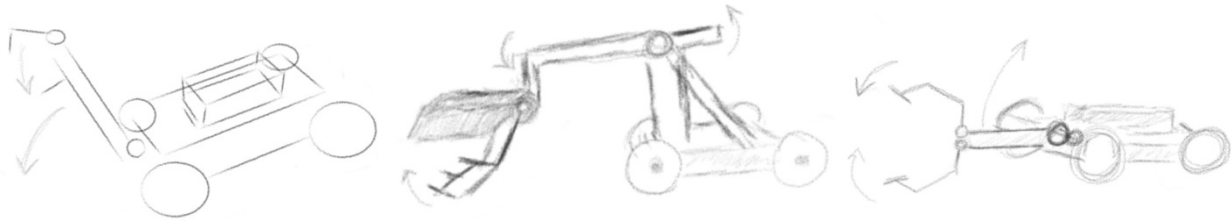
After conducting research, brainstorming, and evaluating competing ideas, it is time to draw a conceptual model. For the example, we chose a mechanism that is positioned 2in off the ground. It consists of a 12in arm that can move in an arc out the front of the robot. The end of the arm has a 3in mechanism that can grasp game elements.
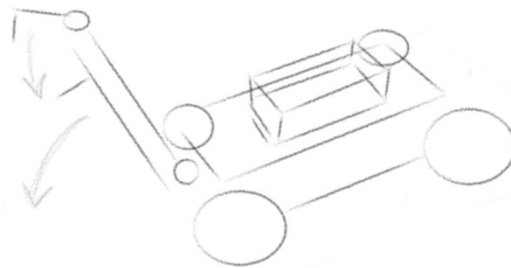

Using Creo to sketch your conceptual model
Sketch of an idea how the subsystem will perform the required functions. Using Creo to do a line drawing of a preliminary idea allows you to test the movements and interactions while still in the preliminary design phase. Sketch conceptual models for each of the subsystems that represent the size, shape, movements, and points where the subsystem interacts with other systems.
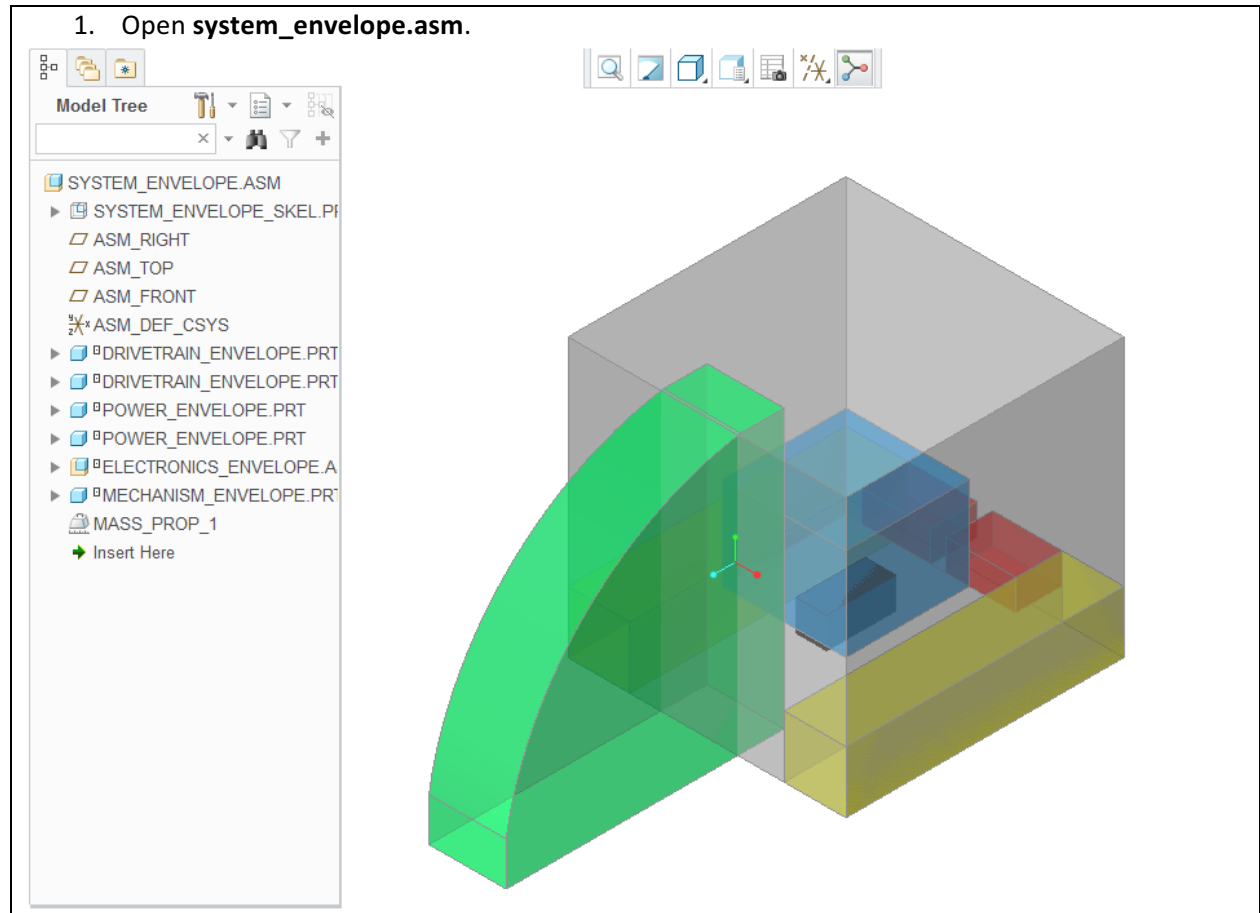
Making 2D sketches of possible subsystem designs lets you quickly compare alternative ideas. The Sketch application in Creo adds in additional functionality, such as movement. The table below shows how a sketch can add important information to different context in which you are designing.

