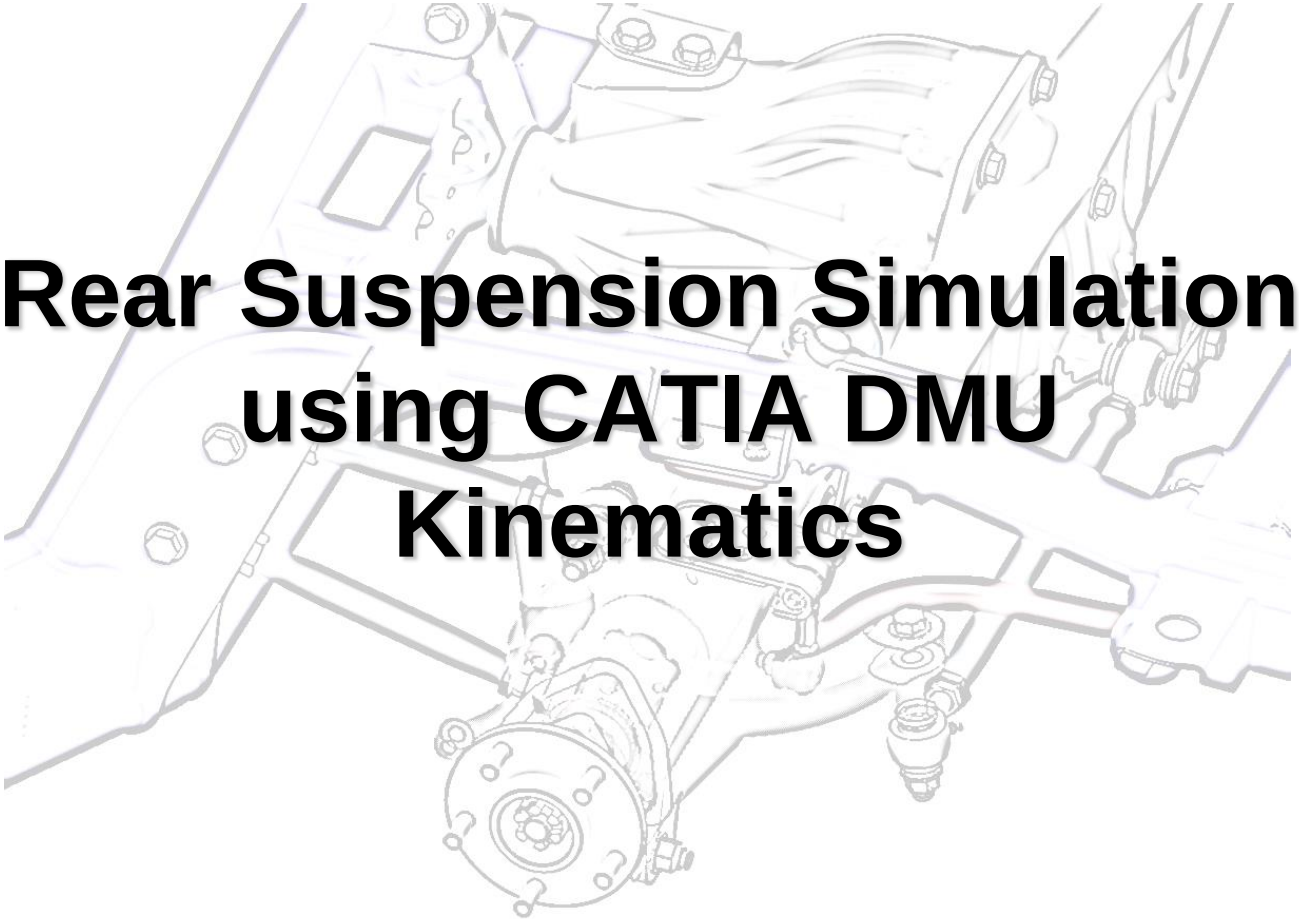
BND TechSource



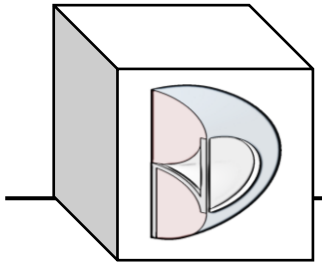
Rear Suspension Simulation using CATIA DMU Kinematics

BND TechSource

- The following licenses are required to create this DMU Kinematic simulation:
  - Digital Mockup Kinematics
  - Mechanical Part Design
  - Generative Shape Design
  - Assembly Design

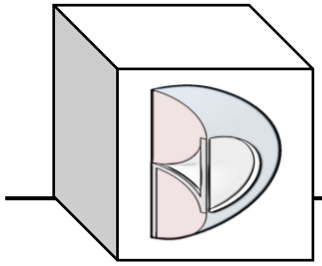
BND TechSource

- To create this DMU Kinematic simulation, we must begin with several known parameters.
- Known:
  - All suspension “hard points”.
    - Pivot points and lines
    - Angles of axes and planes
  - Min/Max Command values
    - Driveshaft rotation (-720deg, 720deg)
    - Shock down/up (-49.5mm, 35.5mm)



BND TechSource

Vehicle Suspension Hardpoints				
Rear Suspension				
Scrub (Pivot) Radius =			162.3 mm	
Kingpin Inclination Angle =			-7.1 deg	
Caster Angle =			1.2 deg	
Mechanical (or caster) trail (if applicable) =			6.83 mm	
Toe Angle =	-0.01 deg		+/- 0.10 deg	
Camber Angle =	-0.18 deg		+/- 0.5 deg	
Knuckle Attachment Points relative to Suspension Analysis Axis				
Various links and arms depend upon the Rear Suspension configuration. (i.e. Dependent vs. Semi-Independent vs. Independent Suspension)				
Configuration:	GM 5-link Independent Rear Suspension (axle half-shaft acts as 5th link)			
List each Knuckle Attachment Point relative to Susp Analysis Axis = (x, y, z)				
Camber Strut Pivot Point (inboard) = (x, y, z)				
Camber Strut Pivot Pt (inboard) =	X	Y	Z	mm
	-2486.13	153.90	201.63	
Camber Strut Pivot Point (outboard) = (x, y, z)				
Camber Strut Pivot Pt (outboard) =	X	Y	Z	mm
	-2486.14	603.67	187.51	

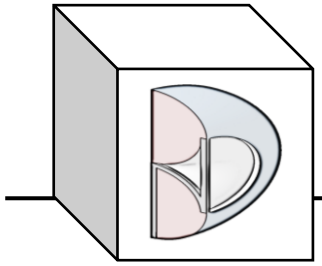


BND TechSource

Tie Rod Pivot Point (inboard) = (x, y, z)				
Tie Rod Pivot Pt (inboard) =	X	Y	Z	mm
	-2687.5	30.00	304.36	
Tie Rod Pivot Point (outboard) = (x, y, z)				
Tie Rod Pivot Pt (outboard) =	X	Y	Z	mm
	-2687.6	526.35	288.72	
Upper Trailing Arm Pivot Point (forward) = (x, y, z)				
Upr Trailing Arm Pivot Pt (forward) =	X	Y	Z	mm
	-2158.46	528.78	410.39	
Upper Trailing Arm Pivot Point (rearward) = (x, y, z)				
Upr Trailing Arm Pivot Pt (rearward) =	X	Y	Z	mm
	-2437.84	528.78	407.14	
Lower Trailing Arm Pivot Point (forward) = (x, y, z)				
Lwr Trailing Arm Pivot Pt (forward) =	X	Y	Z	mm
	-2122.80	528.78	312.57	
Lower Trailing Arm Pivot Point (rearward) = (x, y, z)				
Lwr Trailing Arm Pivot Pt (rearward) =	X	Y	Z	mm
	-2438.99	528.78	242.55	

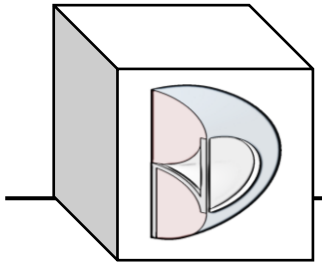
BND TechSource

U-Joint Pivot Point (inboard) = (x, y, z)					
U-Joint Pivot Pt (inboard) =	X	Y	Z	mm	
	-2488.90	197.89	339.18		
U-Joint Pivot Point (outboard) = (x, y, z)					
U-Joint Pivot Pt (outboard) =	X	Y	Z	mm	
	-2488.91	620.91	325.90		
Knuckle/Brakes					
Hub Dimensions:	(i.e. hub dia/thickness, pilot dia, hub face to knuckle, stud size/circle dia, etc.)				
	See CAD Data				
Brake Rotor Dimensions:					
Rotor Thickness =	26.0 mm				
Rotor Diameter =	305.0 mm				
Inner Face of Hub to Inner Rotor Surface =	42.0 mm				
Inner Hub Diameter =	182.0 mm				
Outer Hub Diameter =	202.0 mm				
Center Hole Diameter =	70.0 mm				
Brake Caliper to Wheel (min clearance) =	41.2 mm				
Brake Drum Dimensions (if drum brakes) (i.e. drum dia/depth, ctr hole dia, inner hub face to inner drum surf, etc.)	n/a				



BND TechSource

Springs/Shock Absorbers					
Spring Dimensions:	(i.e. Wire dia., OD, Active coils, Inactive coils, Free length, Ground ends, e				
	See CAD Data				
Spring Rate =				122.5	N/mm
Shock Absorber Adjustable Damping (see chart)					
Shock Absorber Type:	Strange - Double Adjustable Coil-over - S5003				
Extension Length =				326.10	mm
Compressed Length =				241.30	mm
Stroke Length (without bump stop) =				85.34	mm
Bump Stop (length) =				14.30	mm
Shock Mounting Pivot Points relative to Susp Analysis Axis = (x, y, z)					
Shock Upper Pivot Point =	X	Y	Z		mm
	-2330.68	363.45	408.43		
Shock Lower Pivot Point =	X	Y	Z		mm
	-2421.97	470.59	153.70		
Spring and Shock Installation Angle =			70.6/72.9		deg
Spring and Shock Absorber Motion Ratio @ Ride Ht =			0.728		unit/unit



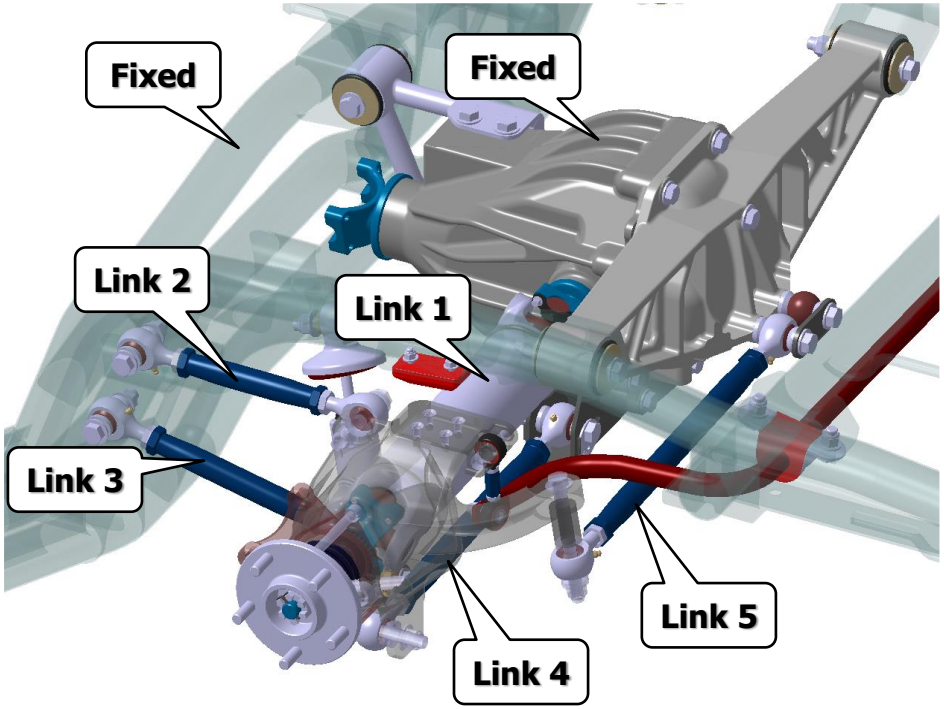
BND TechSource

ARB (anti-roll bar)				
ARB (anti-roll bar) Dimensions:				
Virtual torque arm (A):	216.15	mm		
Length of center (B):	819.91	mm		
Physical torque arm (C):	226.50	mm		
OD in millimeters: (D)	20.00	mm		
ID in millimeters: (if hollow)	0.00	mm		
ARB (anti-roll bar) Spring Rate =	29.20	N/mm		
ARB (anti-roll bar) Motion Ratio @ Ride Ht =	0.749	unit/unit		
ARB Bushing Rates (per deflection at loads)				
Design Results				
Tire Envelope =	(see CAD Data)			
Tool Clearance =	(see CAD Data)			
Routing Clearance (i.e. hoses, brake lines, fuel lines, electrical, etc.) =	(see CAD Data)			
Roll Center Height =	23.39	mm		
Anti-squat Instantaneous Center relative to Susp Analysis Axis = (x, y, z)				
Anti-squat Instant Center =	X	Y	Z	mm
	-1654.6	n/a	416.25	
Wheel Rate incl ARB =	81.31	N/mm		
Ride Rate incl ARB =	63.26	N/mm		

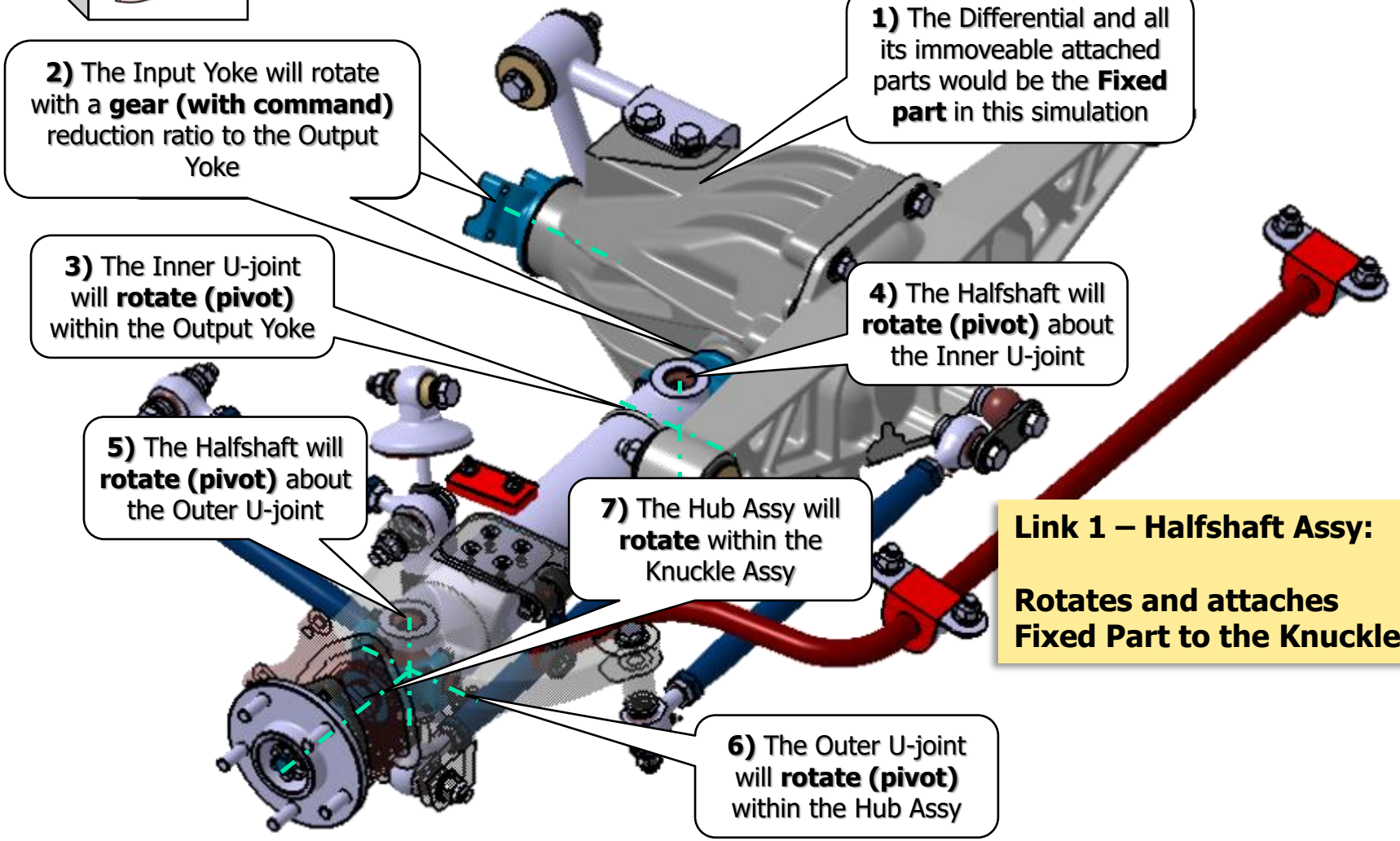
Step 1: Understand the suspension system

BND TechSource

- Begin with the completed Rear Suspension Assembly.
- This will help to understand all the pivot and links within this 5-link system.



