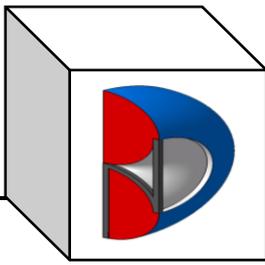


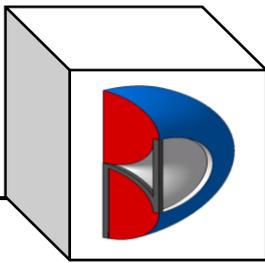
Ergonomic Manikin Manipulation using CATIA V5 DMU Kinematics (Steps 5 - 11 the optimized solution)



BND TechSource



- In the previous example, we showed a simple solution to manipulate an Ergonomic Manikin using CATIA DMU Kinematics.
- In that example the angle of the feet do not follow the angle of the pedals.
- In this example we will optimize the pedals to maintain contact with the feet.



BND TechSource

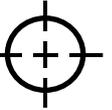
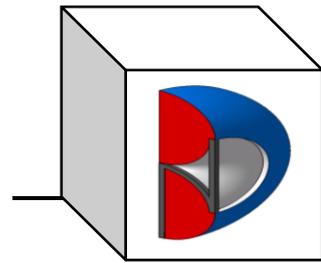


- Previous example:

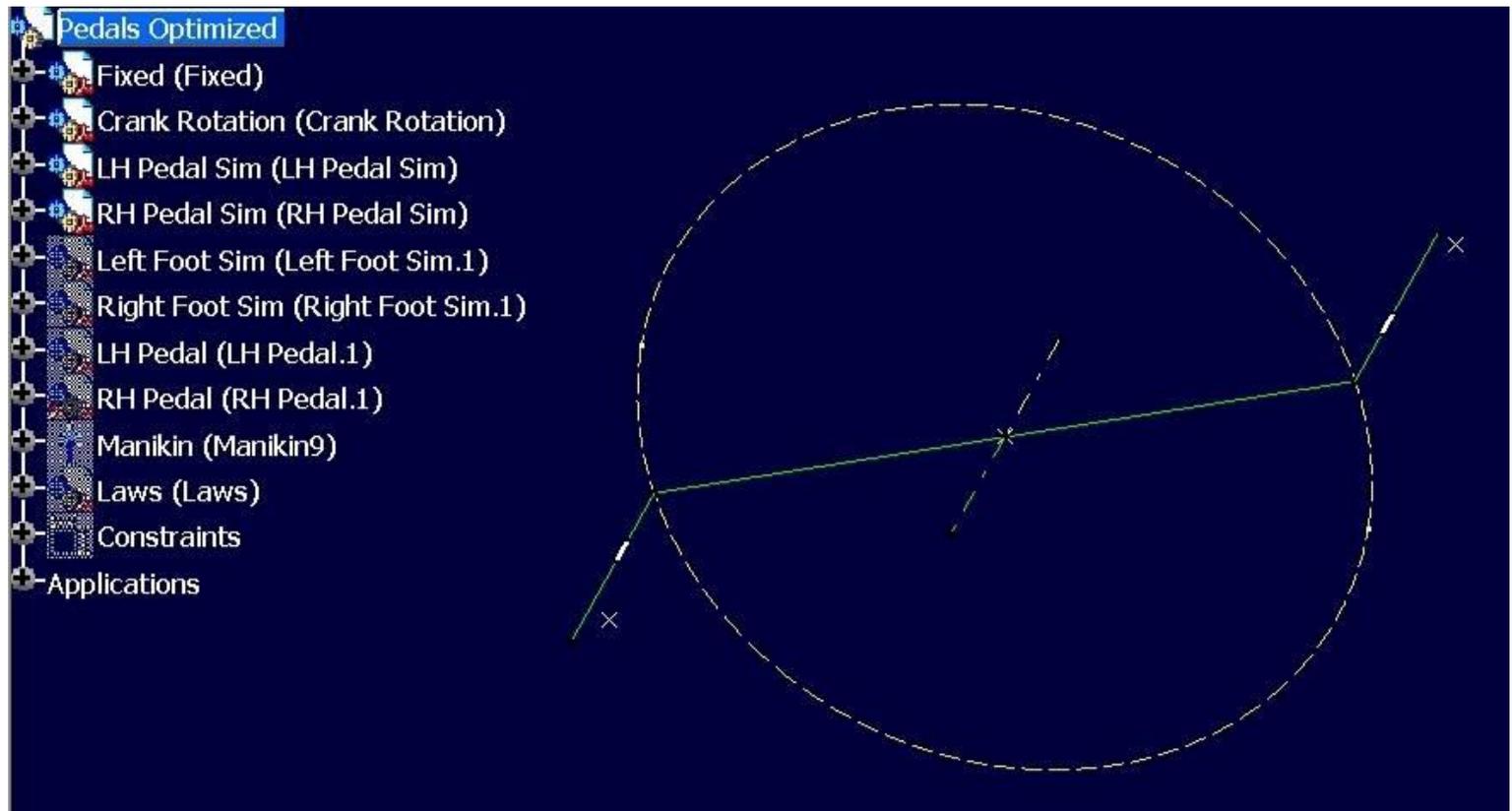
The angle of the feet do not follow the angle of the pedals during rotation.

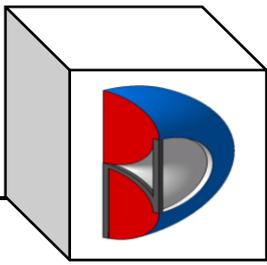
Double click the picture to "Play Movie"

- The rotation angle of the pedals is set to a 1:1 ratio of the crank rotation within the kinematic set.
- While the Manikin may be “attached” to the pedals, it is *driven* by the kinematic set and therefore not editable inside the Kinematic function.
- The main problem to solve in this example is to get the pedals to follow the feet.



- Step 5: Create a Product for a “stick figure” kinematic mechanism.

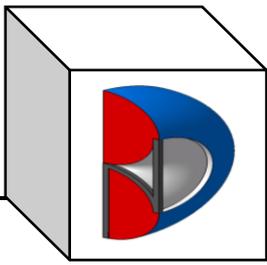




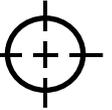
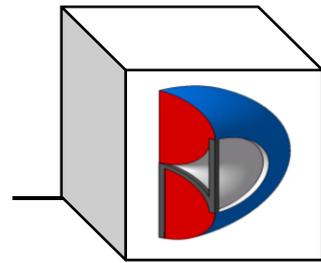
BND TechSource



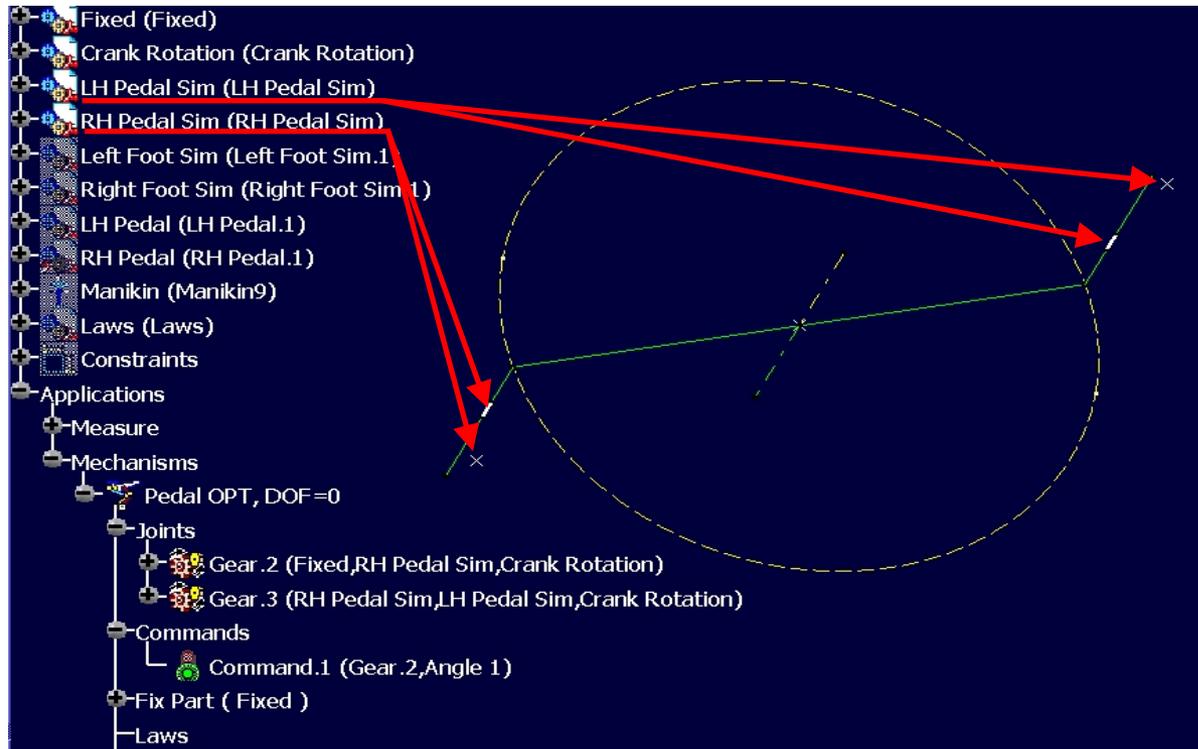
- There will be four Parts to build the kinematic mechanism:
 - Fixed
 - Crank Rotation
 - LH Pedal Simulator
 - RH Pedal Simulator

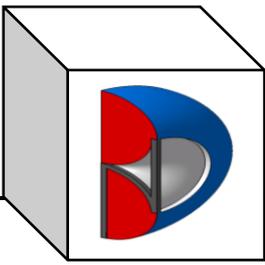


- Other Parts within the Product will be:
 - Manikin (Ergonomic Design & Analysis)
 - Left Foot Simulator
 - Right Foot Simulator
 - LH Pedal (3D Part)
 - RH Pedal (3D Part)
 - Laws

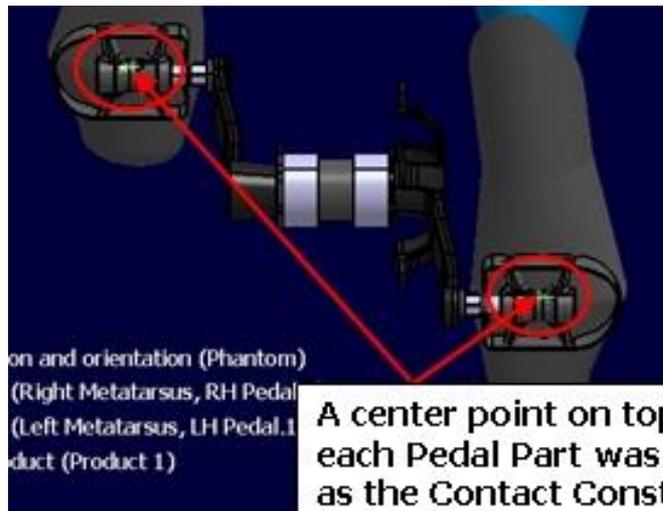


- The kinematic mechanism will start with the Fixed Part and two Gear Joints between the Fixed, Crank Rotation, and Pedal Sim Parts.