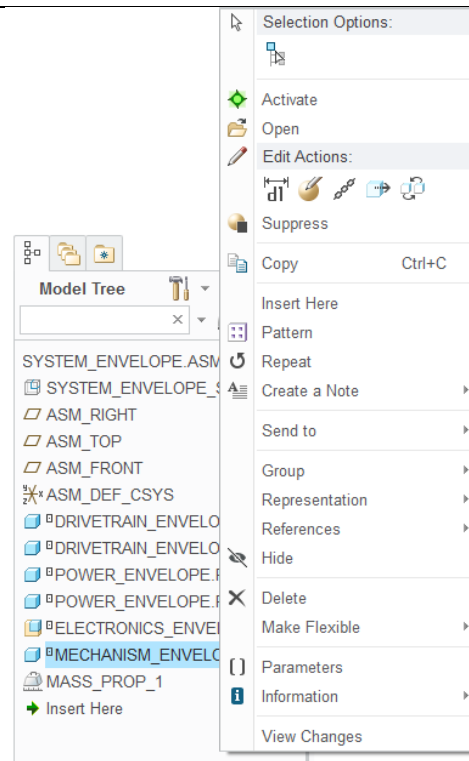| Wheels and gears	Placement of components	Dimensions, position, and motion of mechanisms
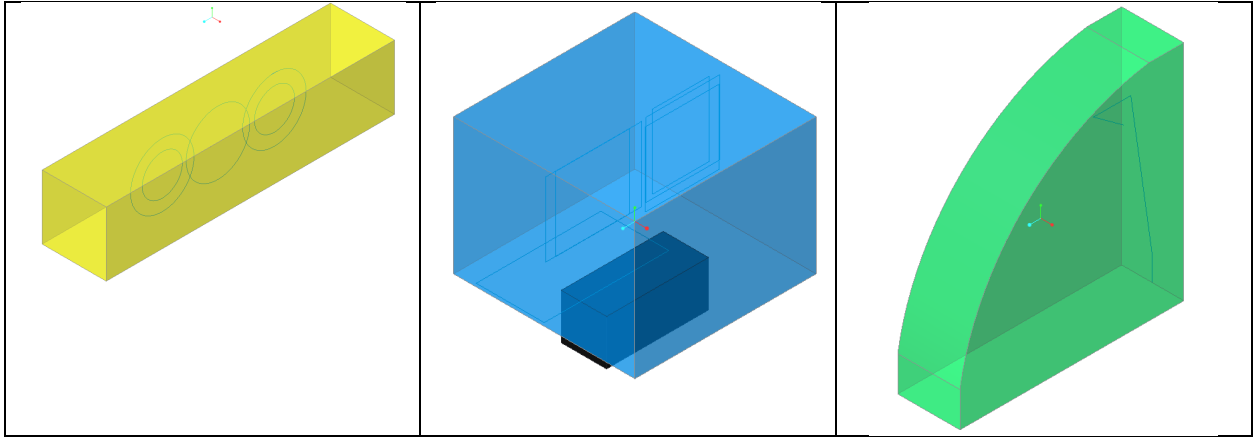
The following set of instructions demonstrates creating a sketch of the mechanism subsystem.