BND TechSource



1) The Differential and all its immoveable attached parts would be the **Fixed part** in this simulation

2) The Input Yoke will rotate with a **gear (with command)** reduction ratio to the Output Yoke

3) The Inner U-joint will **rotate (pivot)** within the Output Yoke

4) The Halfshaft will **rotate (pivot)** about the Inner U-joint

5) The Halfshaft will **rotate (pivot)** about the Outer U-joint

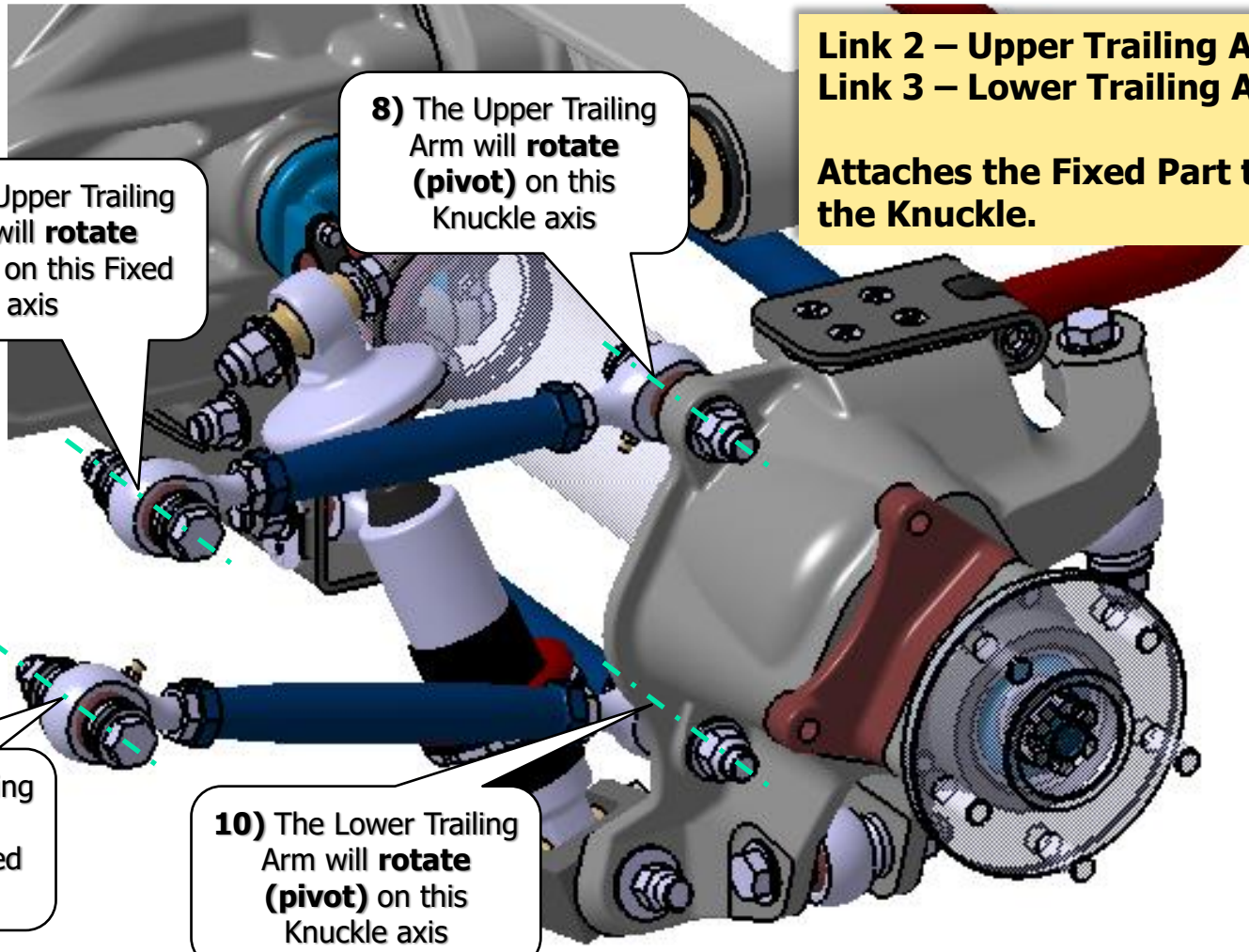
7) The Hub Assy will **rotate** within the Knuckle Assy

6) The Outer U-joint will **rotate (pivot)** within the Hub Assy

Link 1 – Halfshaft Assy:

Rotates and attaches Fixed Part to the Knuckle.

BND TechSource



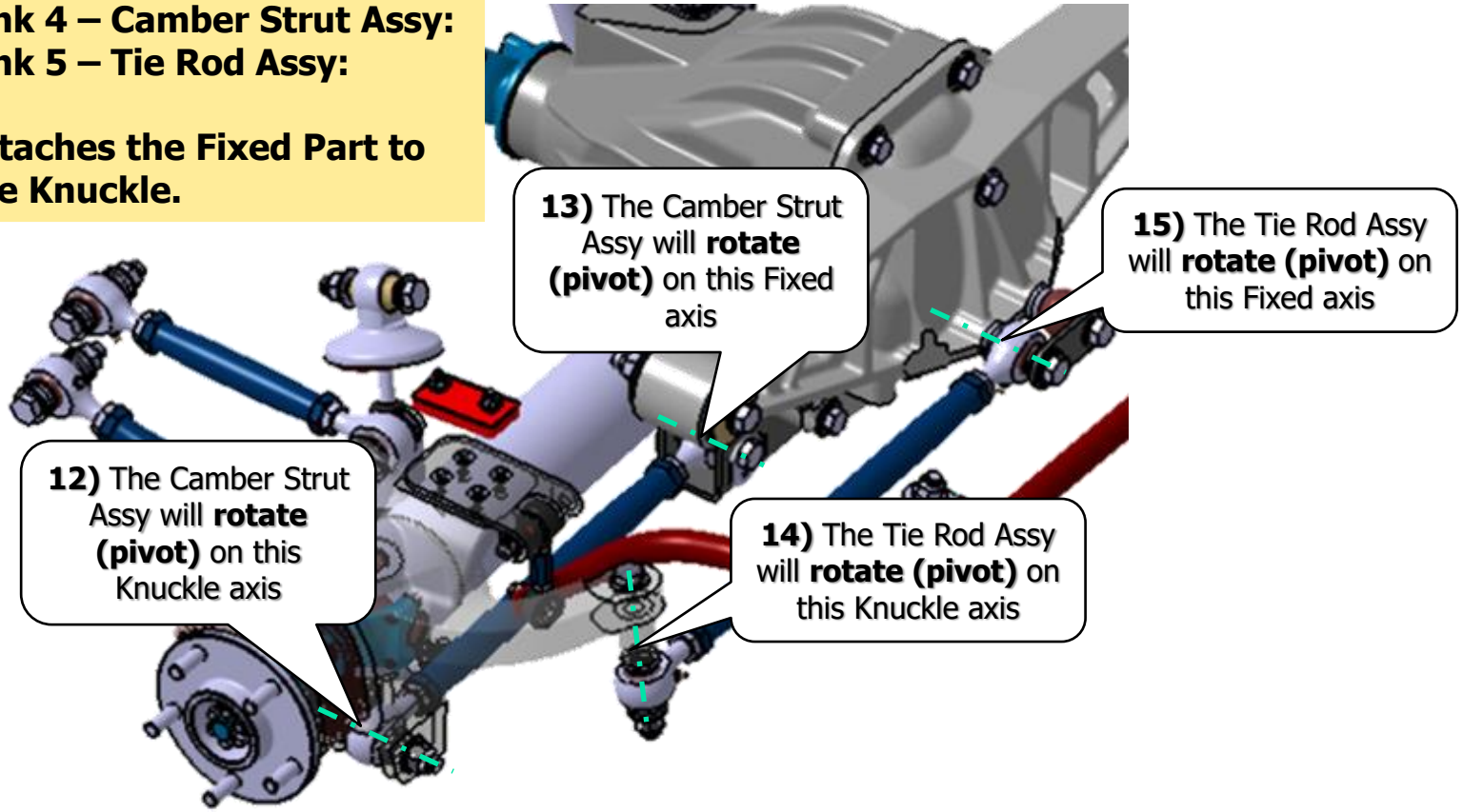
Link 2 – Upper Trailing Arm:
Link 3 – Lower Trailing Arm:

Attaches the Fixed Part to the Knuckle.

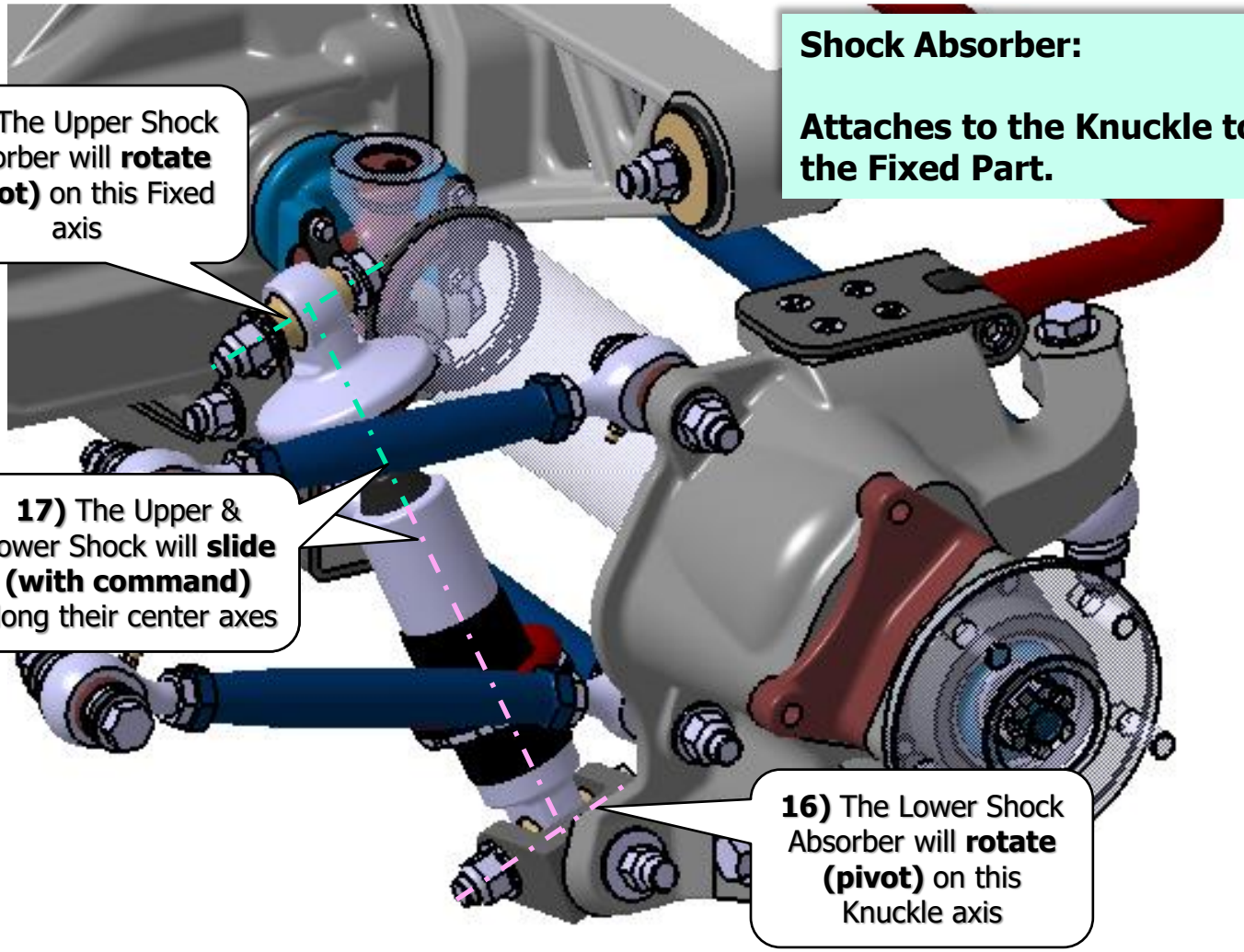
BND TechSource

Link 4 – Camber Strut Assy:
Link 5 – Tie Rod Assy:

Attaches the Fixed Part to the Knuckle.