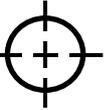
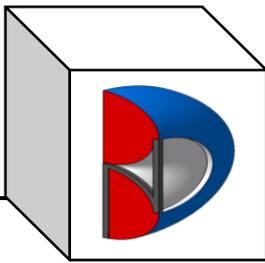




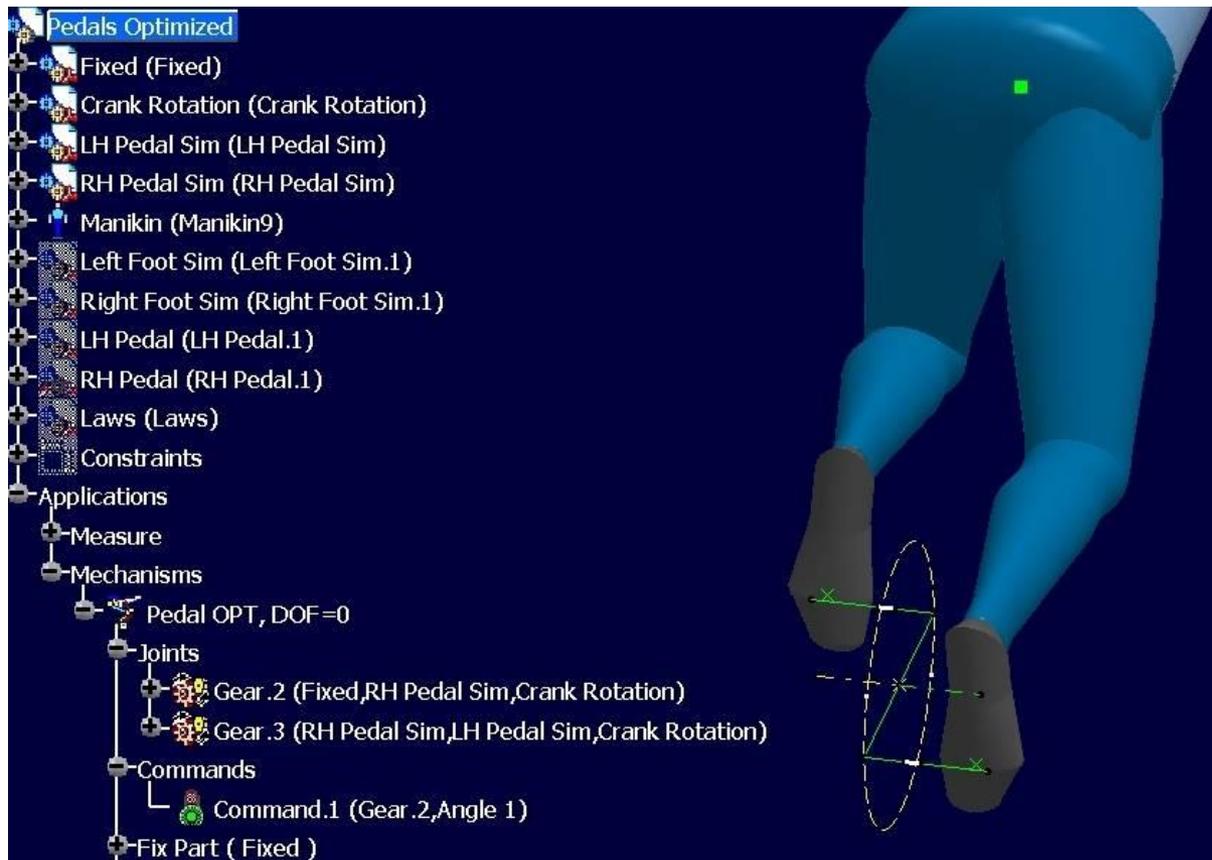
- The LH & RH Pedal Sim Parts consist of a centerline for the pedal pivot and a point.
- They will be used to “attach” the Manikin to the kinematic mechanism as in the previous example.

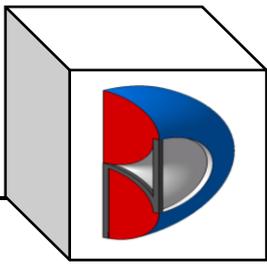


A center point on top of each Pedal Part was used as the Contact Constraint to the foot.



- Step 6: Load the Manikin from the previous example.

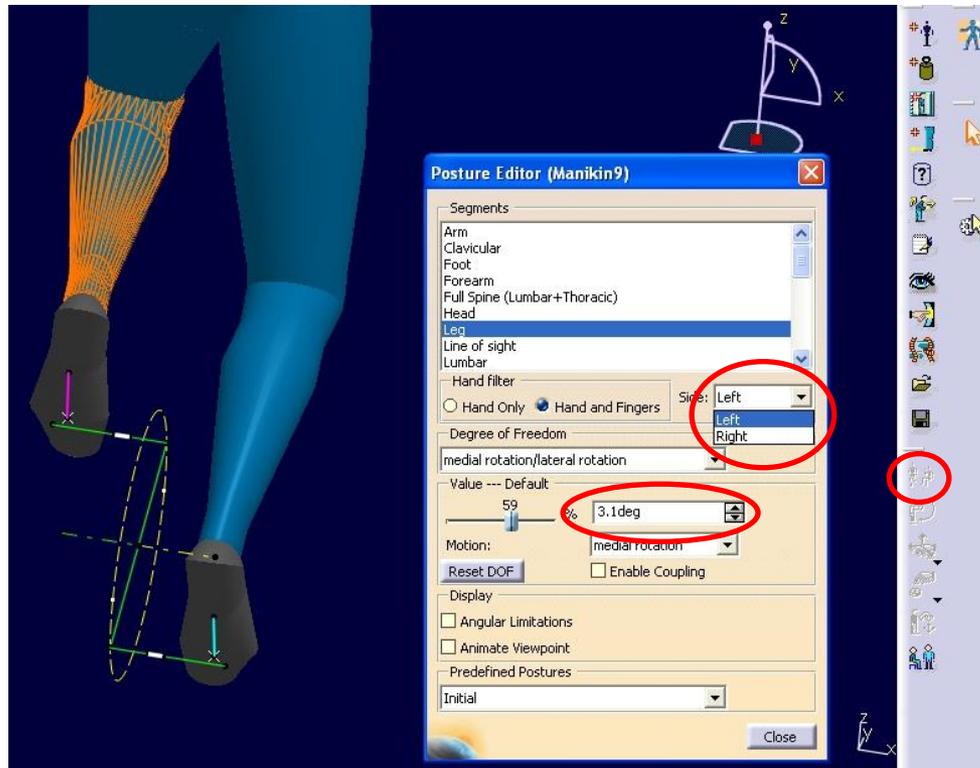




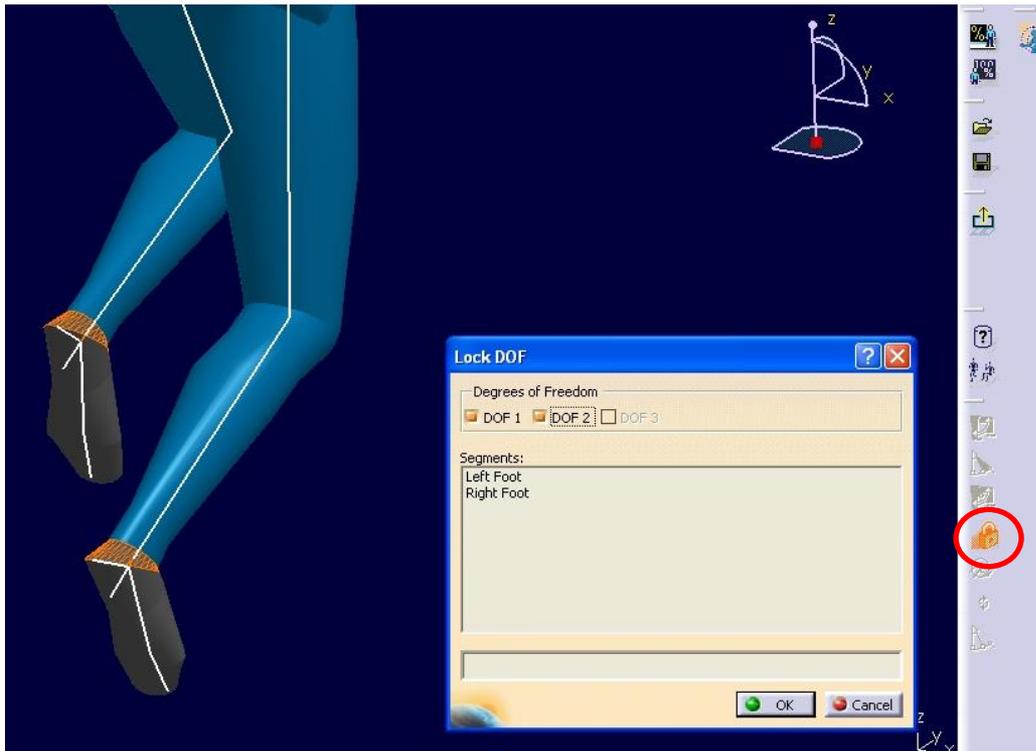
BND TechSource



- Ensure the DOF values for the Feet, Legs, & Thighs are correct and symmetric before locking the DOF.

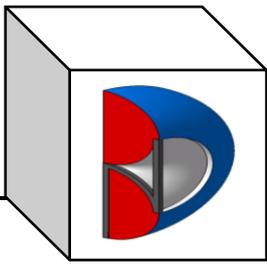


- Open Human Posture Analysis. Lock the Feet DOF 1 & 2, Leg DOF 3, & Thigh DOF 2.

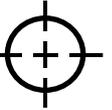


You MUST LOCK the DOF each time you read the Product!

If you run the kinematic set *without* doing this, you may experience unwanted results!