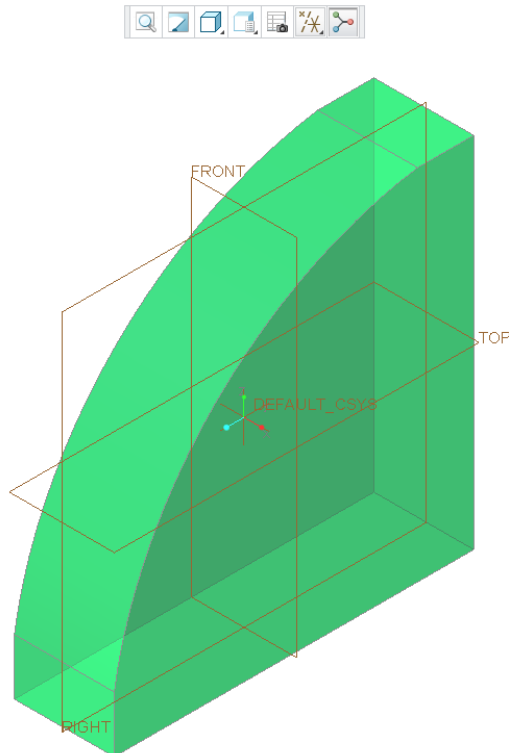Example 1: Draw a 12" arm and claw mechanism:

1. Open **system_envelope.asm**.

2. In the model tree, right-click **MECHANISM_ENVELOPE.PRT**.

3. Select **Open** 📂.

Selection Options:

◆ Activate
📂 Open
✏ Edit Actions:

⊩₁ 🖌 ⚲ ⇨ 🗗
● Suppress
📋 Copy   Ctrl+C
Insert Here
⊞ Pattern
Repeat
A≣ Create a Note   ▸
Send to   ▸
Group   ▸
Representation   ▸
References   ▸
👁 Hide
✕ Delete
Make Flexible   ▸
{} Parameters
ℹ Information   ▸
View Changes

Model Tree

SYSTEM_ENVELOPE.ASM
SYSTEM_ENVELOPE_S
ASM_RIGHT
ASM_TOP
ASM_FRONT
ASM_DEF_CSYS
DRIVETRAIN_ENVELO
DRIVETRAIN_ENVELO
POWER_ENVELOPE.F
POWER_ENVELOPE.F
ELECTRONICS_ENVEI
MECHANISM_ENVELC
MASS_PROP_1
➜ Insert Here

4. Click the **display filter** ⁂.

5. Check **Plane Display** 🔲 so that the datum planes are displayed.

6. Select the RIGHT plane.

7. From the Model toolbar, click **Sketch** .

8. Select **Sketch View** in the display menu to orient your top plane for sketching.
(This may happen automatically.)

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9. From the Sketch toolbar, select **Line Chain** .

| is | Annotate | Render | Tools | View | Flexible Modeling | Applications | **Sketch** |

Line Chain | Center and Point | Center Rectangle | Centerline | One-by-One | Normal

Fillet | Corner
A Text | Mirror
Project | Delete Segment | Modify

Sketcher | More | Editing | Constrain

Use Line Chain to sketch the base of the mechanism.