BND TechSource



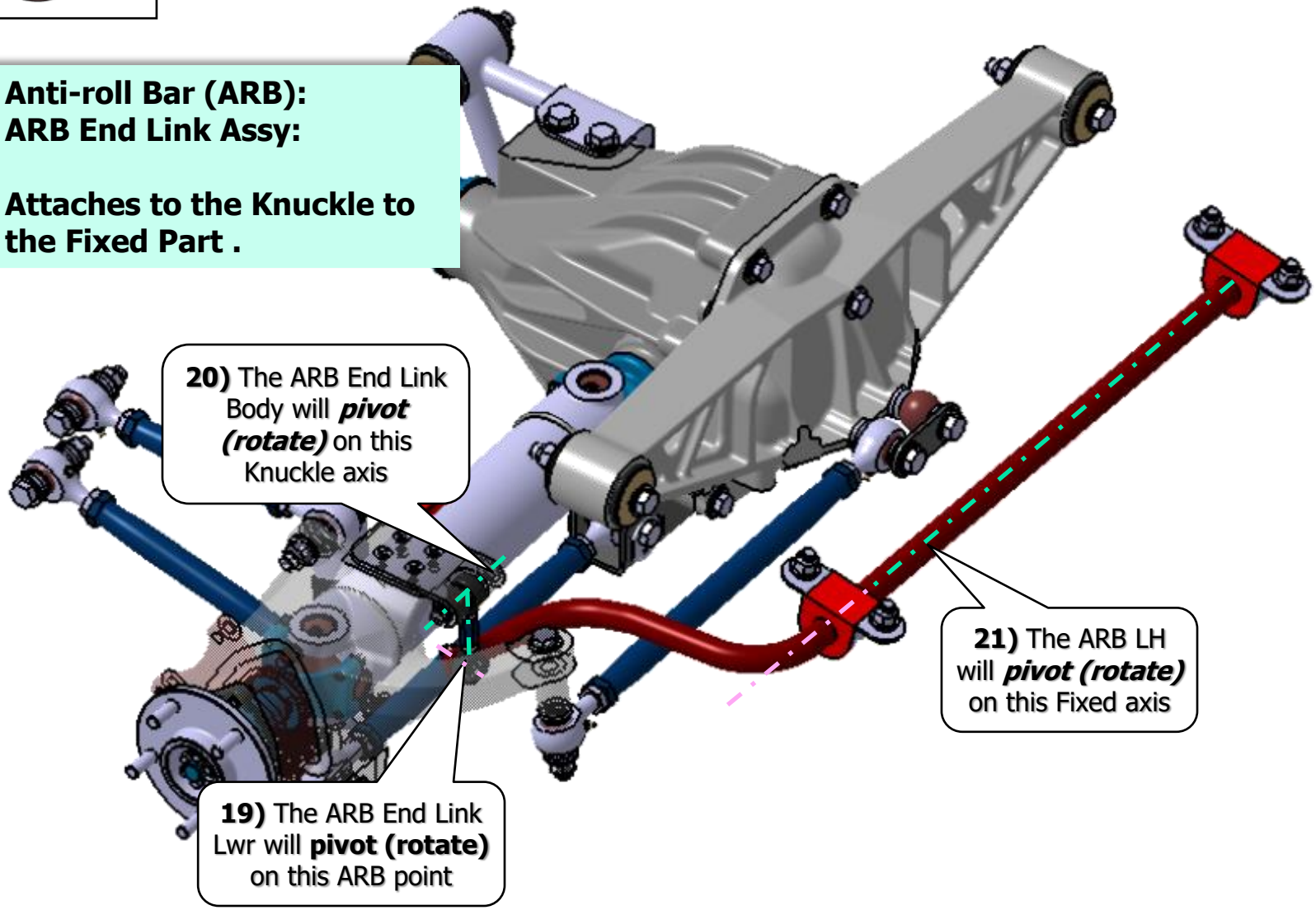
Shock Absorber:

Attaches to the Knuckle to the Fixed Part.

BND TechSource

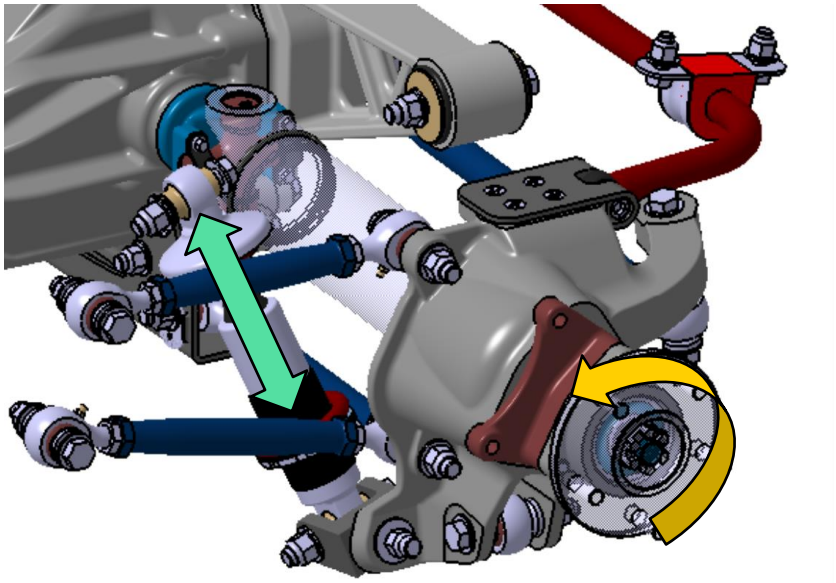
Anti-roll Bar (ARB):
ARB End Link Assy:

Attaches to the Knuckle to the Fixed Part .



BND TechSource

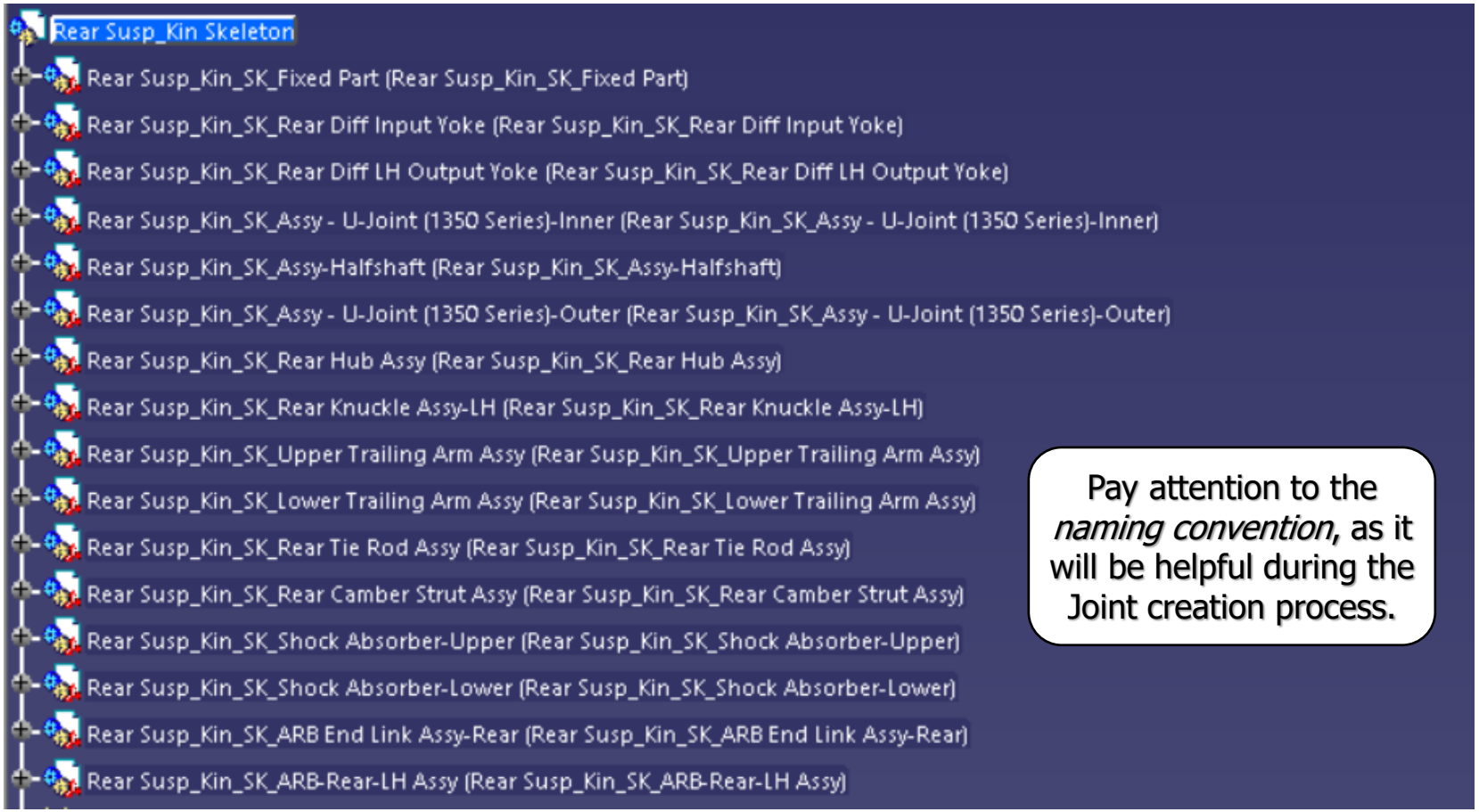
- Understand which joints need commands.
  - Min/Max Command values
    - Driveshaft rotation (-720deg, 720deg)
    - Shock down/up (-49.5mm, 35.5mm)



Step 2: Create a kinematic skeleton structure

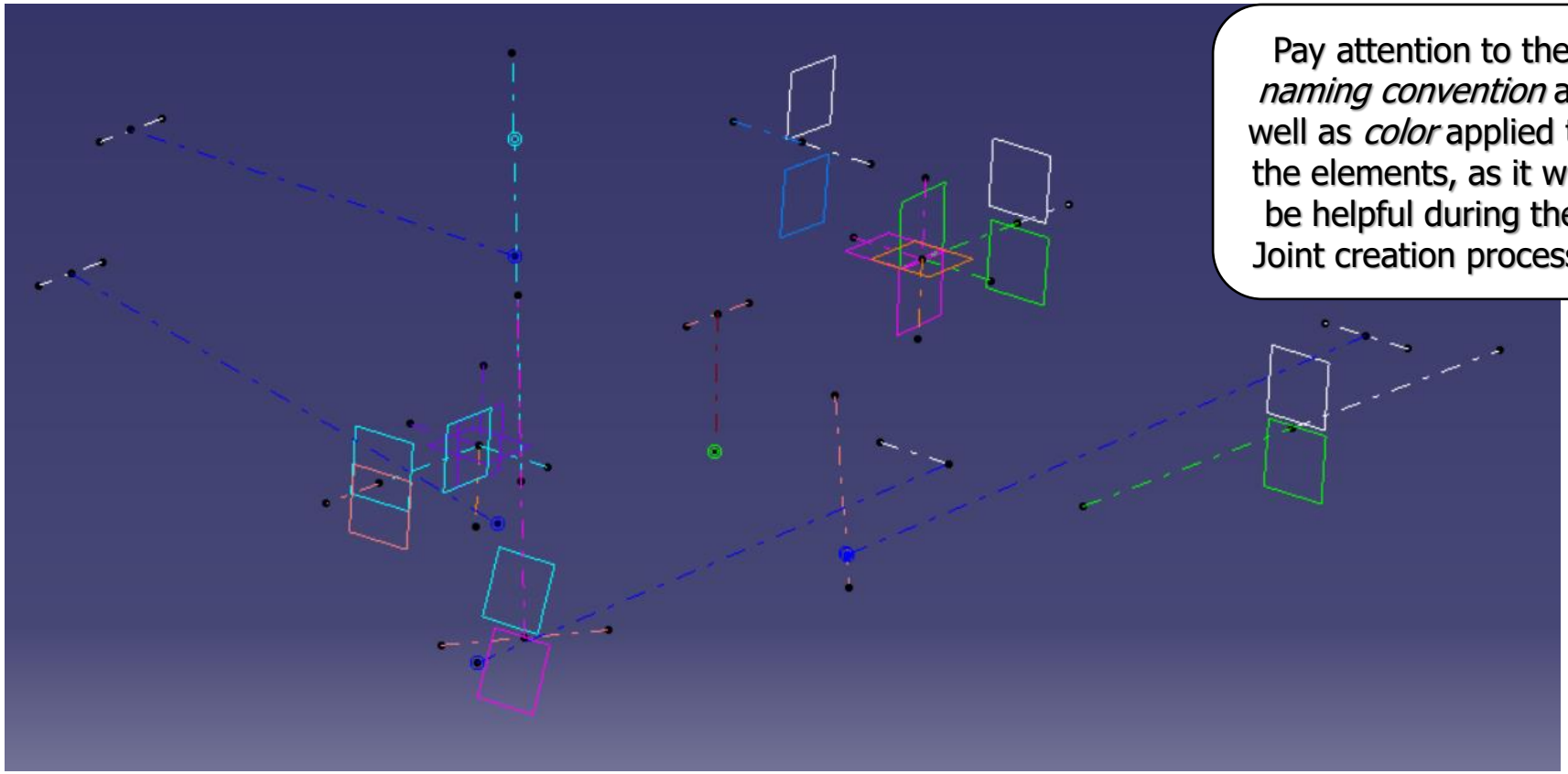
BND TechSource

- Create a Skeleton Product and all Parts required for the kinematic simulation.



BND TechSource

- Create all points, lines, & planes inside each part within the kinematic structure.

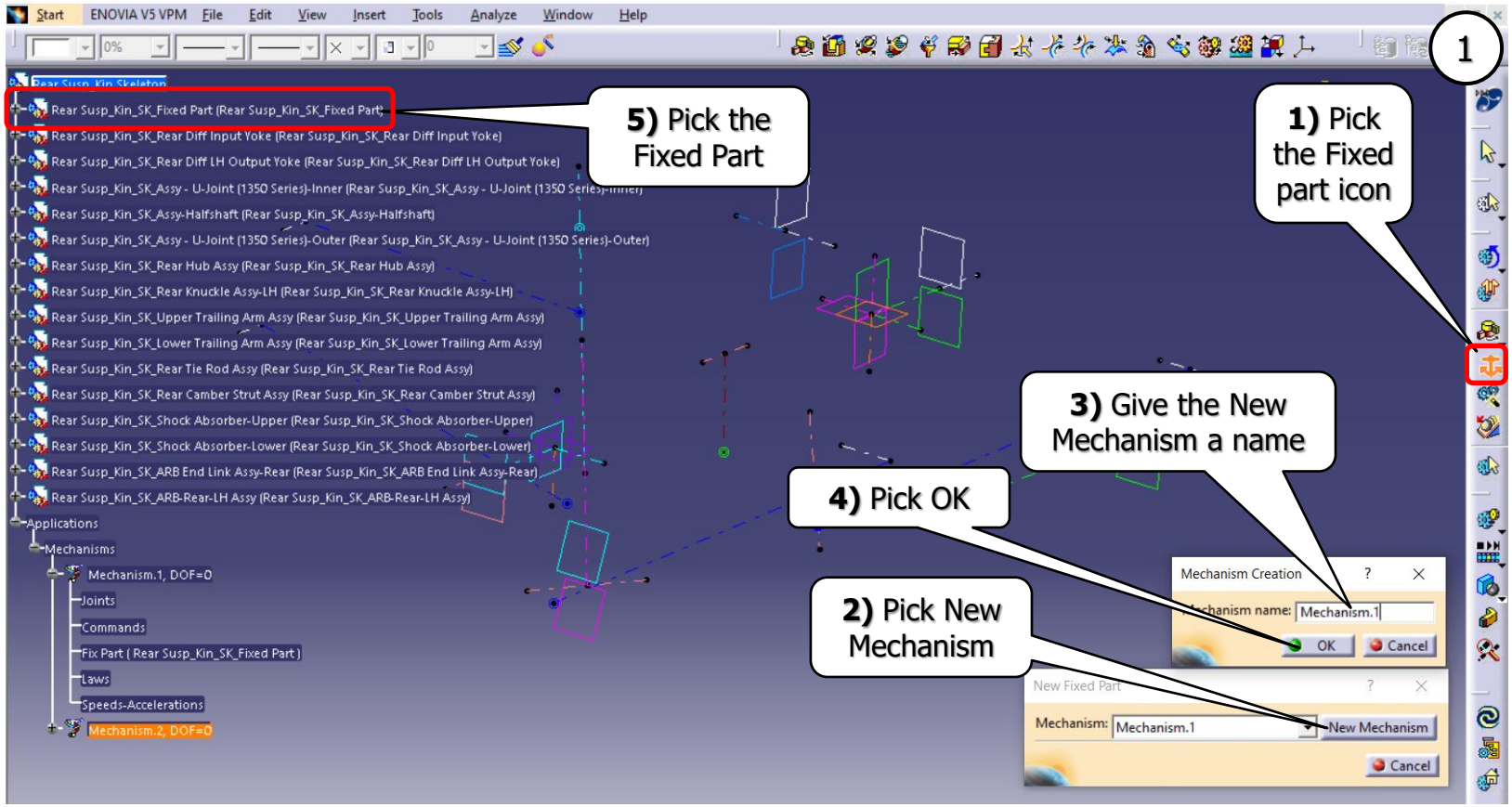


Pay attention to the *naming convention* as well as *color* applied to the elements, as it will be helpful during the Joint creation process.