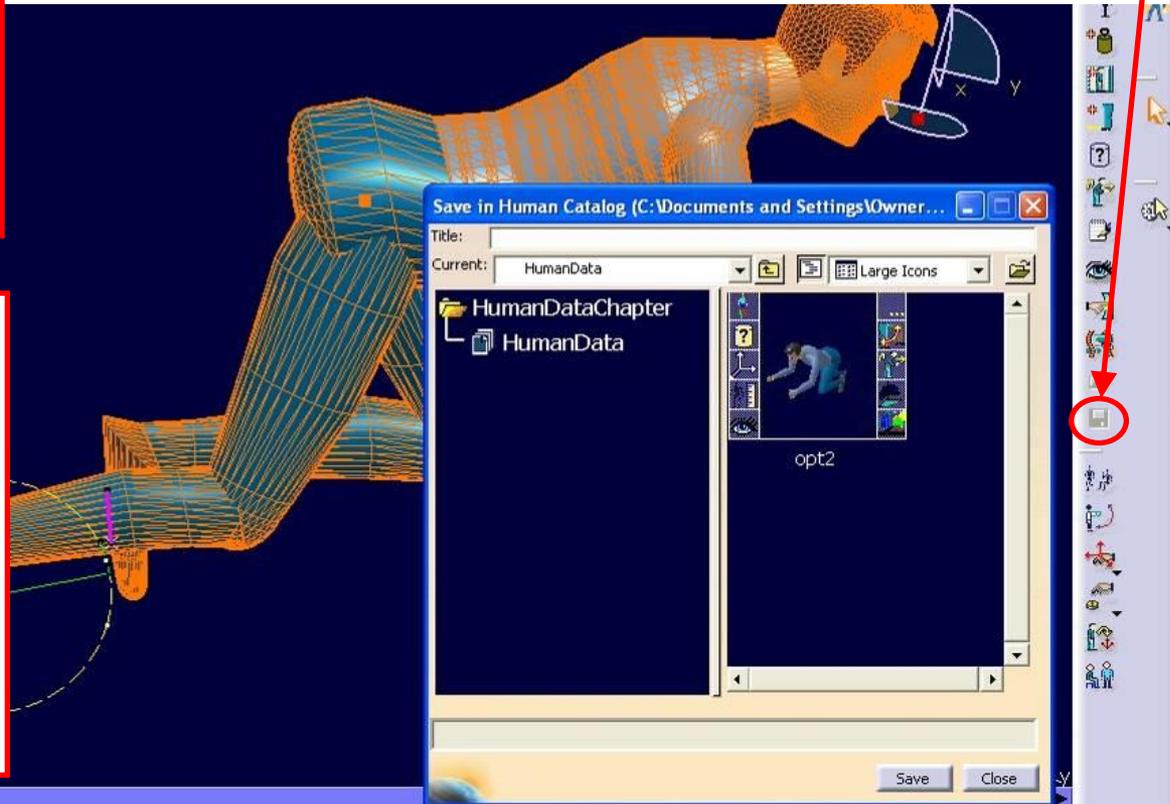
BND TechSource

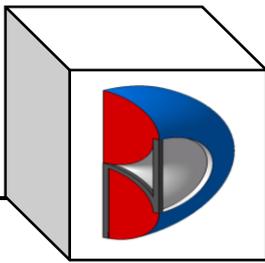


- A helpful tip at this point would be to Save a Manikin Profile in the desired position.

You MUST LOCK the DOF each time you read the Product!

If you save a Manikin profile after locking the DOFs, when that profile is loaded correctly, it maintains these locked DOFs



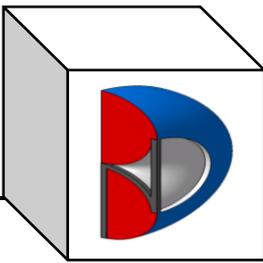


More on Locked DOFs...

After applying the manikin profile check the Properties of the Angular Limitations.

Body elements	DOFs	Lower limit	Upper limit	Manikin
Right Thigh	flexion/extension	None	None	Manikin1
Right Thigh	medial rotation/lat...	None	None	Manikin1
Right Leg	flexion/extension	None	None	Manikin1
Right Foot	dorsiflexion/plant...	49.0	71.5	Manikin1
Right ForeArm	flexion/extension	50.0	27.8	Manikin1
Left Thigh	flexion/extension	None	None	Manikin1
Left Thigh	medial rotation/lat...	None	None	Manikin1
Left Leg	flexion/extension	None	None	Manikin1
Left Foot	dorsiflexion/plant...	49.0	71.5	Manikin1
Left ForeArm	flexion/extension	50.0	27.8	Manikin1

No DOFs locked.

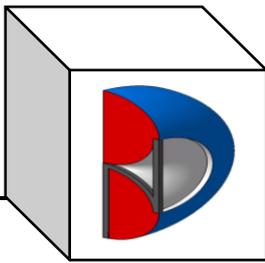


More on Locked DOFs...

Angular Limitations must be chosen alone to apply the locked DOFs. Check the Properties to verify.

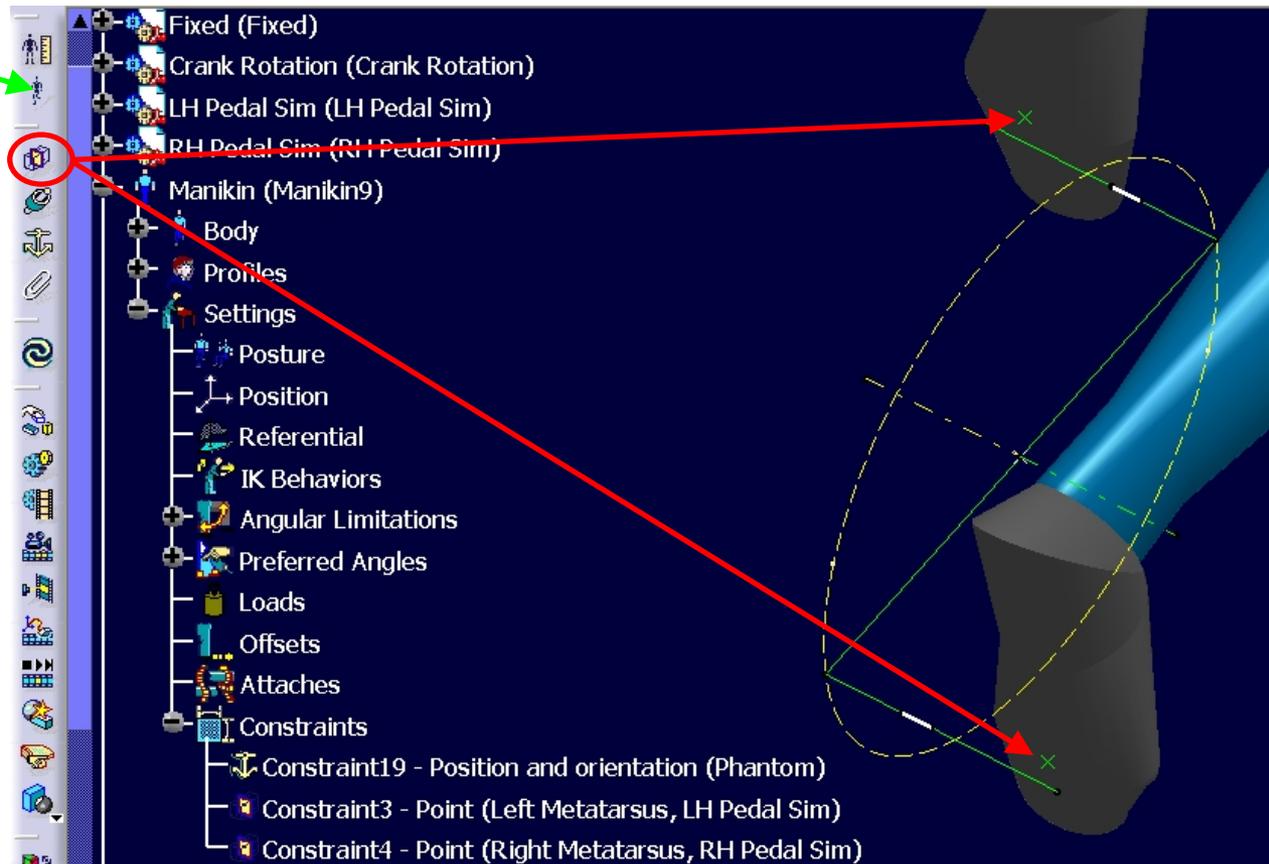
DOFs locked.

Body elements	DOFs	Lower limit	Upper limit	Manikin
Right Thigh	flexion/extension	None	None	Manikin1
Right Thigh	abduction/adduction	5.0 deg	Lock	Manikin1
Right Thigh	medial rotation/lat...	None	None	Manikin1
Right Leg	flexion/extension	None	None	Manikin1
Right Leg	medial rotation/lat...	3.1 deg	Lock	Manikin1
Right Foot	dorsiflexion/plant...	3.3 deg	Lock	Manikin1
Right Foot	eversion/inversion	0.2 deg	Lock	Manikin1
Right ForeArm	flexion/extension	50.0	27.8	Manikin1
Left Thigh	flexion/extension	None	None	Manikin1
Left Thigh	abduction/adduction	5.0 deg	Lock	Manikin1

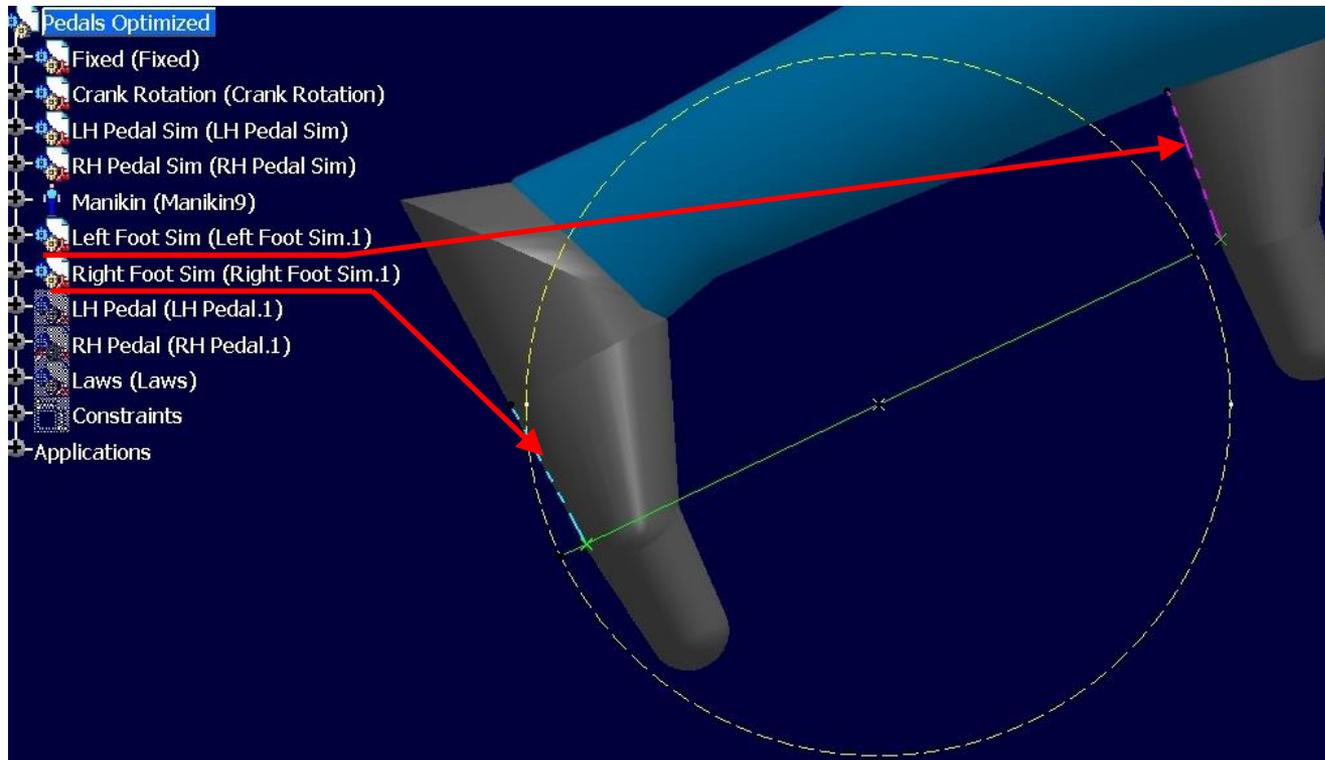


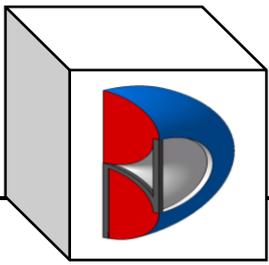
- Constrain the feet to the points in each Pedal Simulator Part (use Contact Constraint).