10. Click the bottom-right corner to start the first line segment.

11. Click again to select the end point for the first line segment and starting point for the second.

12. Middle-click to release the line chain.

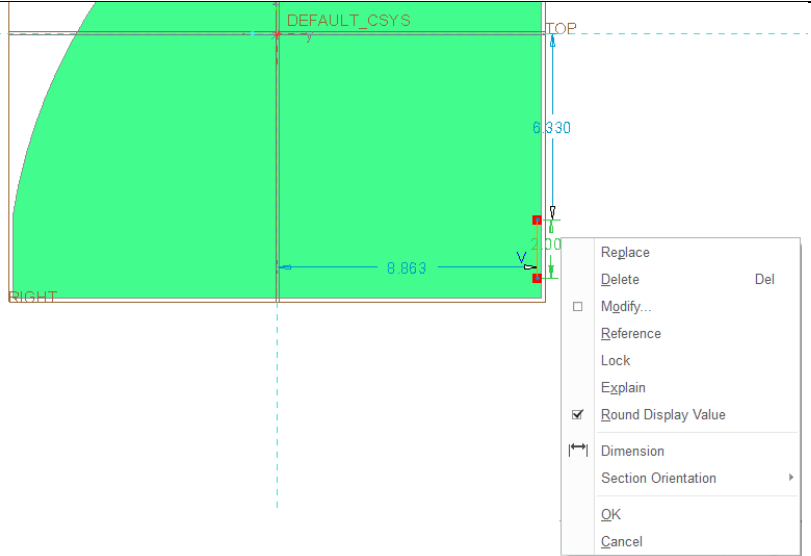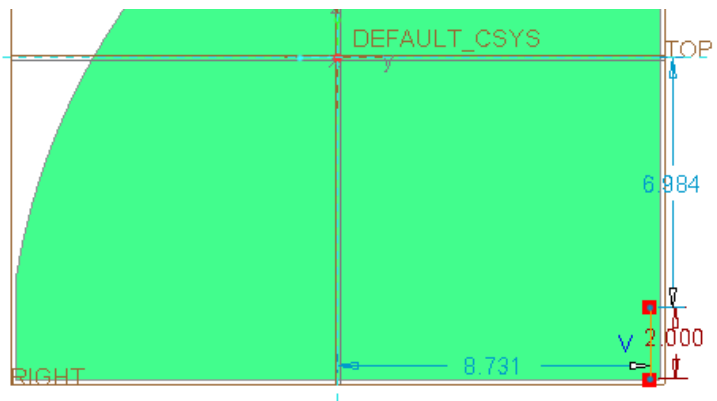|	
13. From the Sketch toolbar, select **Normal** |↔|. 14. Click to select the line segment. 15. Middle-click to the side of the line segment. 16. Set the dimension to **2**. 17. Middle-click to release the Line Chain.	
18. From the Sketch toolbar, select **One-by-One**.	
19. Click to select the dimension of the first line segment. It appears green when selected. 20. Right-click and hold on the selected dimension. 21. Select **Lock** from the menu.	
If the line segment is no longer on the bottom edge of the envelope, click on the bottom end of the line segment and reposition it on the bottom edge.	
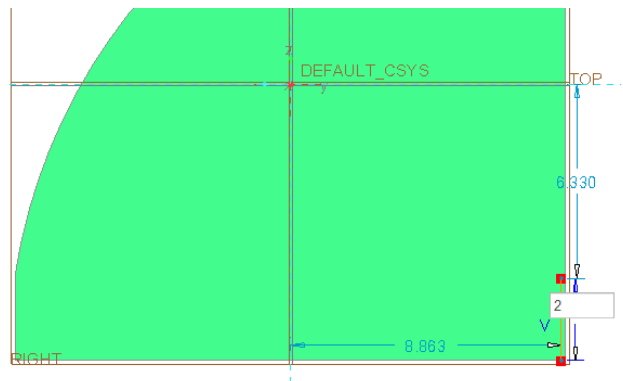
22. From the Sketch toolbar, select **Line Chain** ⌄.

23. Start a new line chain from the endpoint of your first line segment.

24. Create three line segments inside the mechanism envelope.

Don't worry about the exact dimensions. We set and lock them in the next steps.