Step 3: Create the kinematic Joints

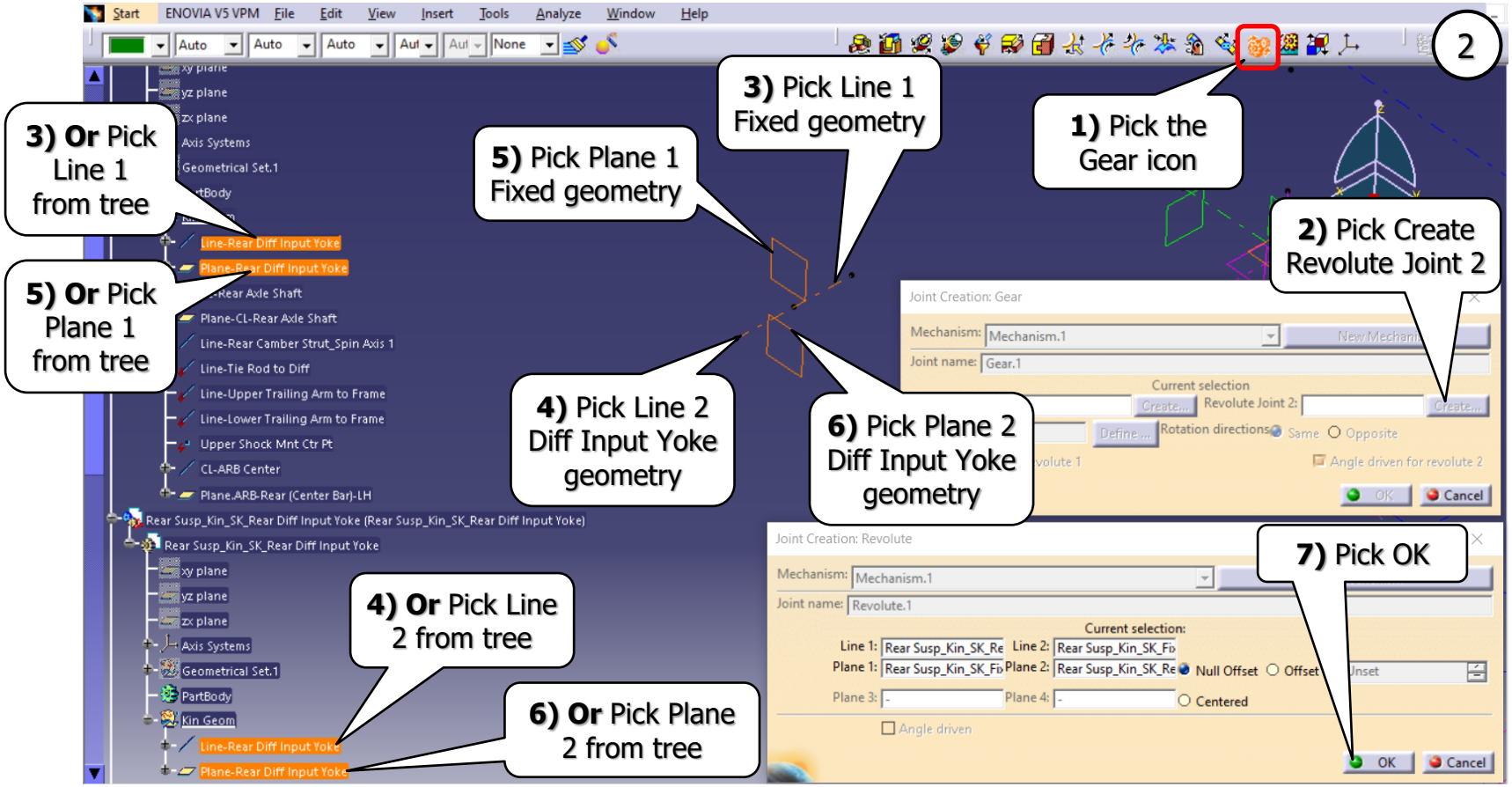
BND TechSource

- Create the Fixed Part and name the Mechanism.



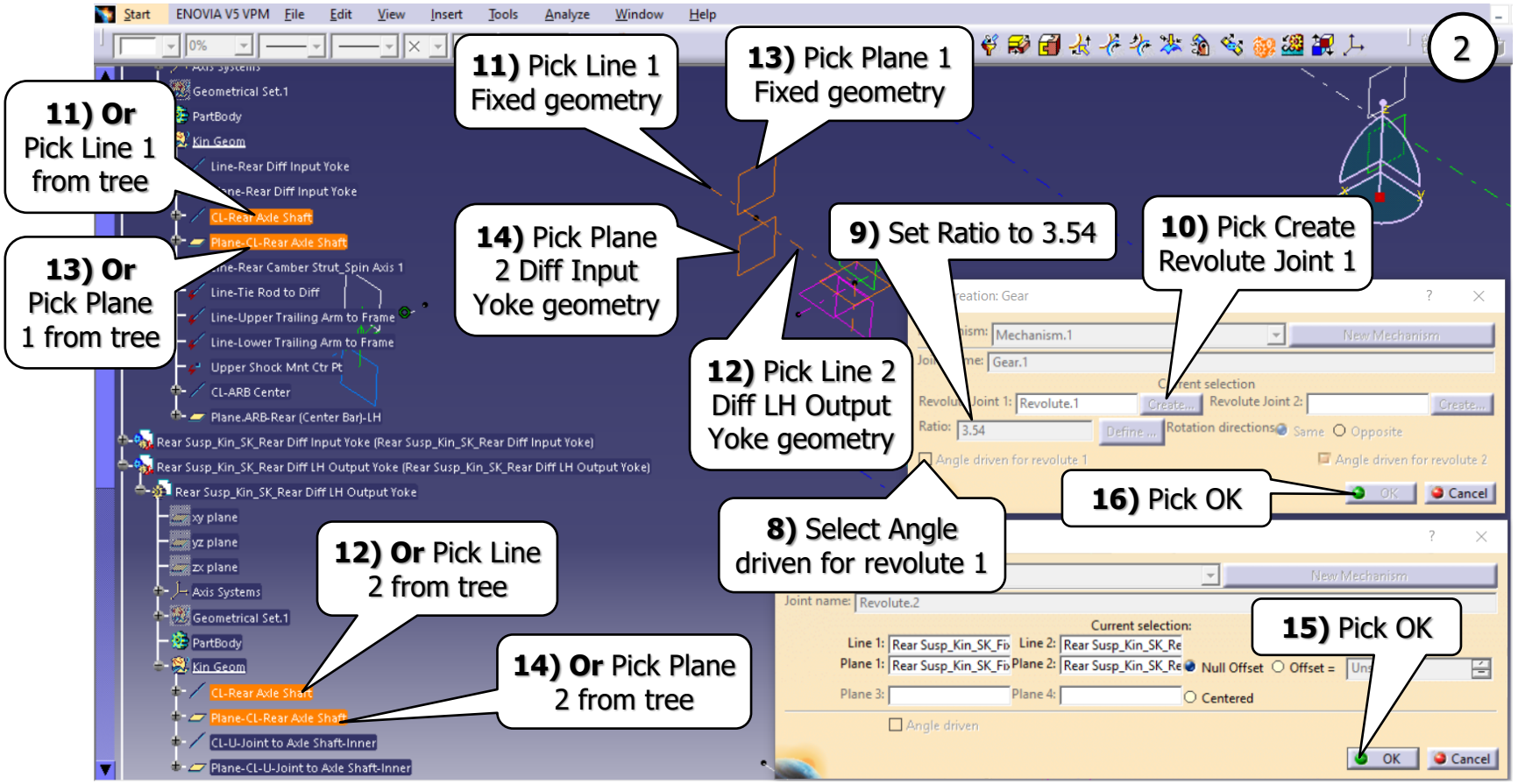
BND TechSource

- Create a Gear Joint between the Diff Input Yoke and the Diff LH Output Yoke.



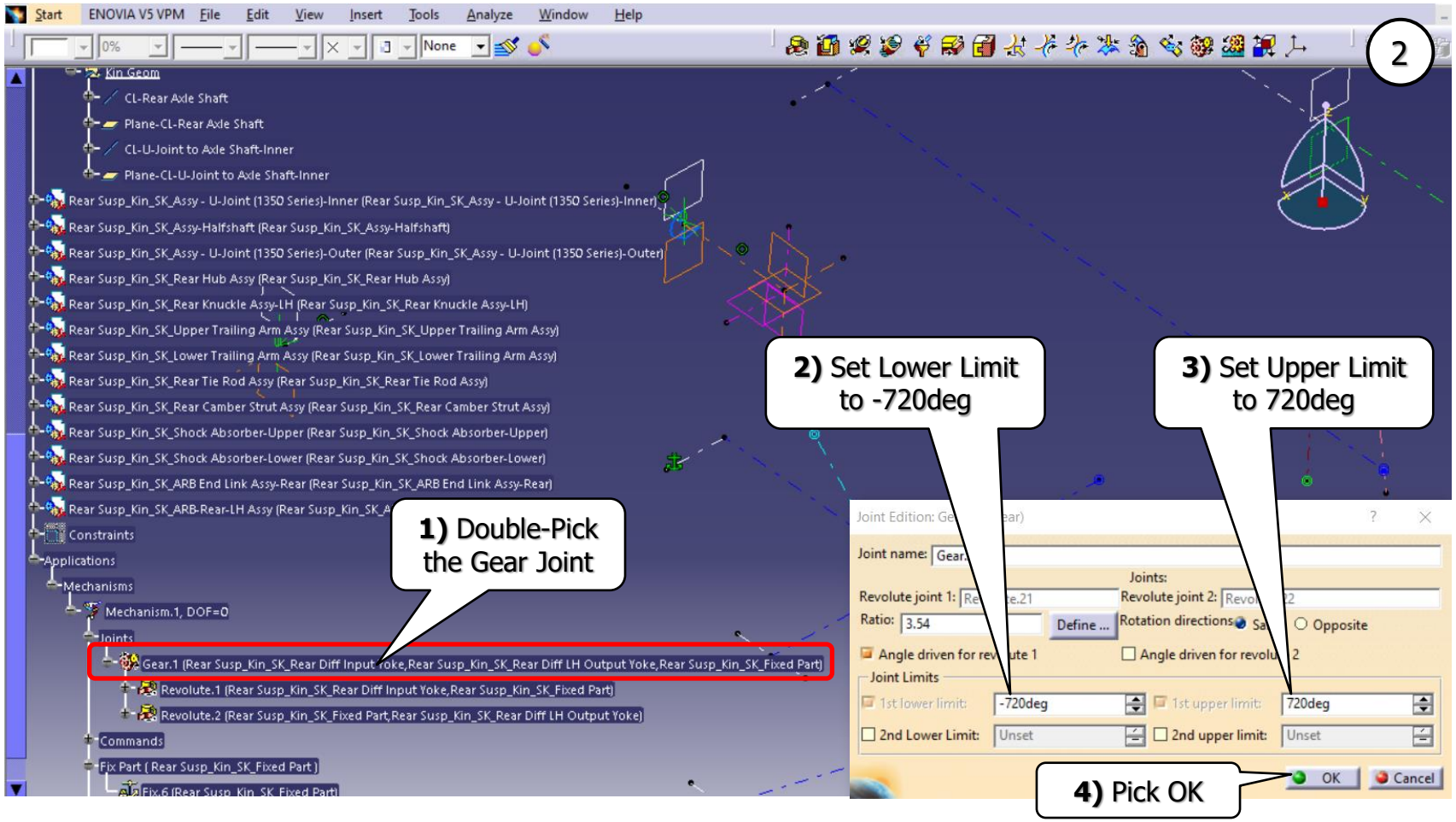
BND TechSource

- Create a Gear Joint between the Diff Input Yoke and the Diff LH Output Yoke.