**Human
Posture
Analysis**

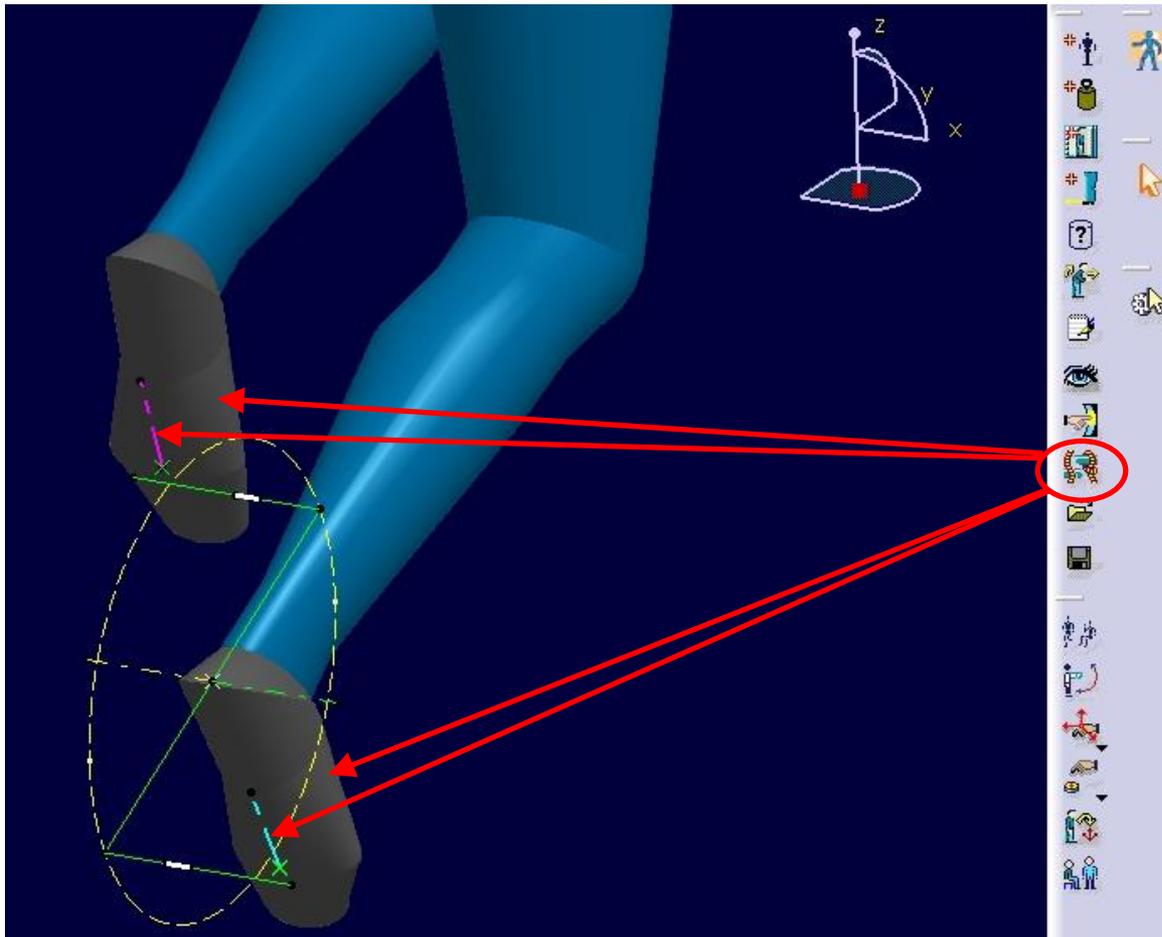


- Step 7: Create a line inside each Foot Simulator Part. This will be used later to measure the foot angle relative to the pedal.

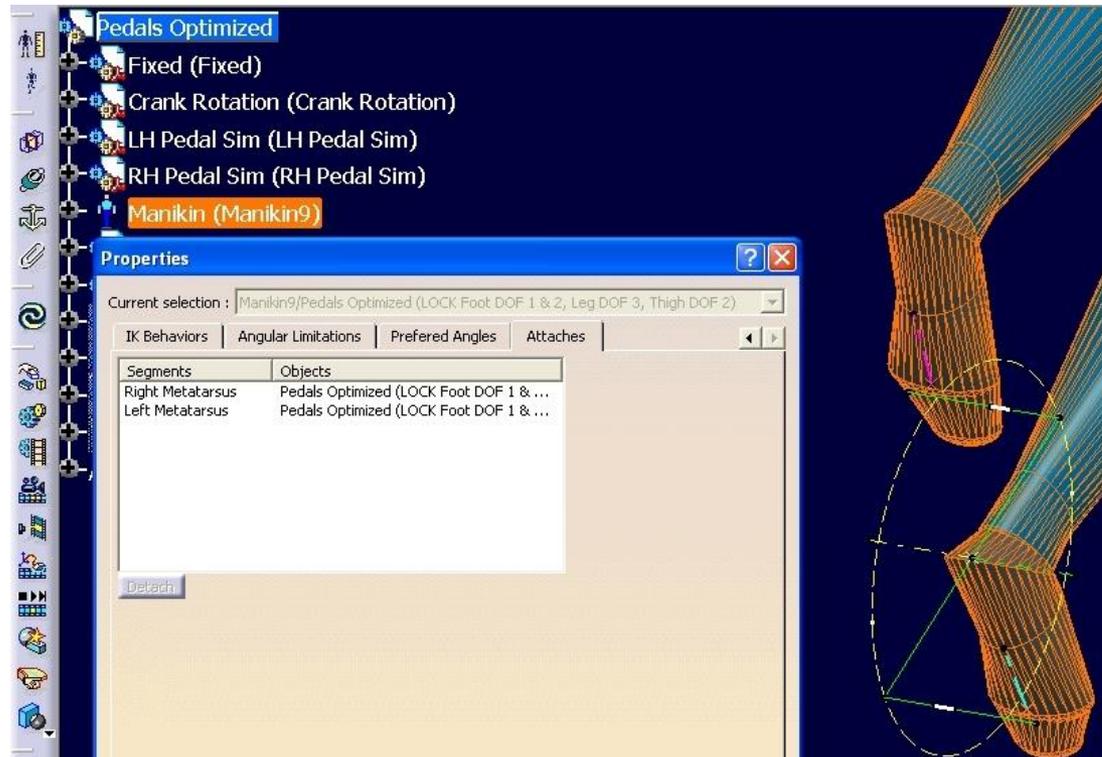


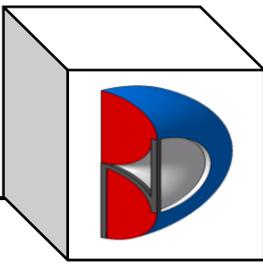


- Attach the Feet Simulator Parts to each foot.



- Attaches to the Manikin can be verified by right-clicking the Part name from the tree, and open Properties.





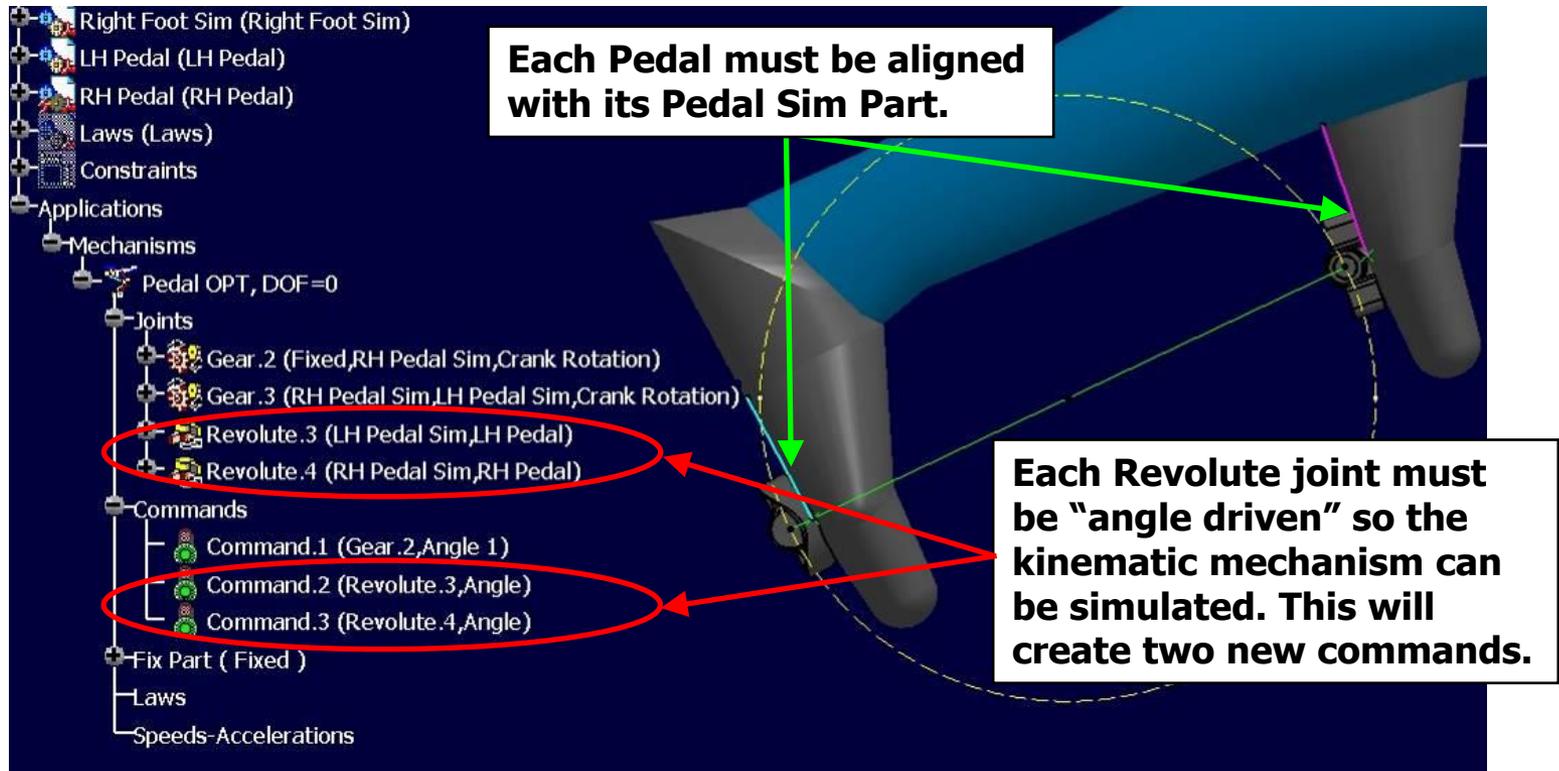
BND TechSource

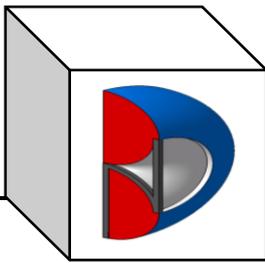


- Run a test using DMU Kinematics.