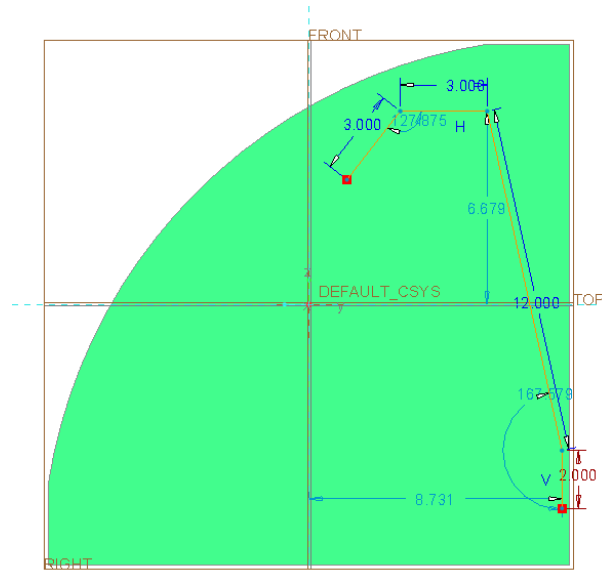25. Middle-click to release the line chain.
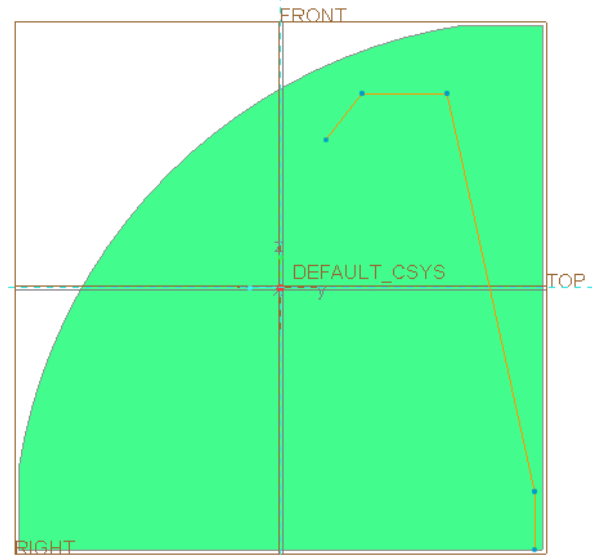
26. From the Sketch toolbar, select **Normal** |↔|.

27. Click to select the first of the three line segments created in step 31.

The line segment appears green when selected.

28. Middle-click above the line segment.

29. Set the dimension to **12**.

Repeat steps 34 and 35 to set the other two line segments created in step 31 to **3**.

30. From the Sketch toolbar, select **One-by-One** ⬉.

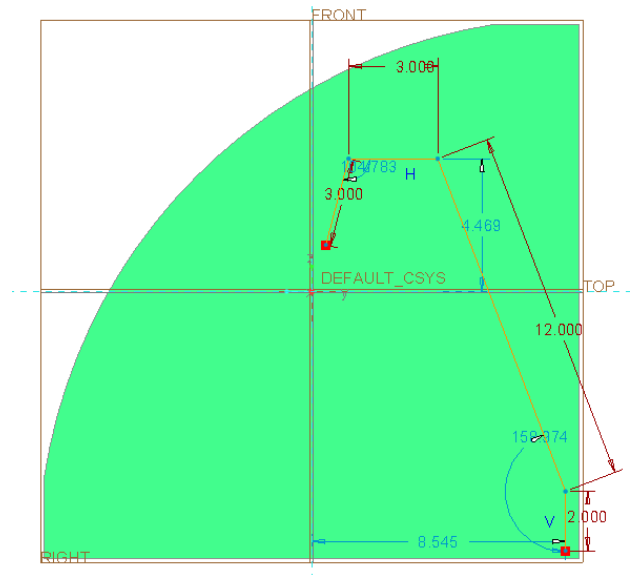31. Click to select the length dimension of the last line segment.

32. Right-click and hold on the selected dimension.

33. Select **Lock** from the menu.

Repeat steps 39-41 for the other two line segments.