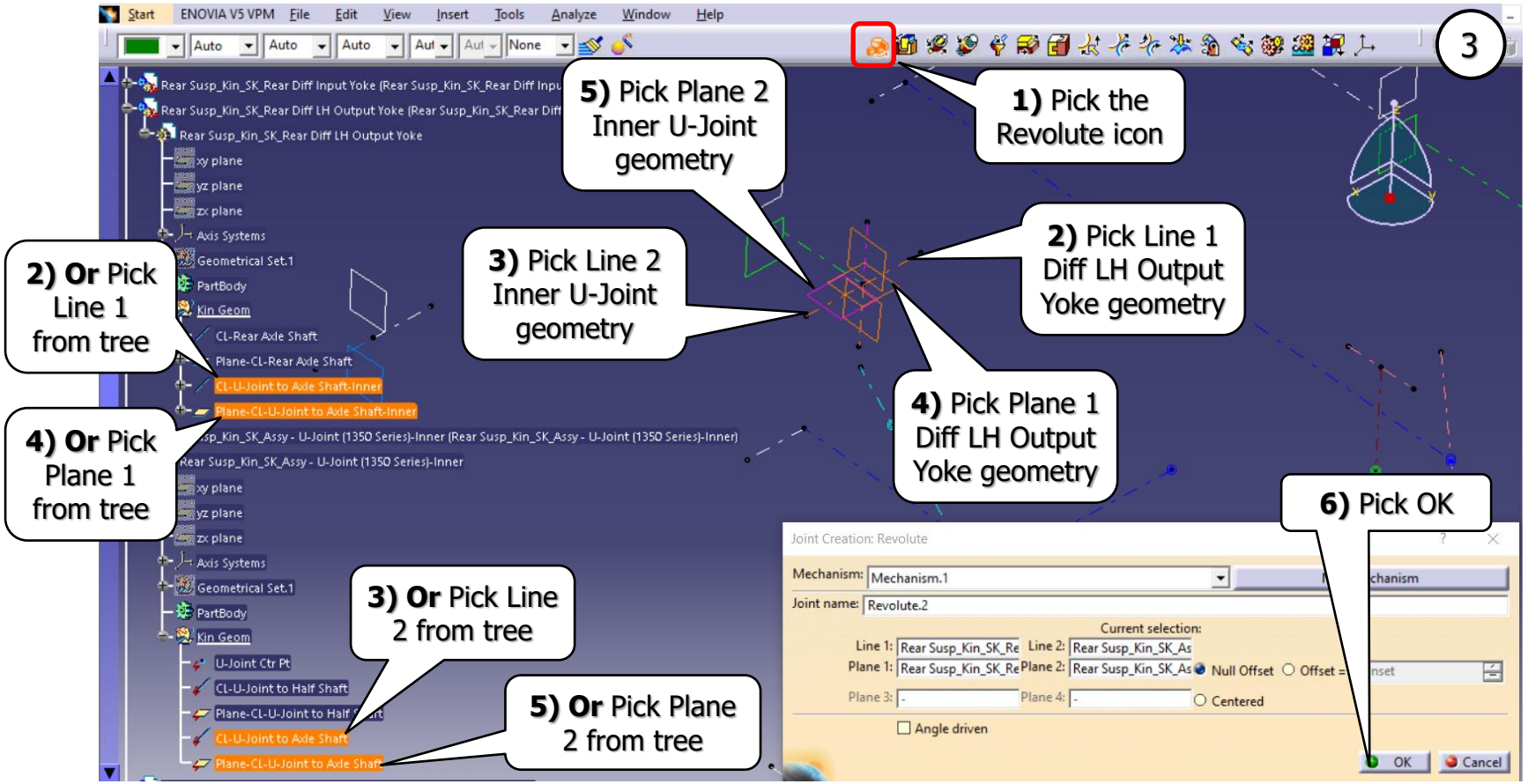
BND TechSource

- Set the Min/Max values for the Gear Joint.



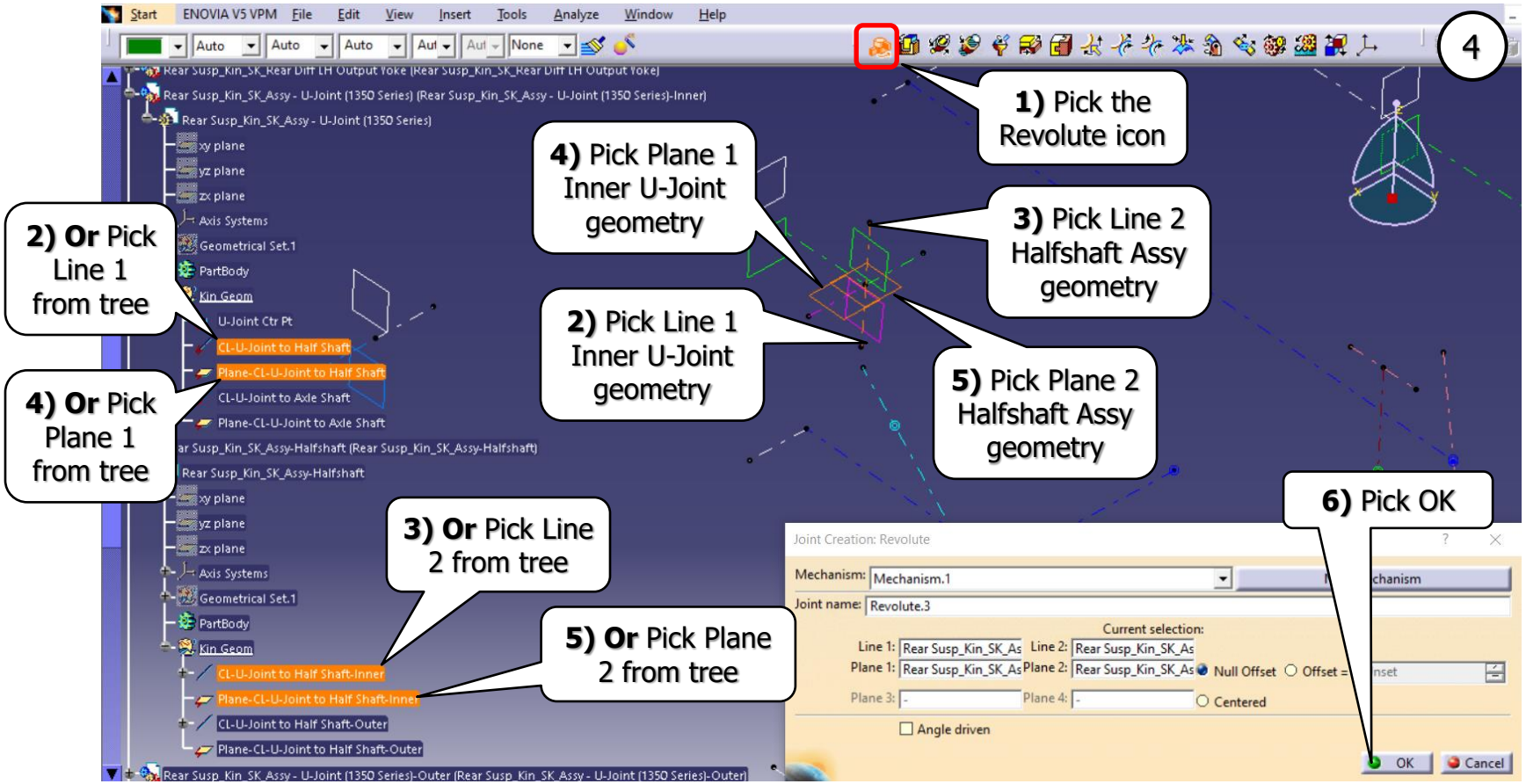
BND TechSource

- Create a Revolute Joint between the Diff LH Output Yoke and the Inner U-Joint.



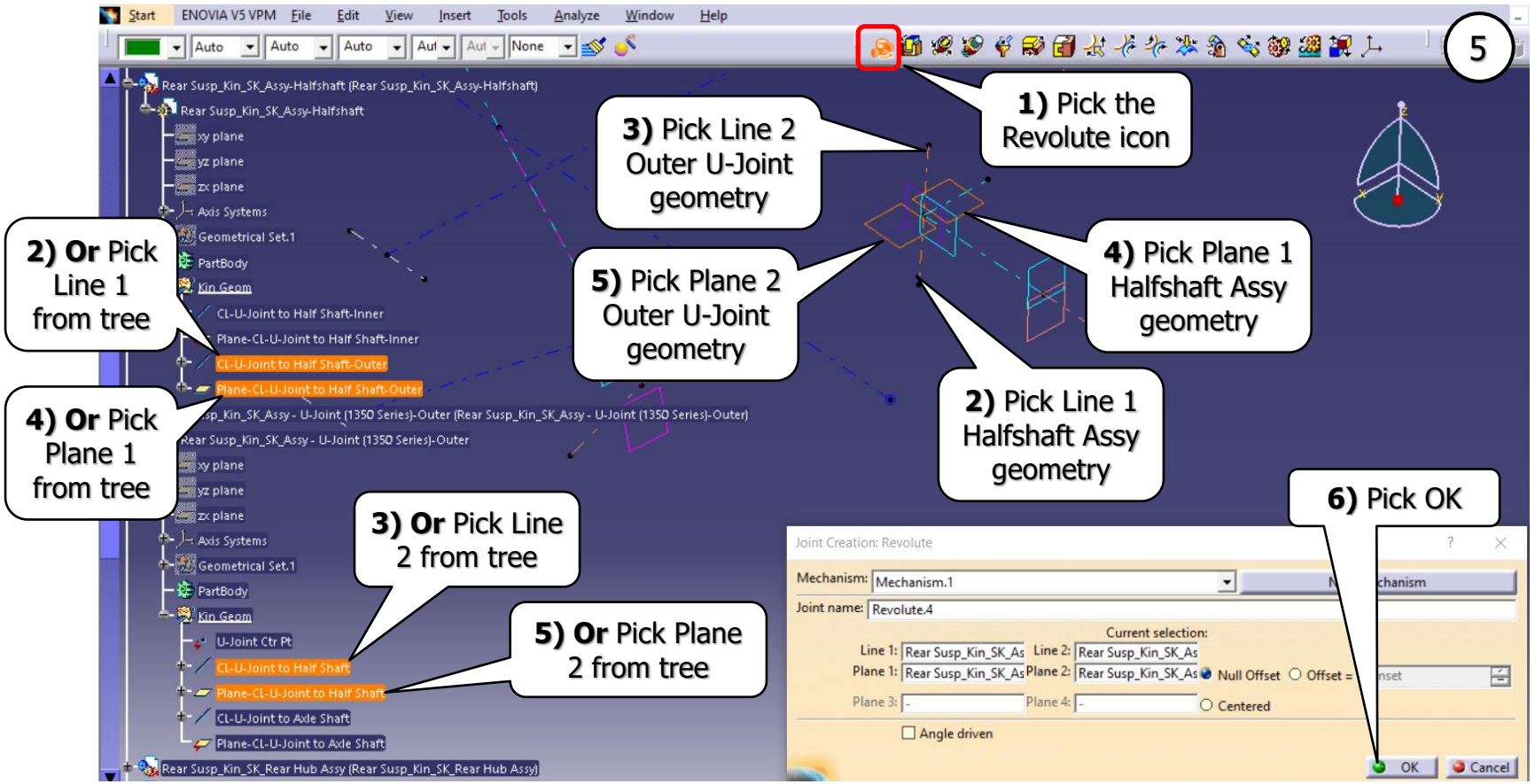
BND TechSource

- Create a Revolute Joint between the Inner U-Joint and the Halfshaft Assy.



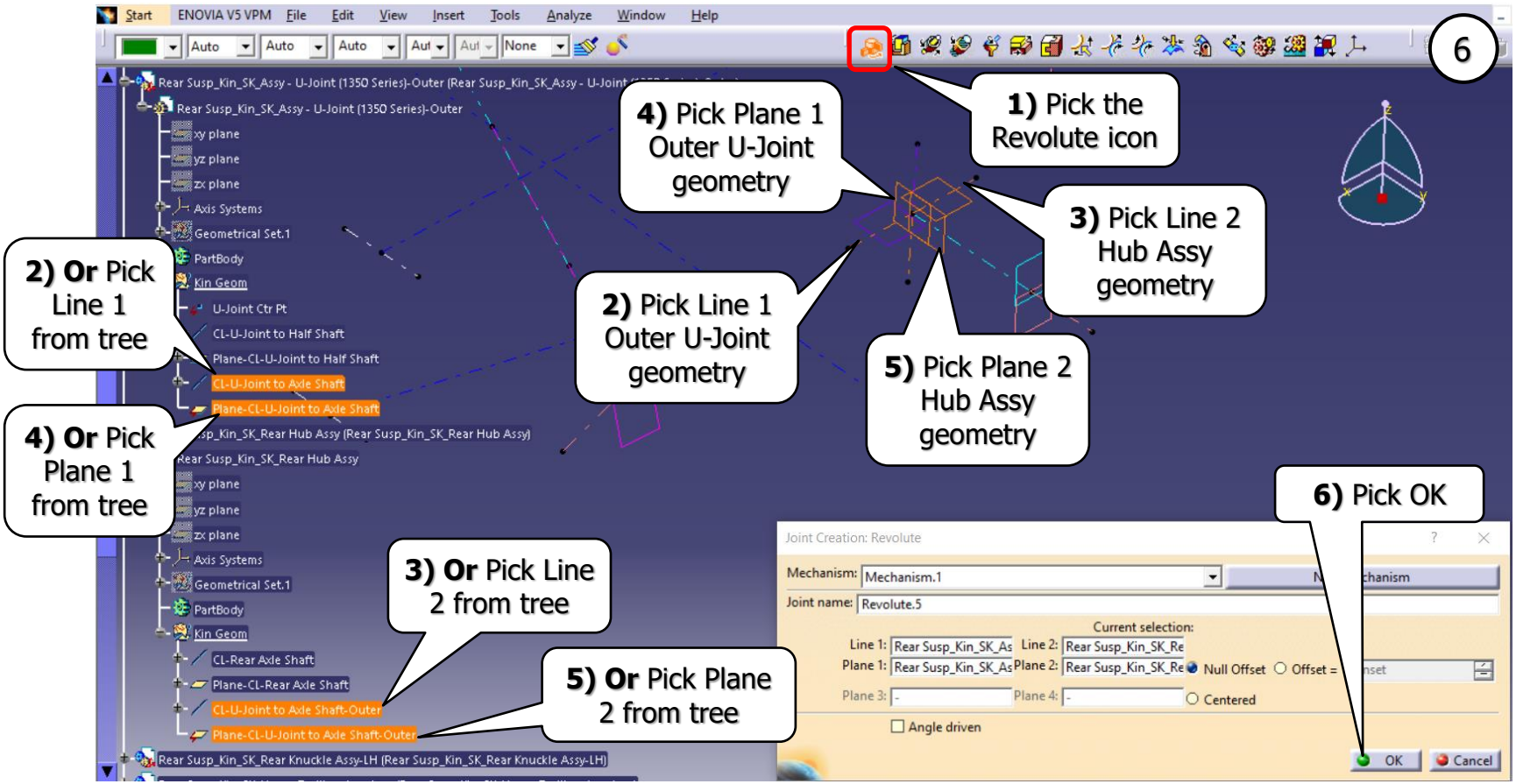
BND TechSource

- Create a Revolute Joint between the Halfshaft Assy and the Outer U-Joint.