Double click on the picture to "Play Movie"

- Step 8: Load in the 3D Pedals. Create two Revolute joints between each Pedal and Pedal Simulator Parts.



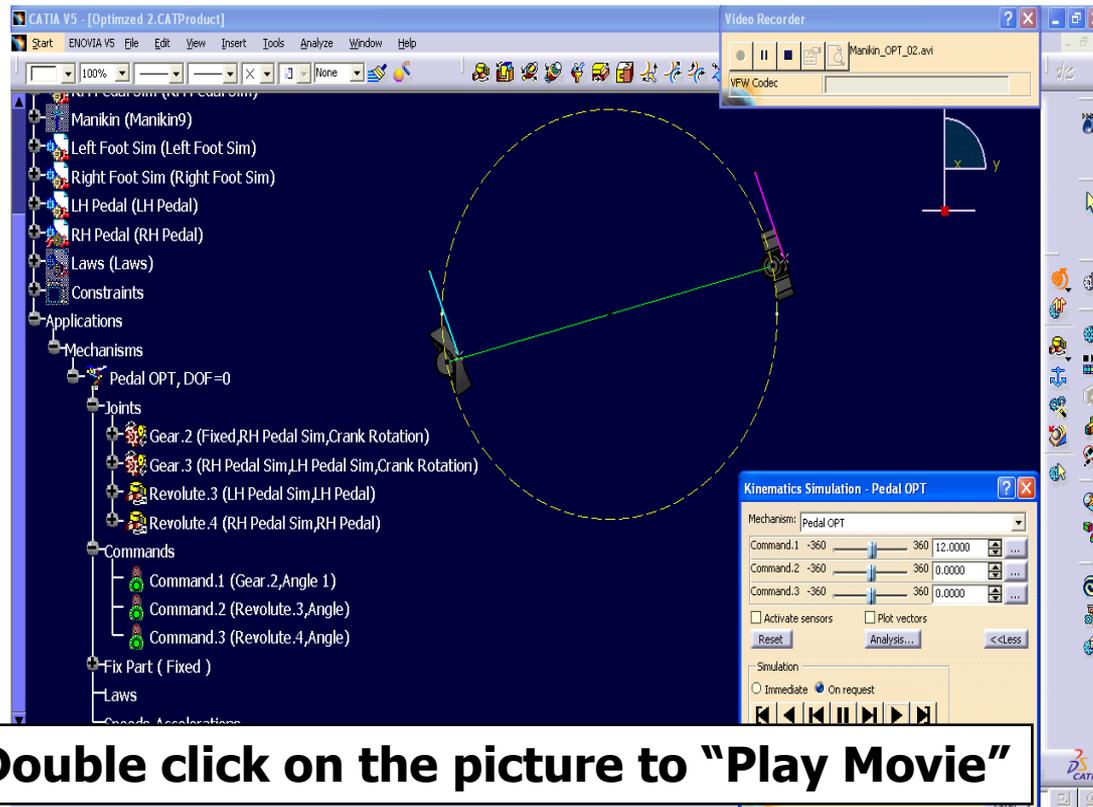


BND TechSource



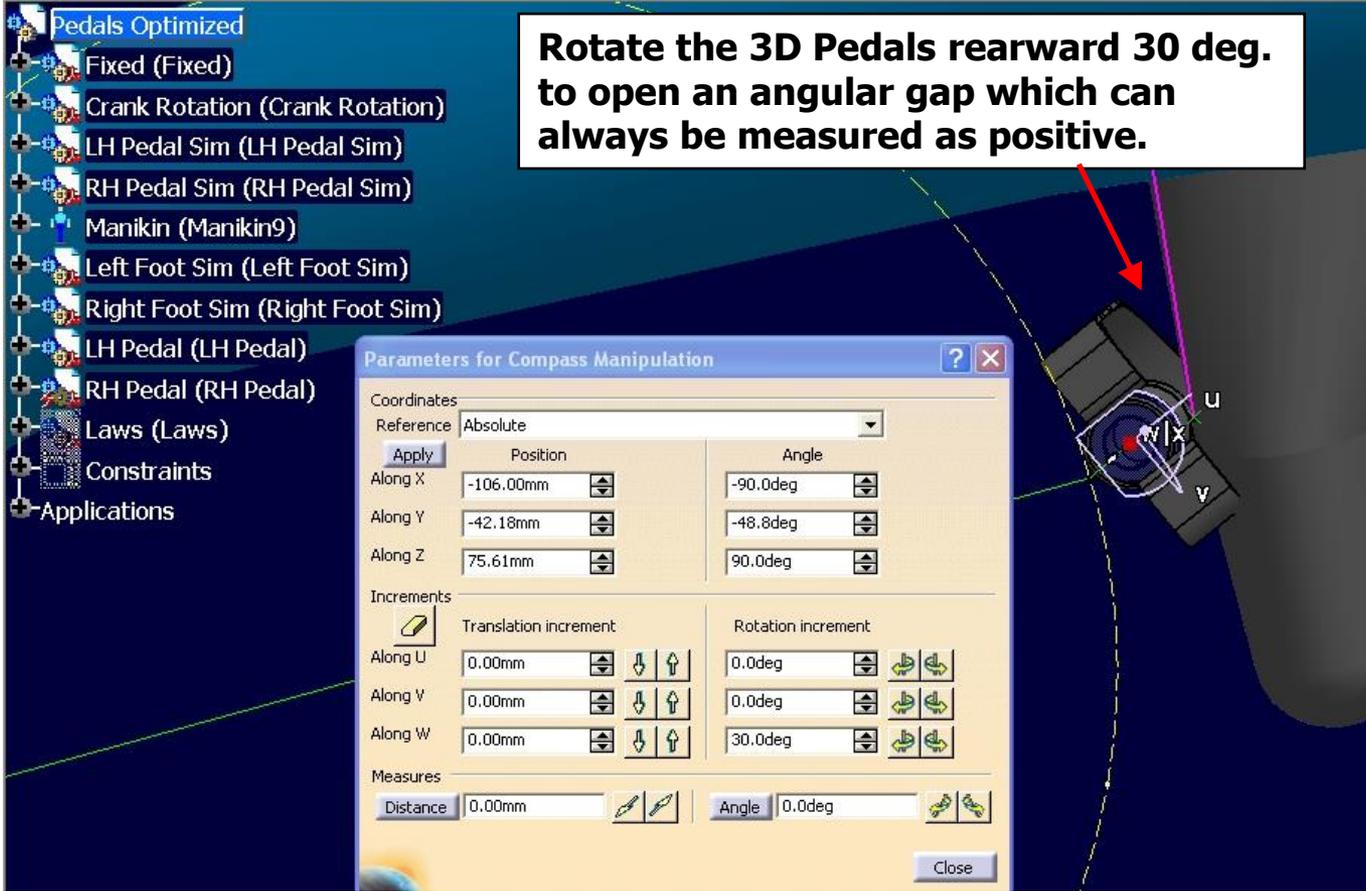
- Run a test using DMU Kinematics.

Run the simulation with a value only for Command 1. Notice the angular deviation between the Pedal and Pedal Sim Parts.



- The Pedal Sim Parts are “attached” to the Manikin.
- The Manikin is constrained to the kinematic mechanism.
- This means the angular deviation due to the kinematic simulation occurs outside the kinematic mechanism.
- To correct this, we must measure the angular deviation and apply the measurement back into the kinematic mechanism.

- Step 9: Measure the angular deviation.



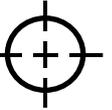
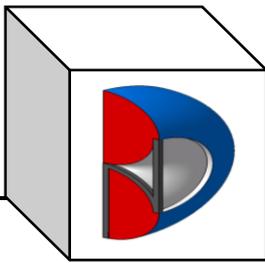
Rotate the 3D Pedals rearward 30 deg. to open an angular gap which can always be measured as positive.

Parameters for Compass Manipulation

Coordinates	Position	Angle
Reference	Absolute	
Along X	-106.00mm	-90.0deg
Along Y	-42.18mm	-48.8deg
Along Z	75.61mm	90.0deg

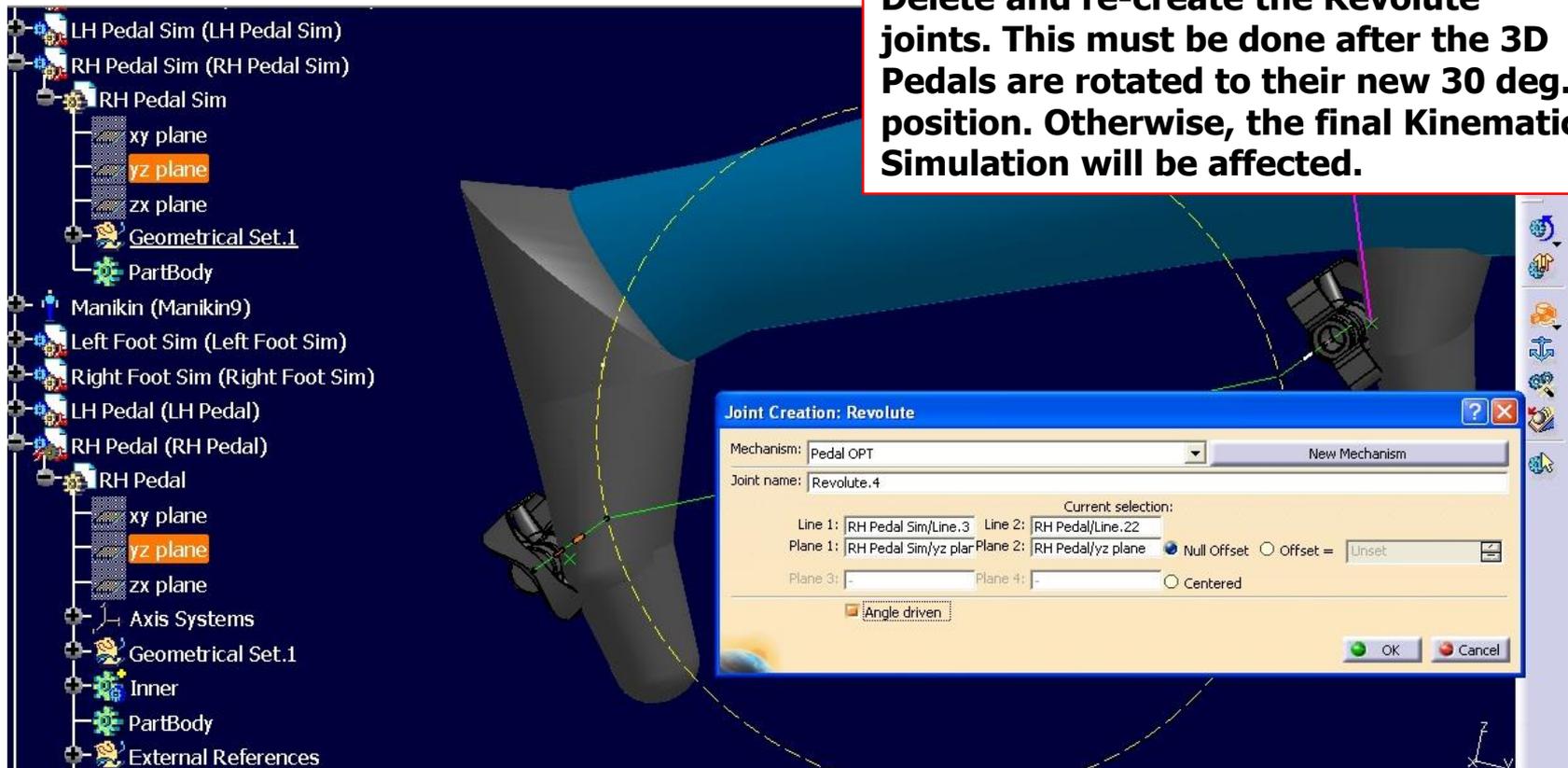
Increments	Translation increment	Rotation increment
Along U	0.00mm	0.0deg
Along V	0.00mm	0.0deg
Along W	0.00mm	30.0deg

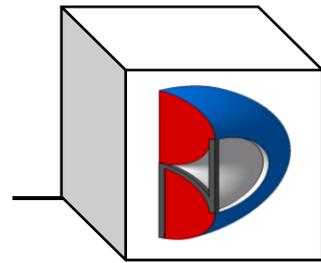
Measures: Distance 0.00mm, Angle 0.0deg



- Out with the old...In with the new.