If the line segment is no longer on the bottom edge of the envelope, click on the bottom end of the line segment and reposition it on the bottom edge.
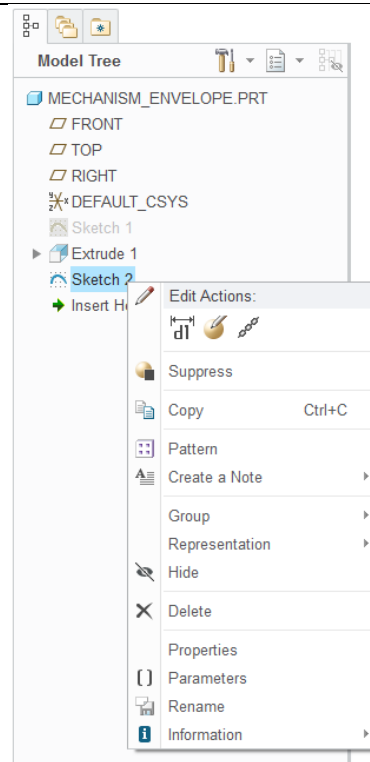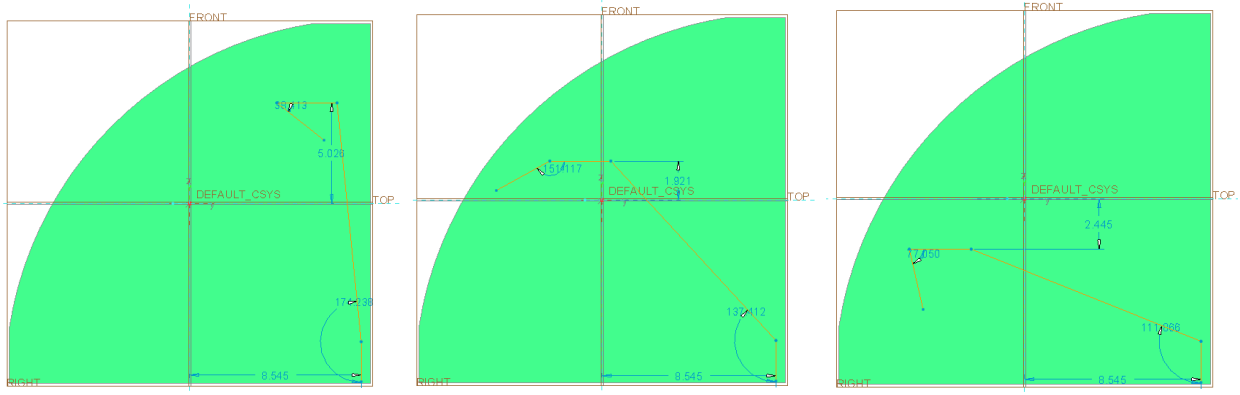
34. Click **OK** ✔.

Example 2: Analyze the motion of your mechanism using PTC Creo's sketch application

1. In the model tree, right-click on **Sketch 2**.

2. Select **Edit Definition** 🖌.

3. Click on the end point and move the linkages through their range of motion.
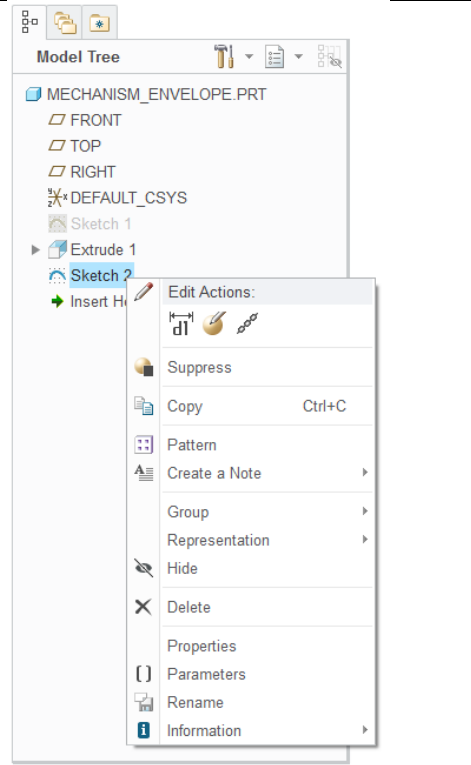

4. When you have finished working with the conceptual model, click **OK**✔ to exit the Sketch tool.

Revise the conceptual model using the Sketch tools.

5. In the model tree, right-click on **Sketch 2**.

6. Select **Edit Definition** .

The Sketch toolbar is activated. All of the tools you used to make the sketch are available for editing the sketch.

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