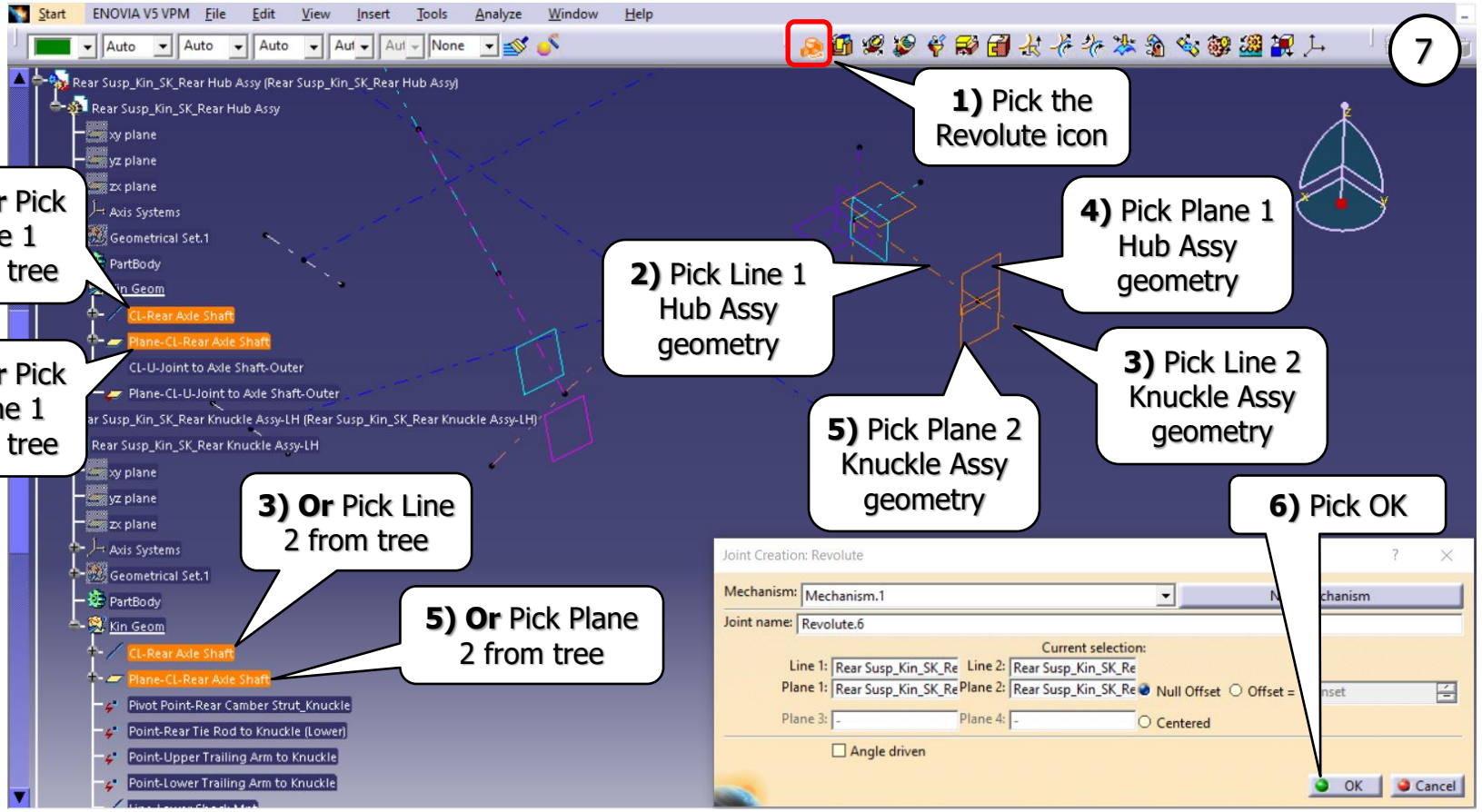
BND TechSource

- Create a Revolute Joint between the Outer U-Joint and the Hub Assy.



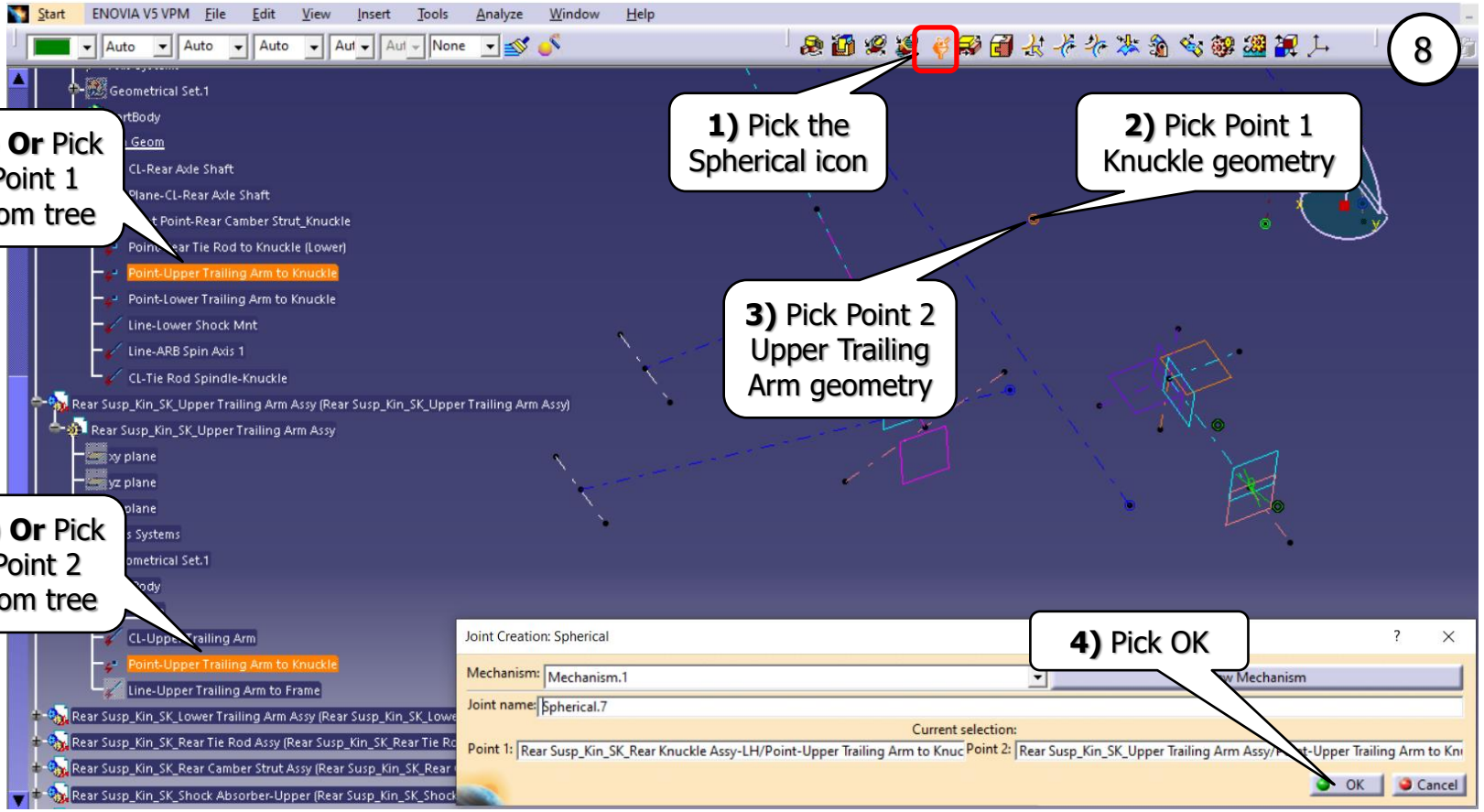
BND TechSource

- Create a Revolute Joint between the Hub Assy and the Knuckle Assy.



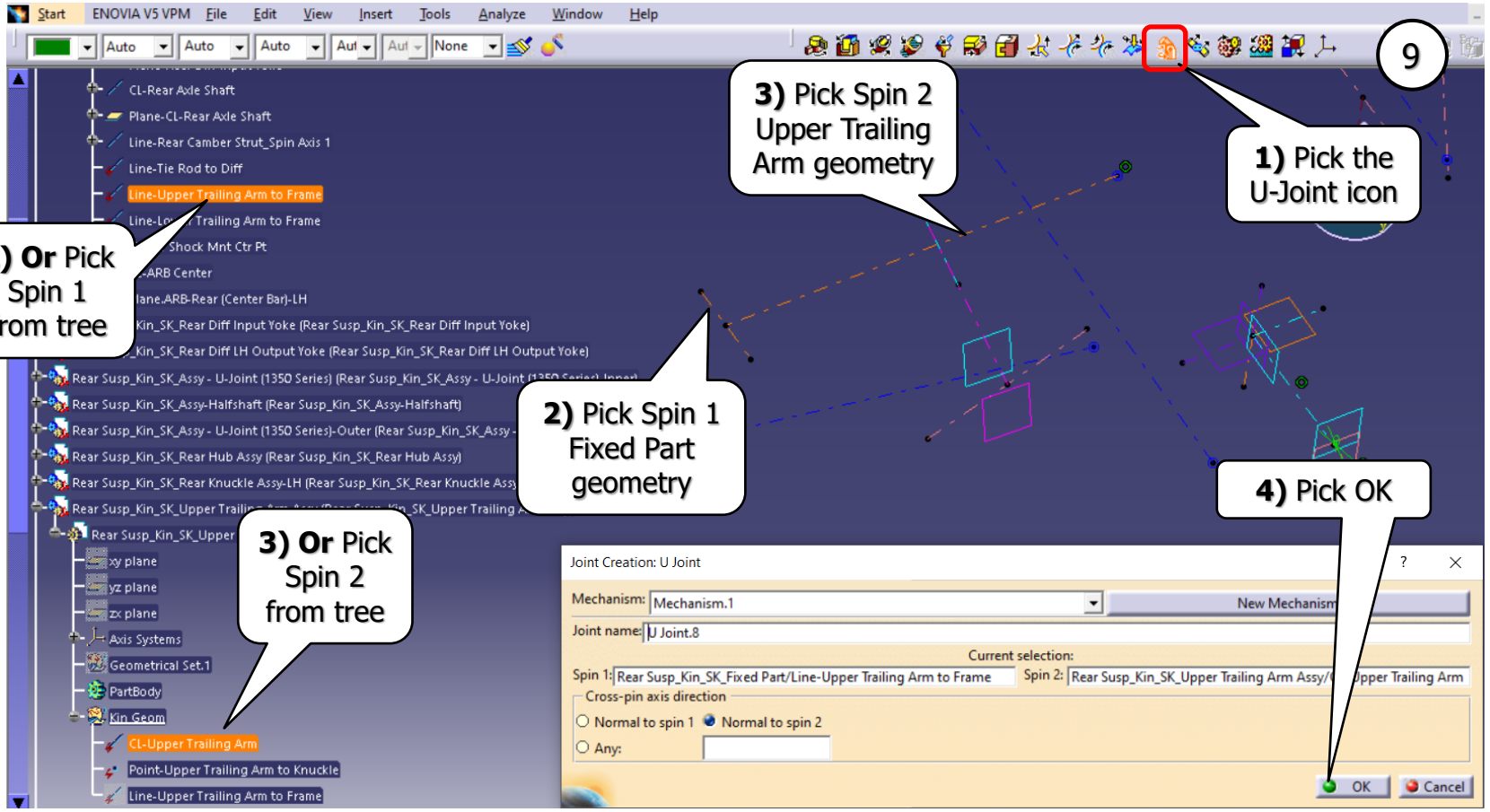
BND TechSource

- Create a Spherical Joint between the Knuckle and the Upper Trailing Arm.



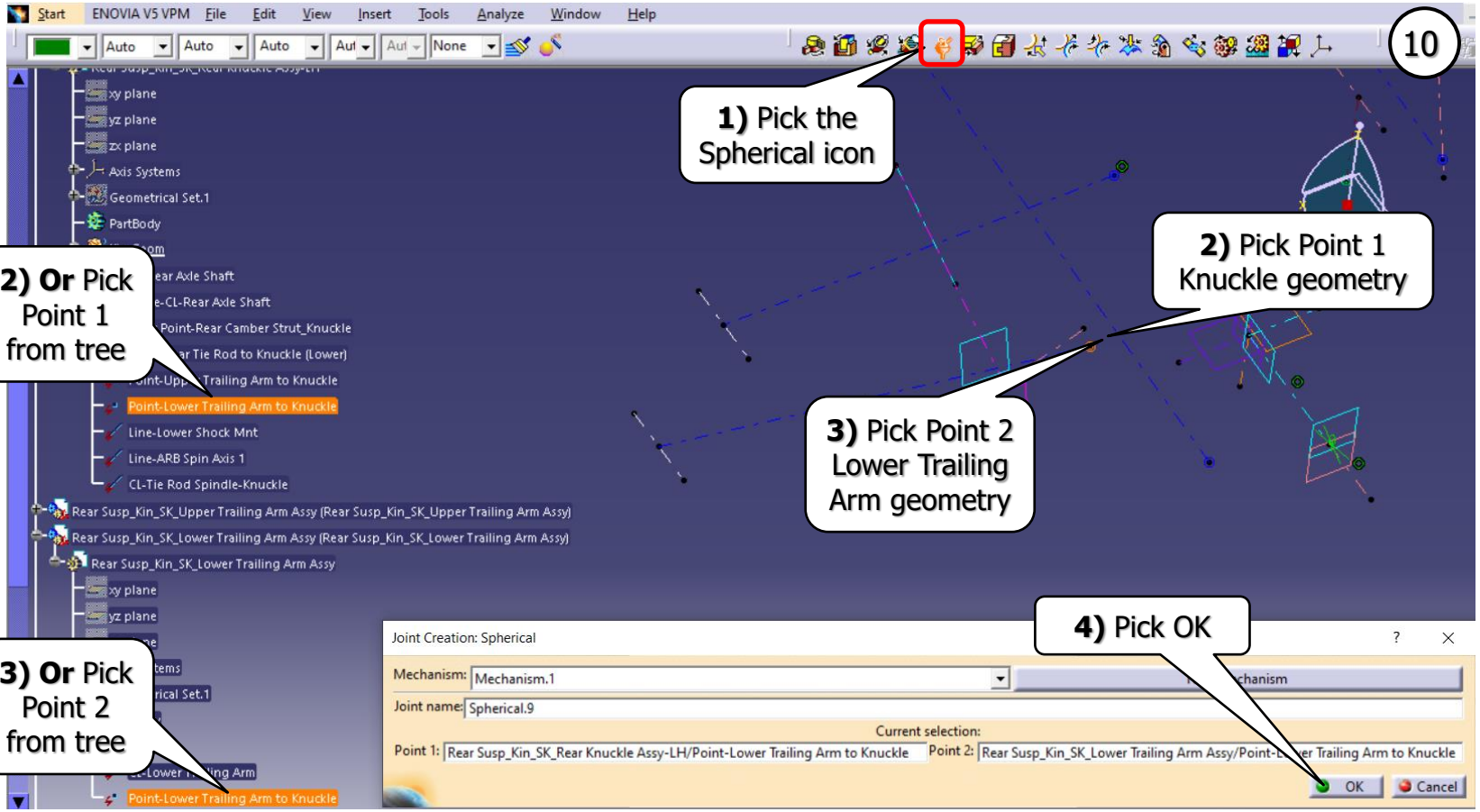
BND TechSource

- To avoid binding in the mechanism*, create a Universal Joint between the Upper Trailing Arm and the Fixed Part.