Delete and re-create the Revolute joints. This must be done after the 3D Pedals are rotated to their new 30 deg. position. Otherwise, the final Kinematic Simulation will be affected.





- Ensure the Pedal rotation direction is correct.

Picking the arrow will reverse the rotation direction

Double-click Command.2

Constraints

Applications

Measure

Mechanisms

Pedal OPT, DOF=0

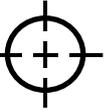
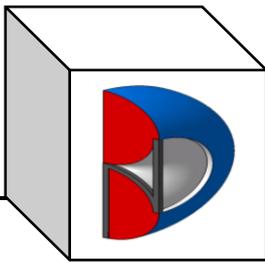
Joints

- Gear.2 (Fixed,RH Pedal Sim,Crank Rotation)
- Gear.3 (RH Pedal Sim,LH Pedal Sim,Crank Rotation)
- Revolute.3 (RH Pedal Sim,RH Pedal)
- Command.2 (RH Pedal Sim,LH Pedal)

Commands

- Command.1 (Gear.2,Angle 1)
- Command.2 (Revolute.3,Angle)**
- Command.3 (Revolute.4,Angle)

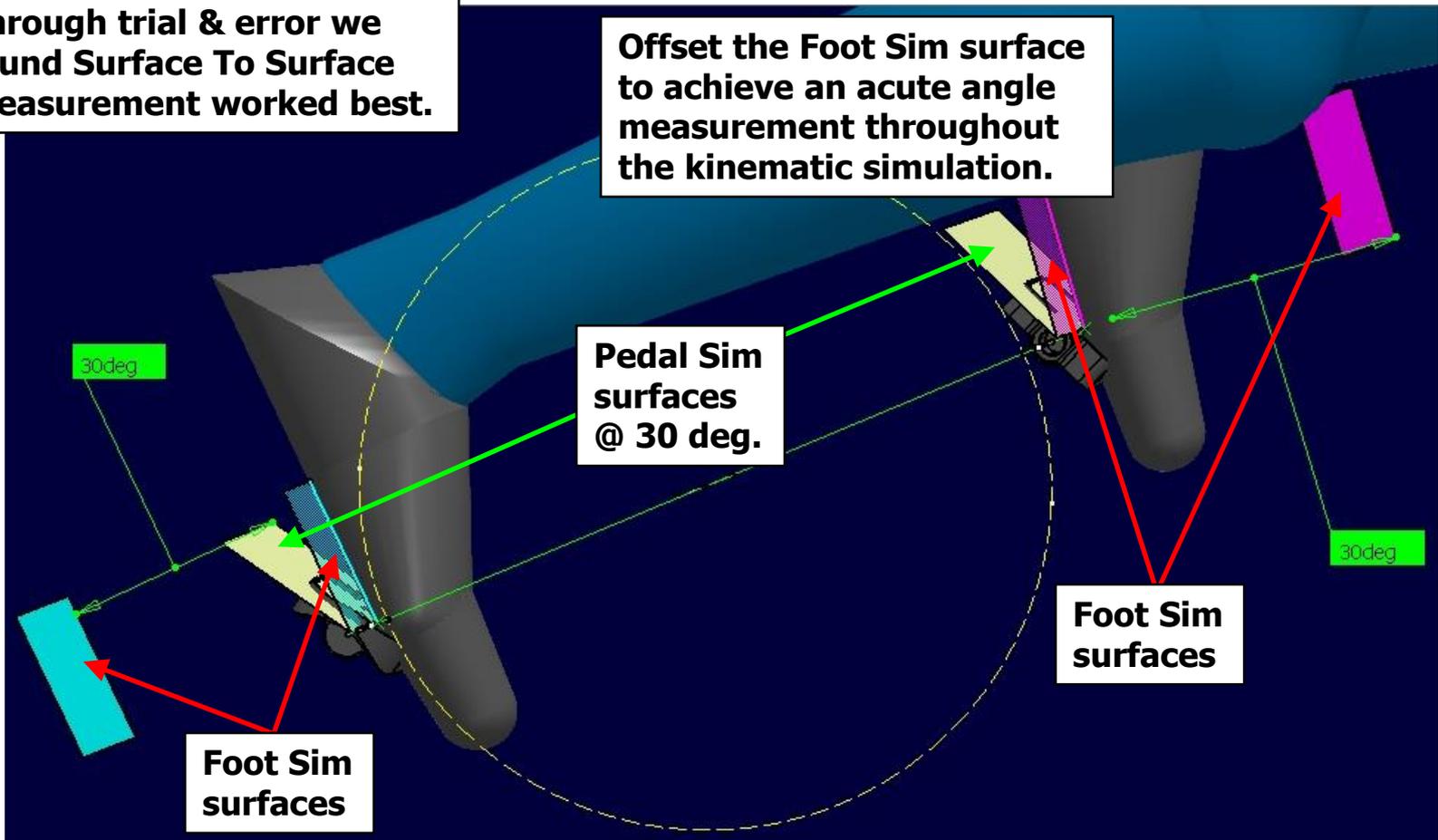
The image shows a CAD software interface with a mechanism tree on the left and a 3D model of a pedal assembly on the right. The tree is expanded to show the 'Commands' section, where 'Command.2 (Revolute.3,Angle)' is highlighted in orange. A red arrow points to this command. A text box above the 3D model says 'Picking the arrow will reverse the rotation direction'. The 3D model shows a pedal with a blue arrow indicating rotation direction.



- Create Surfaces to measure between.

Through trial & error we found Surface To Surface measurement worked best.

Offset the Foot Sim surface to achieve an acute angle measurement throughout the kinematic simulation.



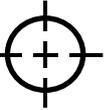
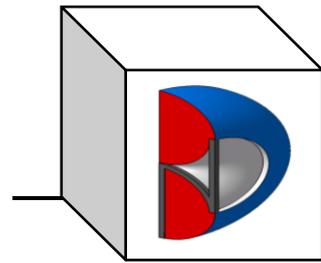
Foot Sim surfaces

Foot Sim surfaces

Pedal Sim surfaces @ 30 deg.

30deg

30deg



- Prepare the test using DMU Kinematics.

Pick Yes on the LH & RH Angular Measures.

Click Activate sensors.

Sensor	Unit	Observed
Pedal OPT\Joints\Gear.2\Angle 2	Degree	No
Pedal OPT\Joints\Gear.3\Angle 1	Degree	No
Pedal OPT\Joints\Gear.3\Angle 2	Degree	No
Pedal OPT\Joints\Revolute.3\Angle	Degree	No
Pedal OPT\Joints\Revolute.4\Angle	Degree	No
'Pedals Optimized(LH Measure)Length'	Millimeter	No
'Pedals Optimized(LH Measure)Max Distance'	Millimeter	No
'Pedals Optimized(LH Measure)Angle'	Degree	Yes
'Pedals Optimized(LH Measure)PT1x'	Millimeter	No
'Pedals Optimized(LH Measure)PT1y'	Millimeter	No
'Pedals Optimized(LH Measure)PT1z'	Millimeter	No

Kinematics Simulation - Pedal OPT

Mechanism: Pedal OPT

Command.1: -360 to 360, 0.0000

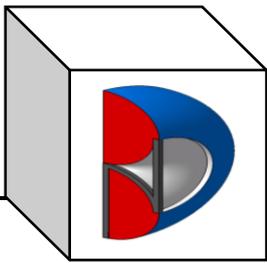
Command.2: -360 to 360, 30.0000

Command.3: -360 to 360, 30.0000

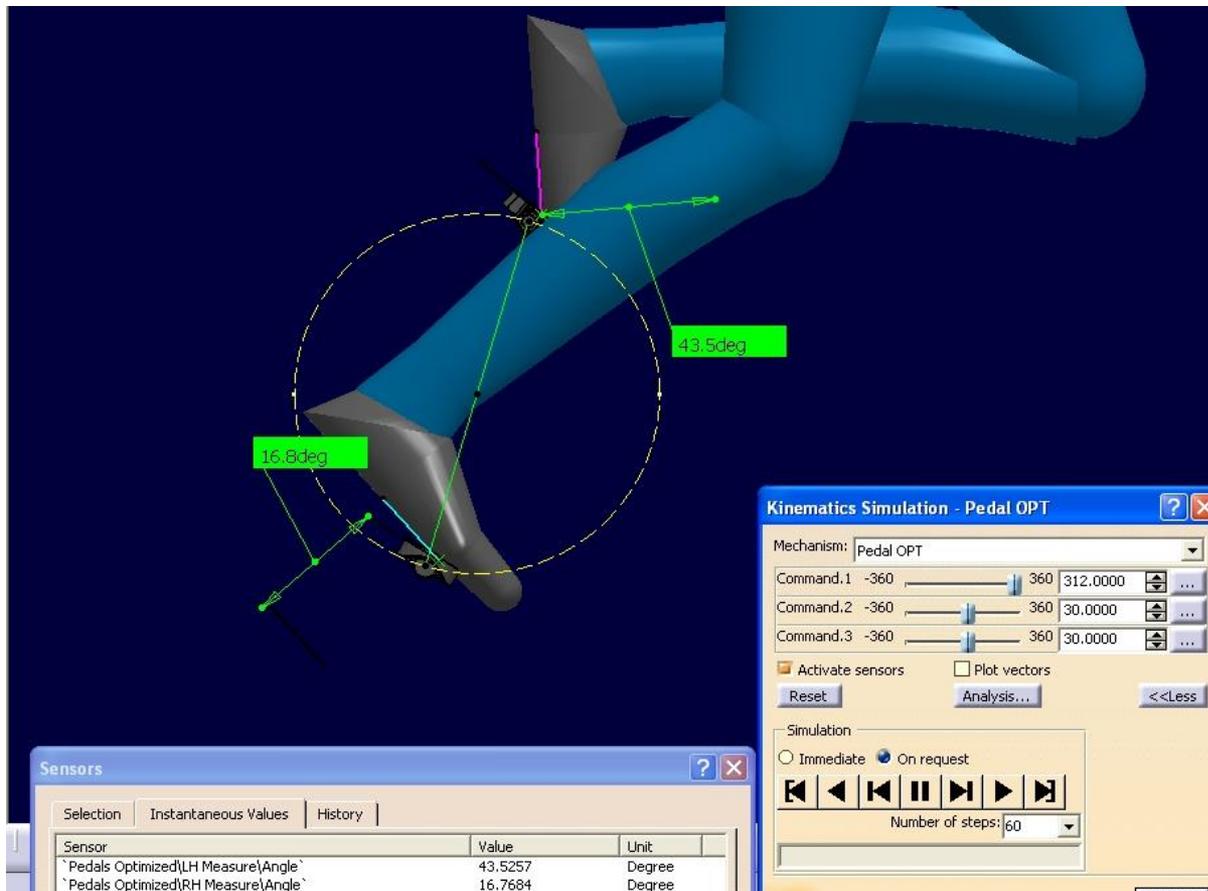
Activate sensors

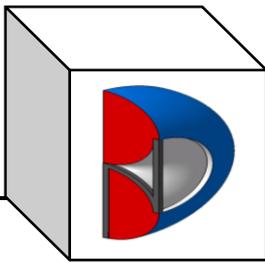
Simulation: Immediate On request

Number of steps: 60

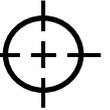


- Run a test using DMU Kinematics.

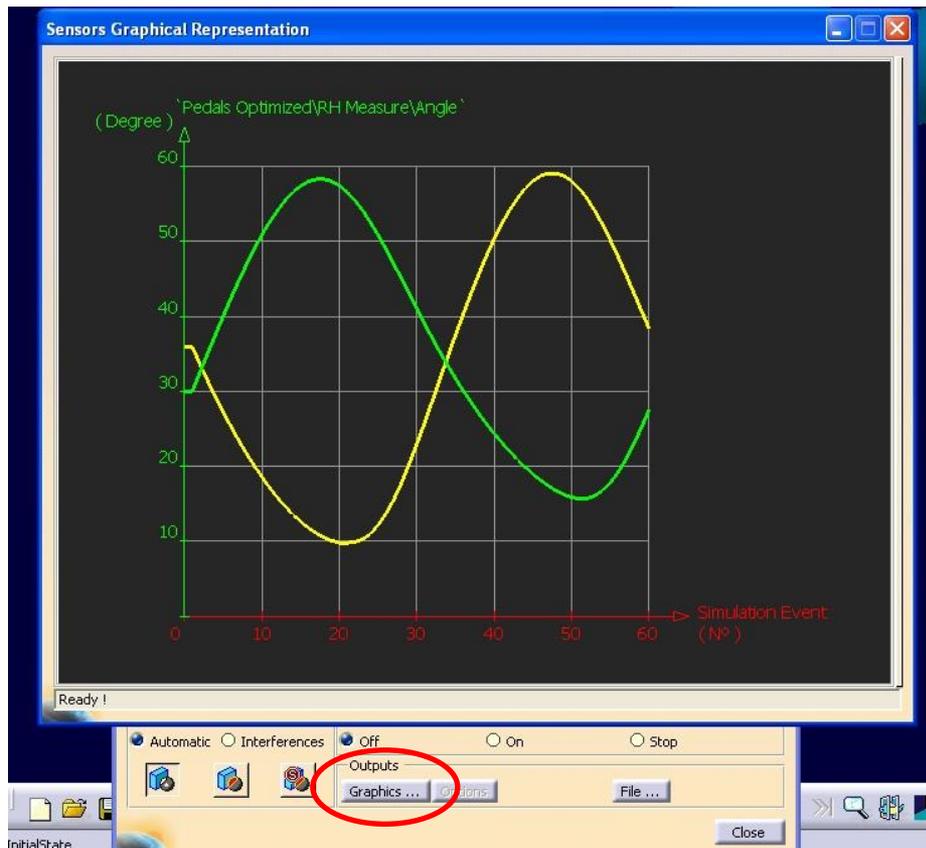


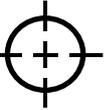
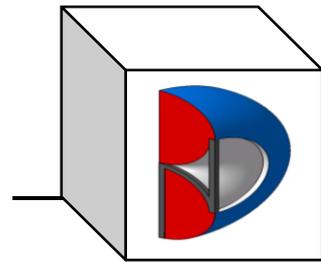


BND TechSource



- The graphic results show measurement output as acute angles.





- Step 10: Set up Functions for the Commands.

The screenshot shows the SolidWorks interface with the 'Formulas: Command.3' dialog box open. The CAD tree on the left shows a hierarchy: Laws (Laws), Constraints, Applications, Measure (LH Measure, RH Measure), Mechanisms (Pedal OPT, DOF=0), Joints (Gear .2, Gear .3, Revolute .3), Command.1, Command.2, Command.3, Fix Part (Fixed), and Laws. The 'Formulas: Command.3' dialog box has a table with the following data:

Parameter	Value	Formula	Active
Pedal OPT\Commands\Command.3\Angle	30.0deg		

Annotations in the image include:

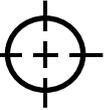
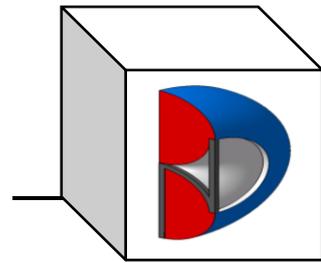
- Select the Command.**: A callout pointing to 'Command.3 (Revolute.4,Angle)' in the CAD tree.
- Select the Function icon.**: A callout pointing to the 'fx' icon in the Windows taskbar.
- Select Add Formula.**: A callout pointing to the 'Add Formula' button in the dialog box.

- Setting up the Functions (RH shown, repeat for LH).

Select Angle from Parameters list.

Dictionary	Members of Parameters	Members of Angle
Parameters	Boolean	"RH Pedal\Body.5\Shaft.2\SecondAngle"
Design Table	CstAttr_Mode	"RH Pedal\Geometrical Set.3\Plane.3\Angle"
Operators	Length	"RH Pedal\Geometrical Set.3\Plane.11\Angle"
Pointer on value function:	Real	"RH Pedal\Geometrical Set.3\Plane.12\Angle"
Point Constructors	String	"LH Measure\Angle"
Law	Time	"RH Measure\Angle"
Line Constructors	Angle	
	Surface	

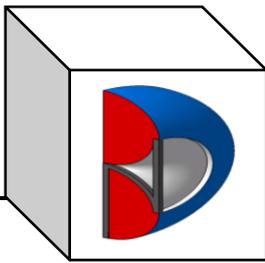
Double-click RH Measure\Angle from Members of Angle list.



- To run a kinematic simulation with Laws, there must be a Law created relative to time.

Laws (Laws)

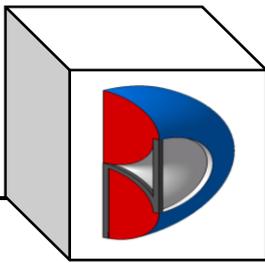
- Constraints
- Applications
 - Measure
 - LH Measure
 - RH Measure
 - Mechanisms
 - Pedal OPT, DOF=0
 - Joints
 - Gear.2 (Fixed,RH Pedal Sim,Crank Rotation)
 - Gear.3 (RH Pedal Sim,LH Pedal Sim,Crank Rotation)
 - Revolute.3 (LH Pedal Sim,LH Pedal)
 - Revolute.4 (RH Pedal Sim,RH Pedal)
 - Commands
 - Command.1 (Gear.2,Angle 1)
 - Command.2 (Revolute.3,Angle)
 - Command.3 (Revolute.4,Angle)
 - Fix Part (Fixed)
 - Laws
 - Formula.2: `Pedal OPT\Commands\Command.2\Angle` = `LH Measure\Angle`
 - Formula.1: `Pedal OPT\Commands\Command.3\Angle` = `RH Measure\Angle`
 - Speeds-Accelerations



■ Create a Time Law.

Kinematic Laws must be Curves. Therefore, to get a linear time relationship to rotation, Connects with Point Continuity are used.

This Law will allow rotation to 360 deg. Then return back 360 deg.



- Apply the time Law to Command.1

Double-click Command.1

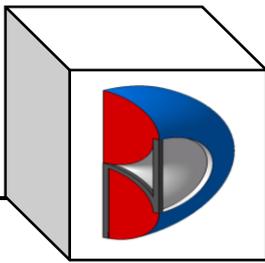
Select Law Sketch

Select Link

Geometrical Set.1
PartBody
Constraints
Applications
Measure
LH Measure
RH Measure
Mechanisms
Pedal OPT, DOF=0
Joints
Gear.2 (Fixed, RH Pedal Sim, Crank Rotation)
Command.1 (Gear.2, Angle 1)
Command.2 (Revolute.3, Angle)
Command.3 (Revolute.4, Angle)
Revolute.4 (RH Pedal Sim, RH Pedal)
Fix Part (Fixed)
Laws
Formula.2: `Pedal OPT\Commands\Command.2\Angle` = `LH Measure\Angle`
Formula.1: `Pedal OPT\Commands\Command.3\Angle` = `RH Measure\Angle`

Sketch Selection for Command.1
Select the sketch you want to link the command
Sketch name: Pedals Optimized/Laws/Laws/Geometrical Set.1/Sketch.1
Maximum time value: 100
OK Cancel

Command Edition: Command.1 (Angle 1)
Command name: Command.1
Command value: 0.0deg
Reset to Zero
Law Management
Import... Display... Edit **Link...** Link...
OK Cancel