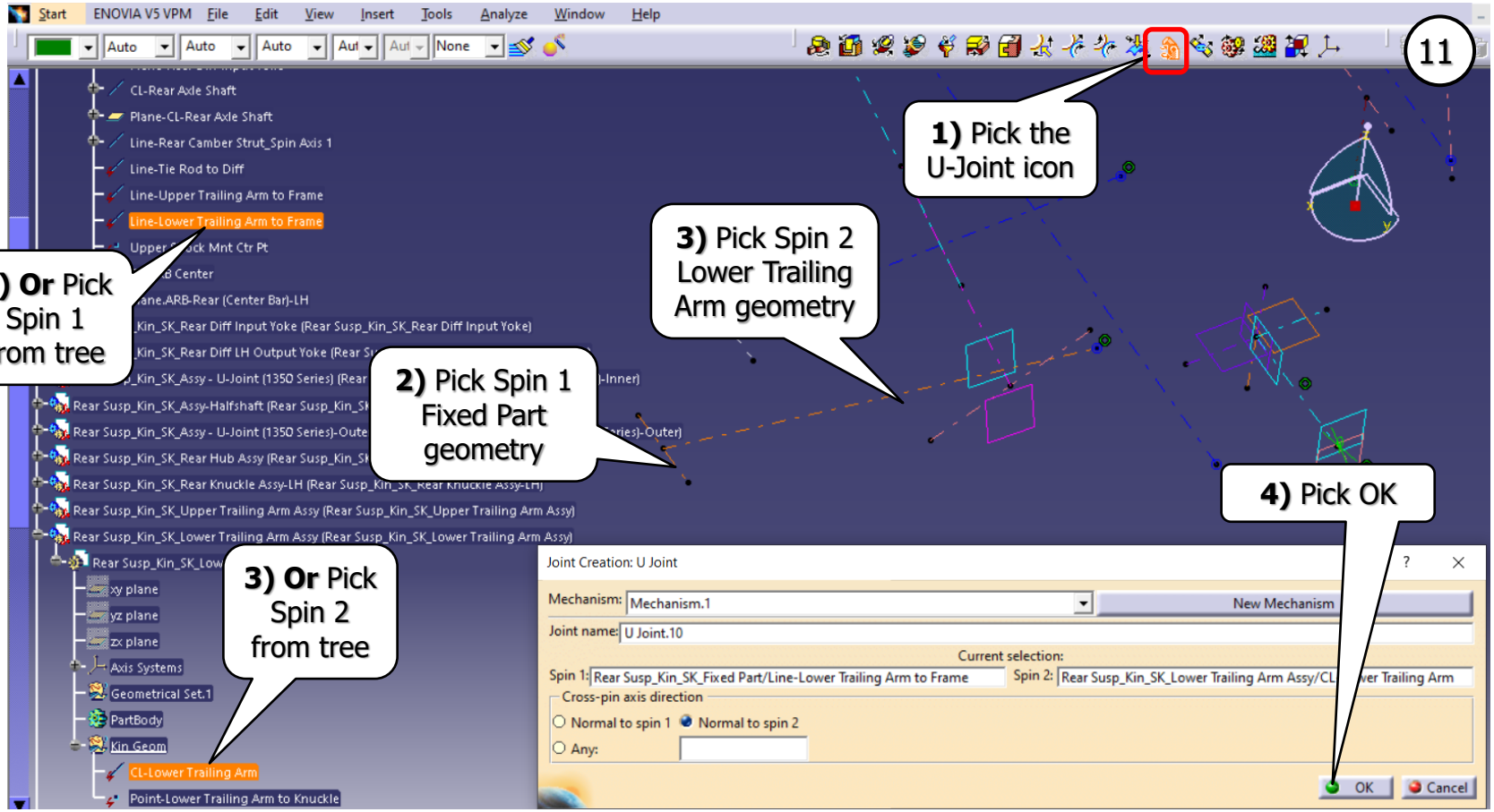
BND TechSource

- Create a Spherical Joint between the Knuckle and the Lower Trailing Arm.



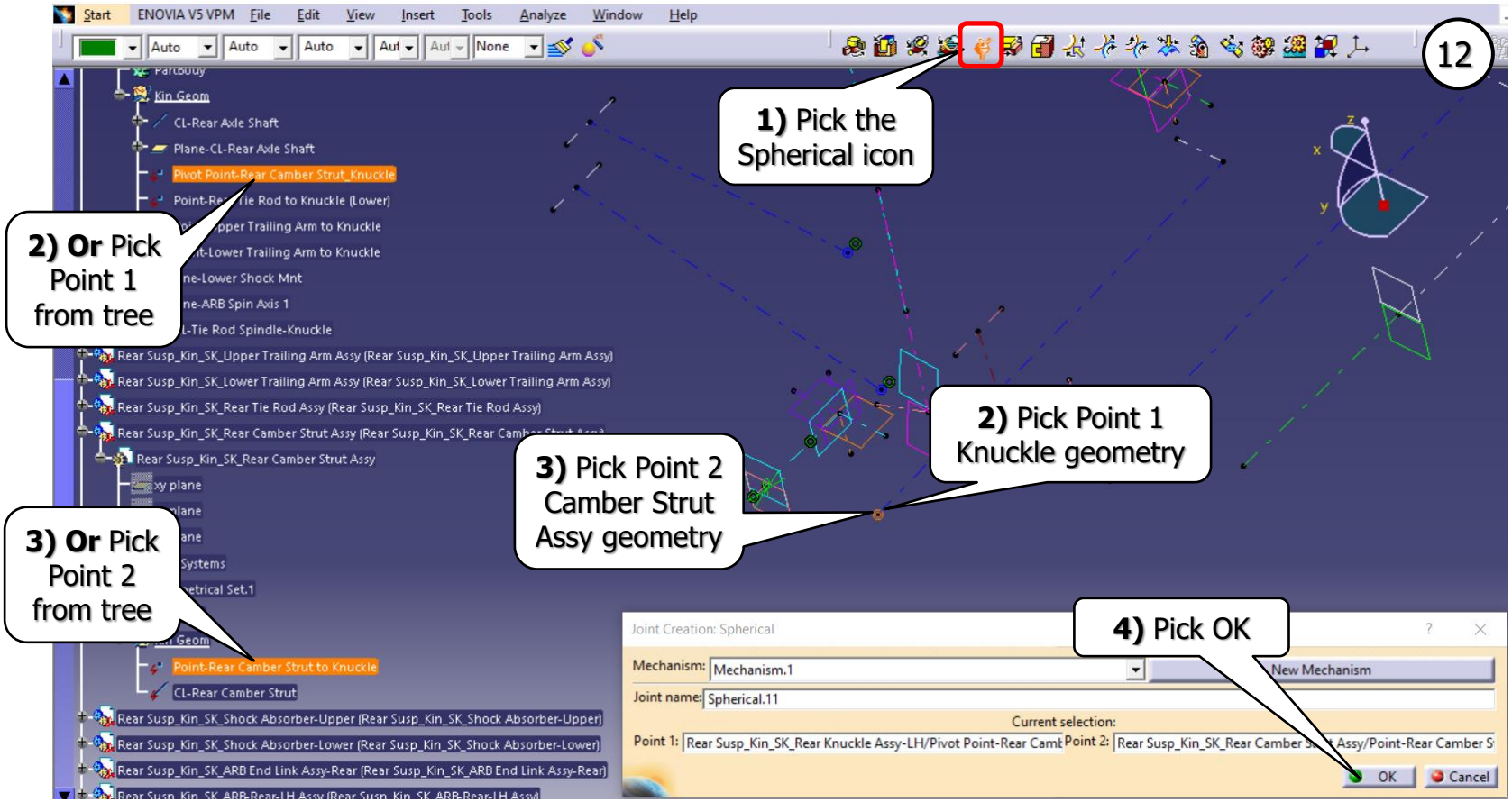
BND TechSource

- To avoid binding in the mechanism*, create a Universal Joint between the Lower Trailing Arm and the Fixed Part.



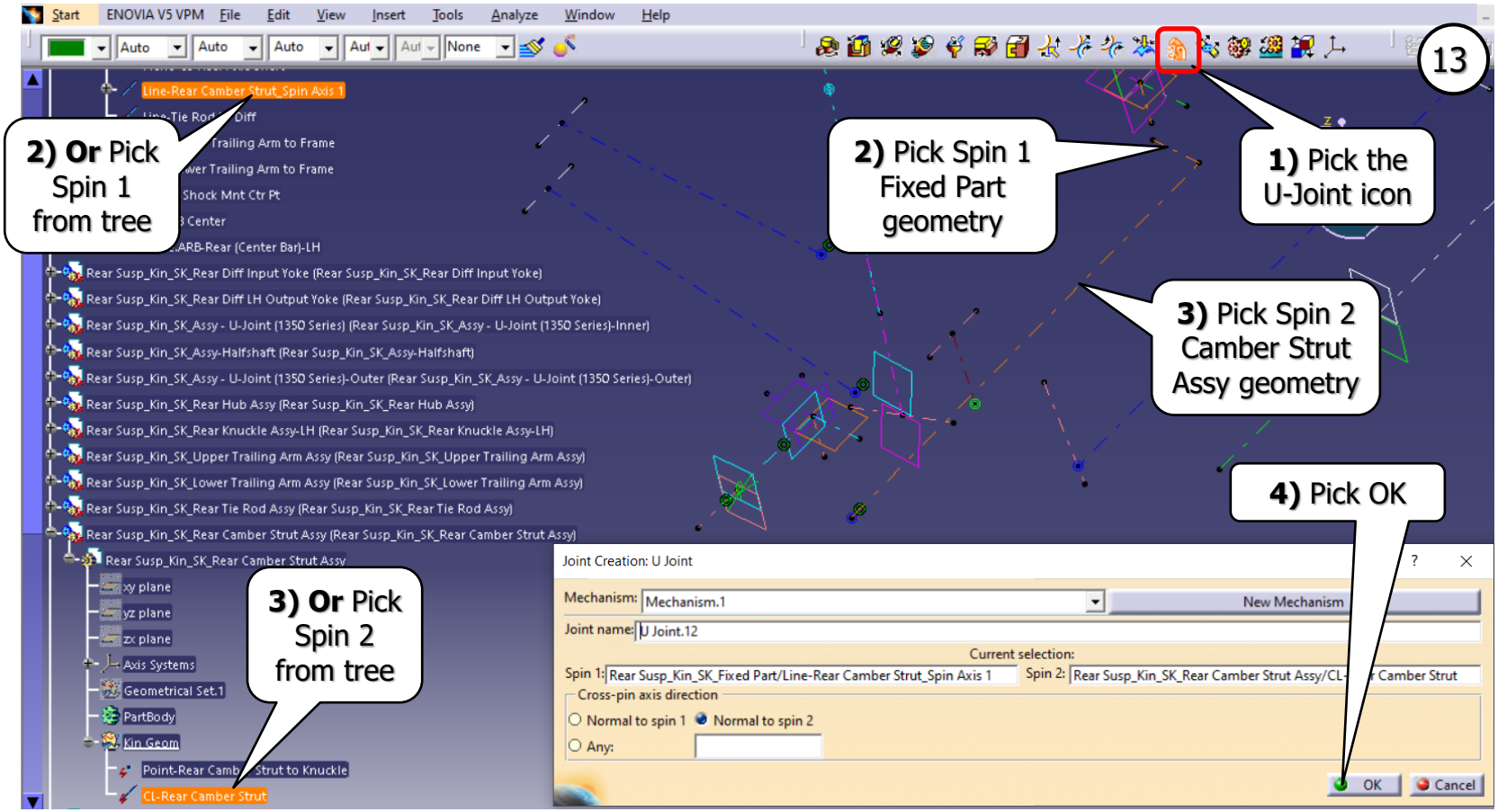
BND TechSource

- Create a Spherical Joint between the Knuckle and the Camber Strut Assy.



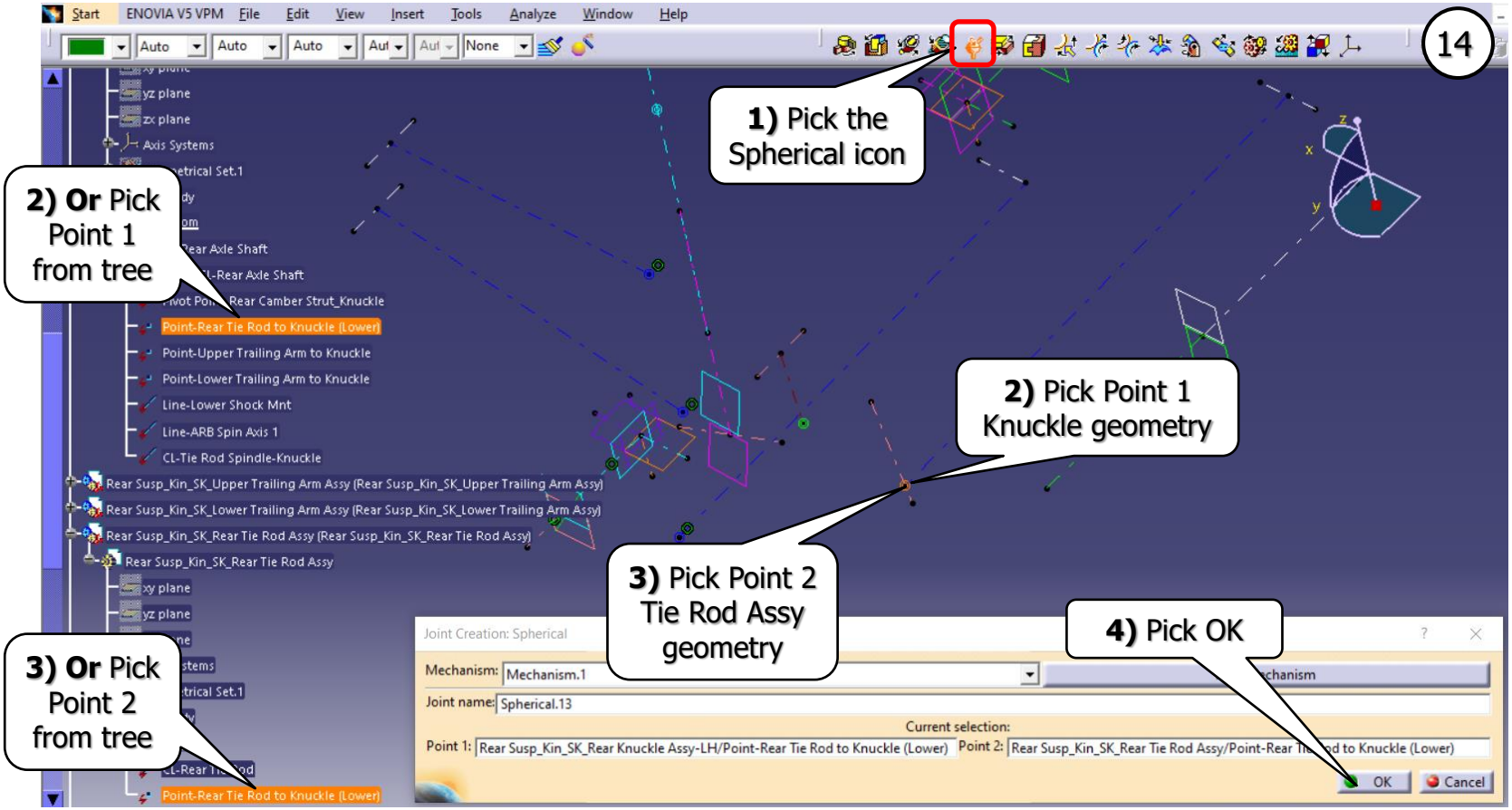
BND TechSource

- To avoid binding in the mechanism*, create a Universal Joint between the Camber Strut Assy and the Fixed Part.