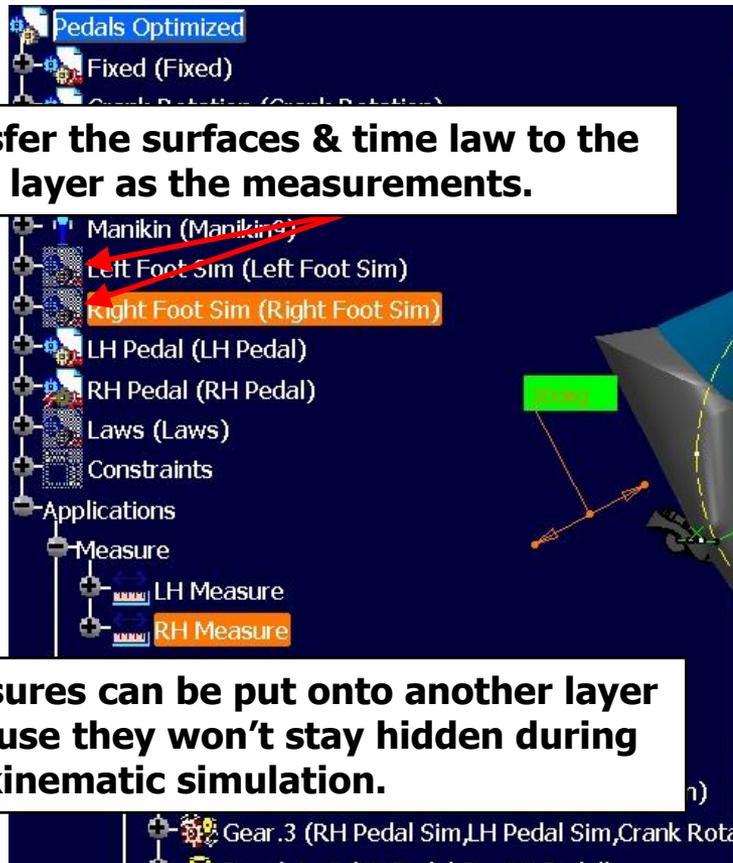


BND TechSource

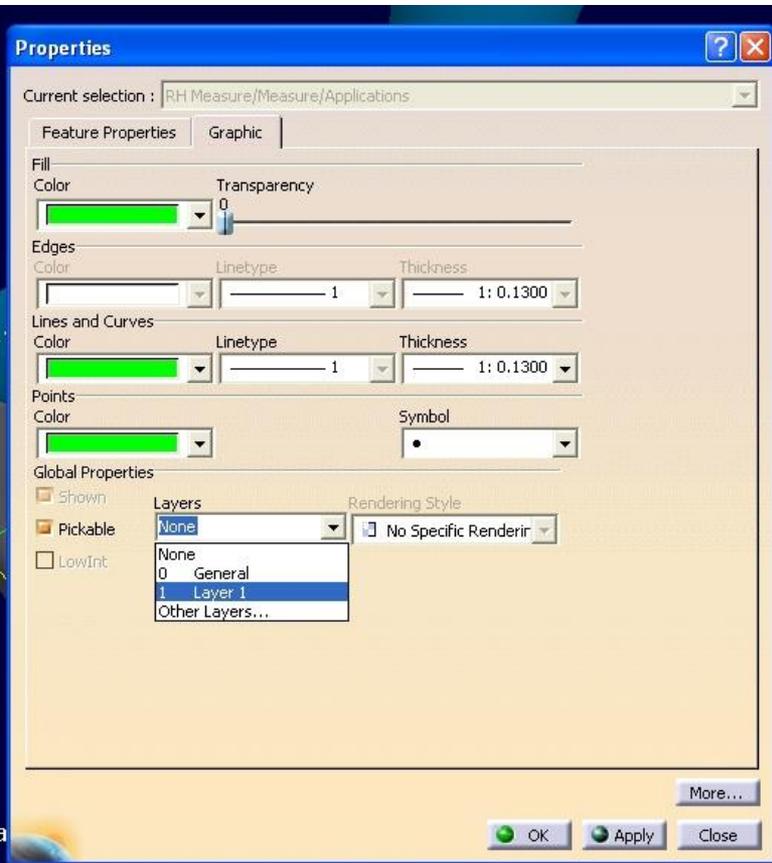


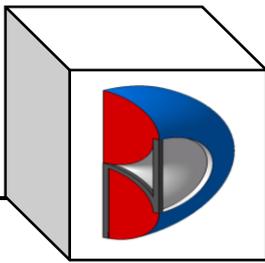
- Step 11: Clean up the appearance.

Transfer the surfaces & time law to the same layer as the measurements.

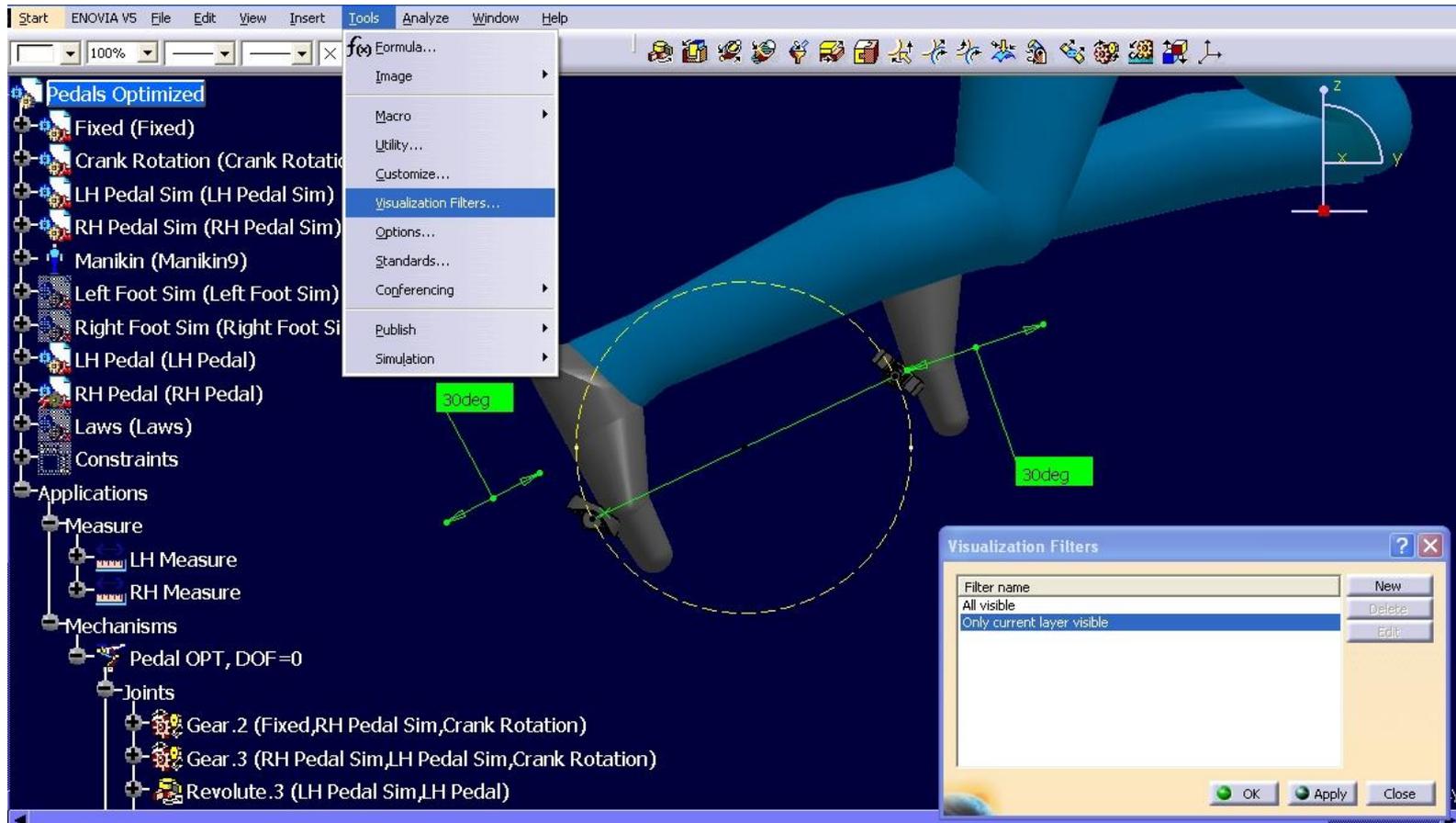


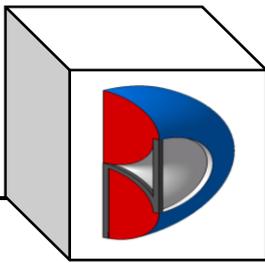
Measures can be put onto another layer because they won't stay hidden during the kinematic simulation.



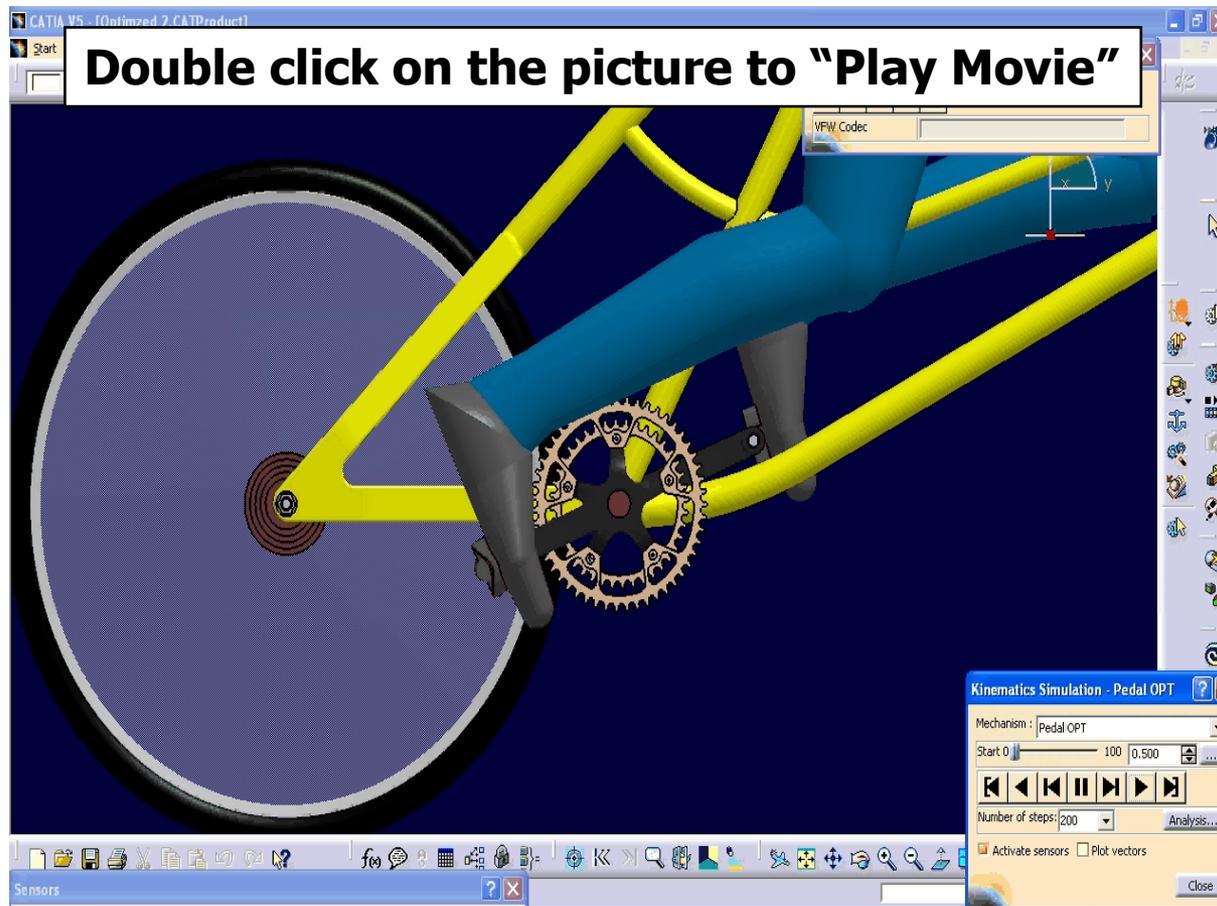


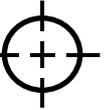
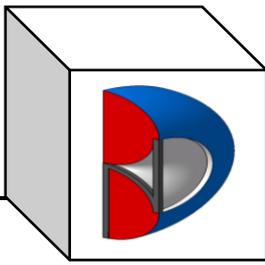
- Apply a Filter for the Kinematic simulation.





- Run the DMU Kinematic Simulation with Laws.





- Conclusion:

This is an example of how to use CATIA DMU Kinematics along with Ergonomic Design & Analysis to simulate a 3D Manikin pedaling a bicycle.

We hope this will help those who need this type of simulation.

As always, we are open to any discussions this may bring.