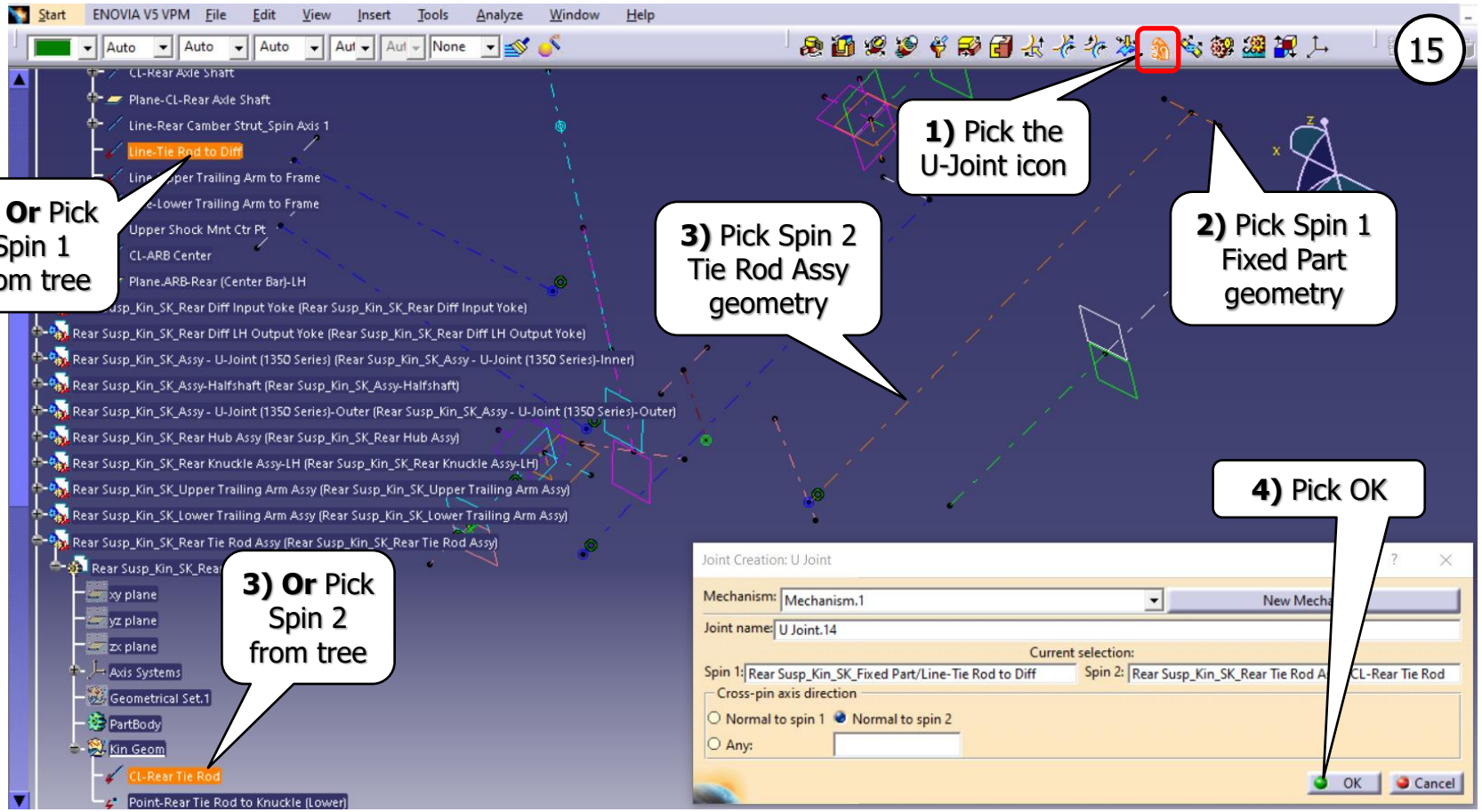
BND TechSource

- Create a Spherical Joint between the Knuckle and the Tie Rod Assy.



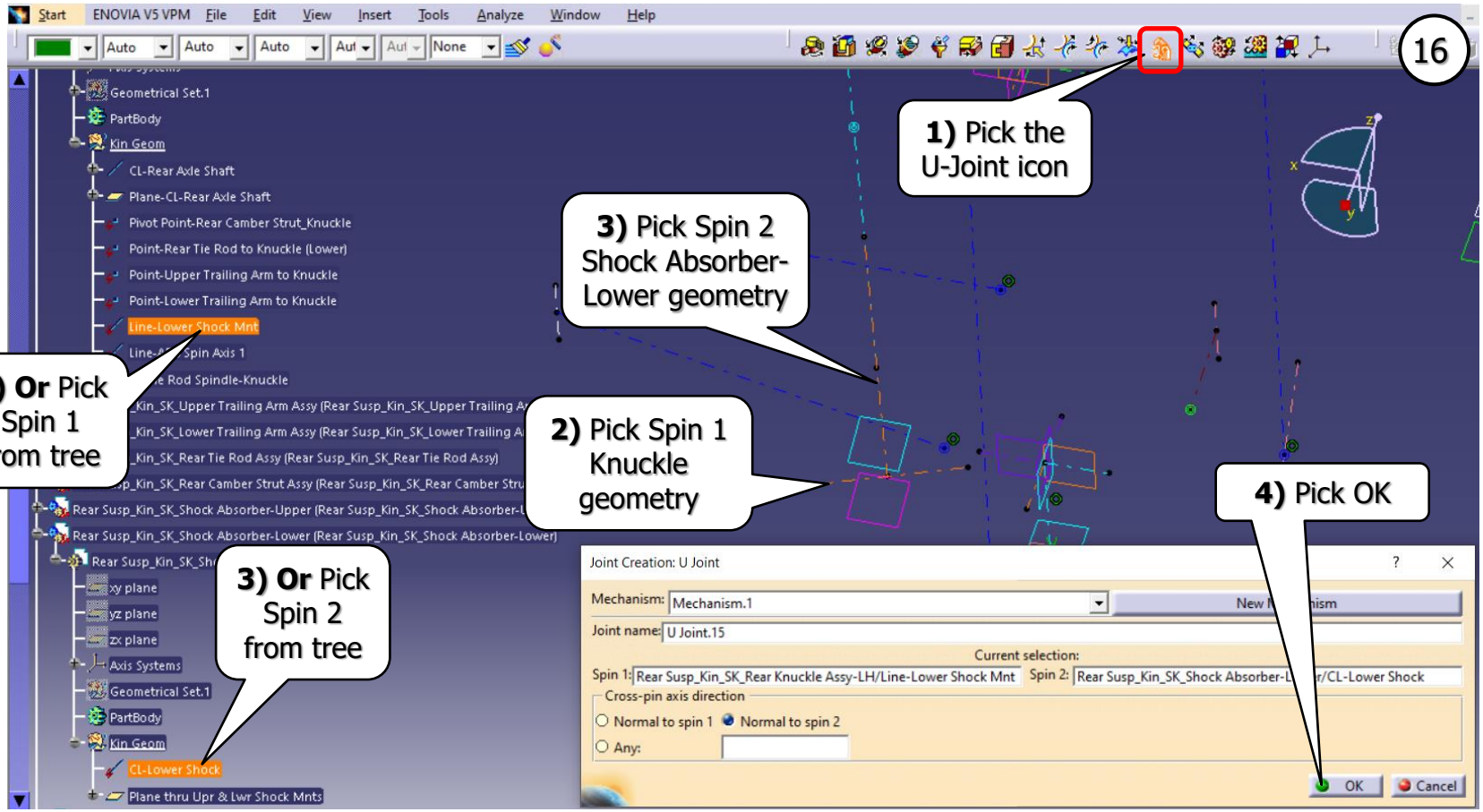
BND TechSource

- To avoid binding in the mechanism*, create a Universal Joint between the Tie Rod Assy and the Fixed Part.



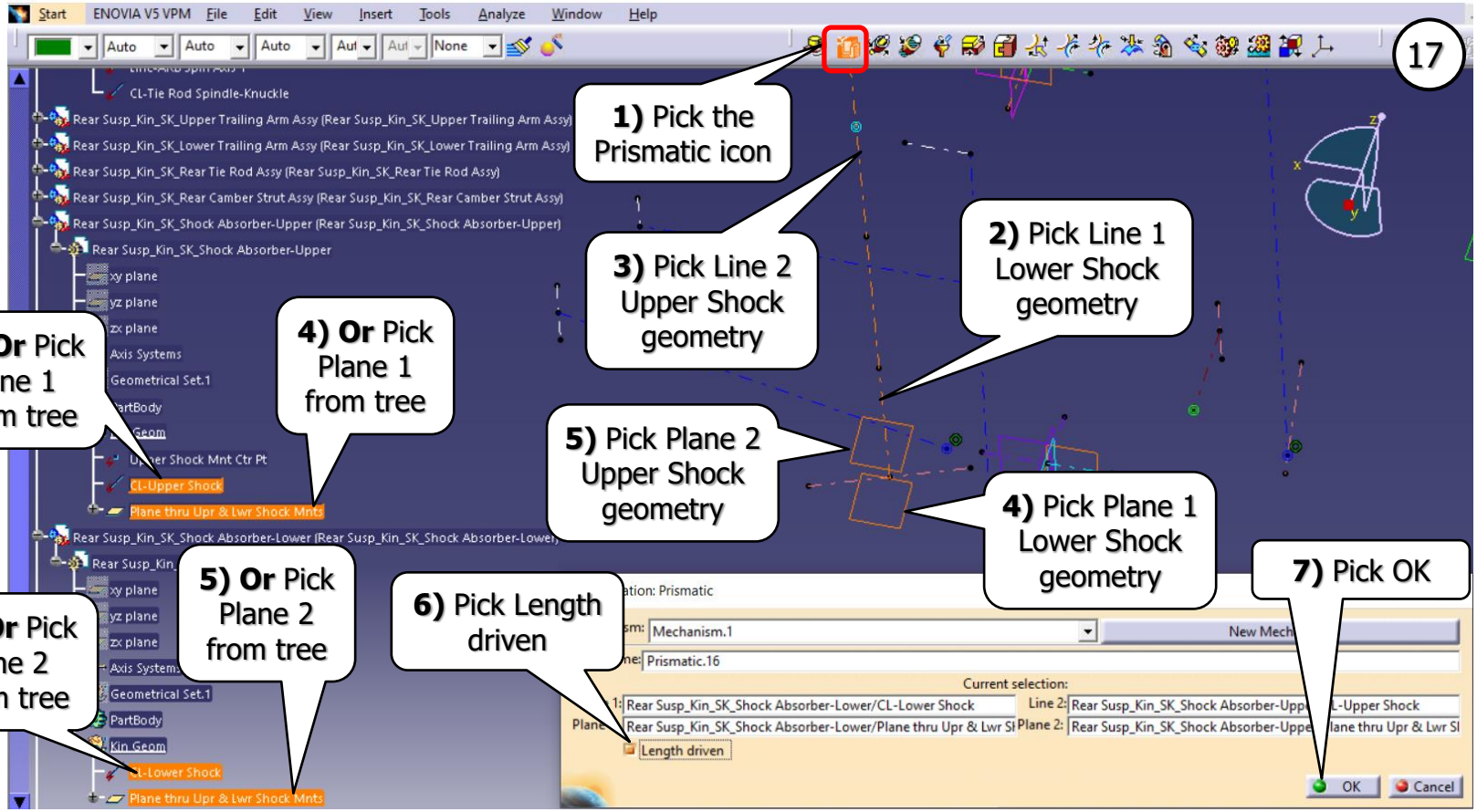
BND TechSource

- To avoid binding in the mechanism*, create a Universal Joint between the Knuckle and the Shock Absorber-Lower.



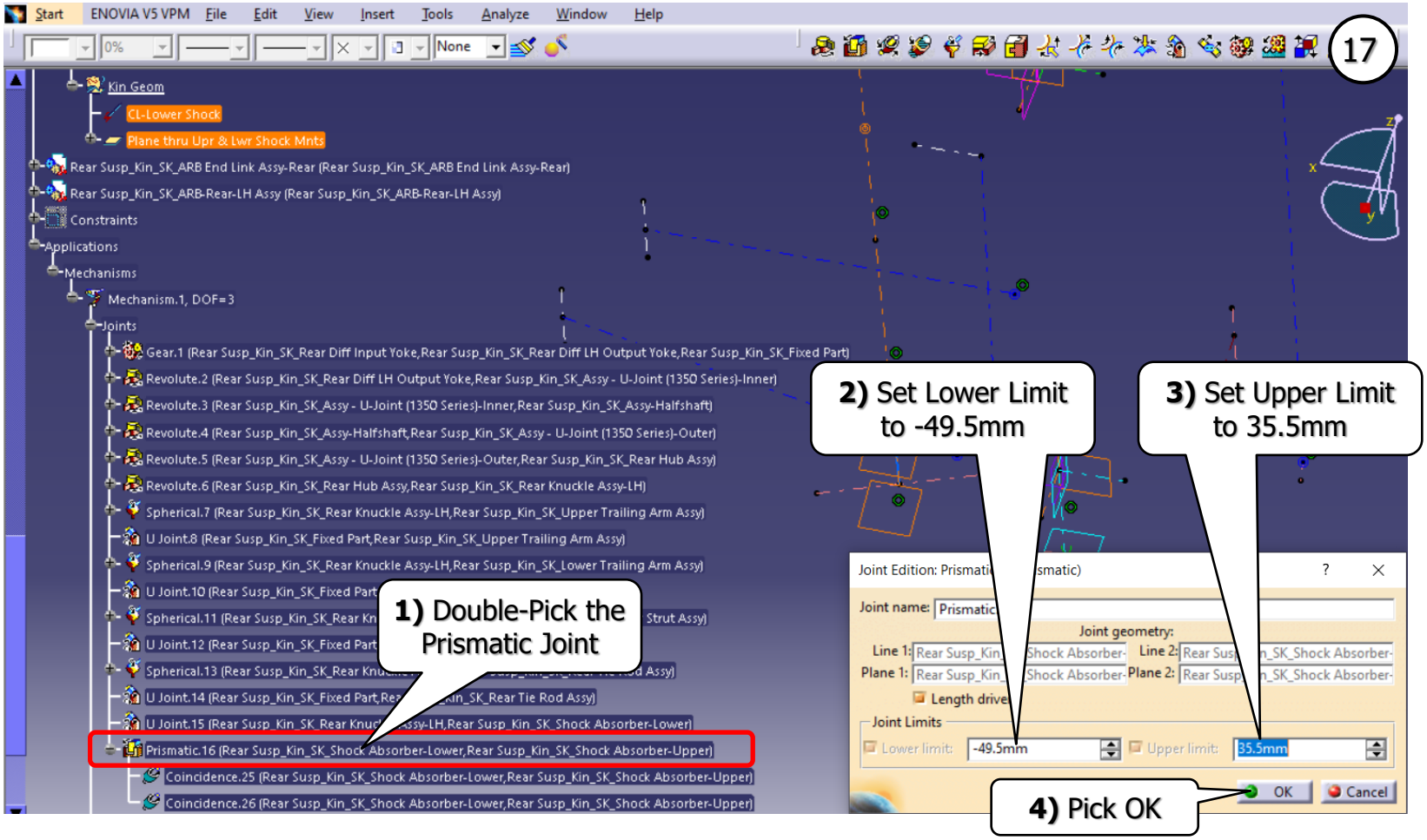
BND TechSource

- Create a Prismatic Joint between the Lower Shock CL and the Upper Shock CL and make it *Length driven*.



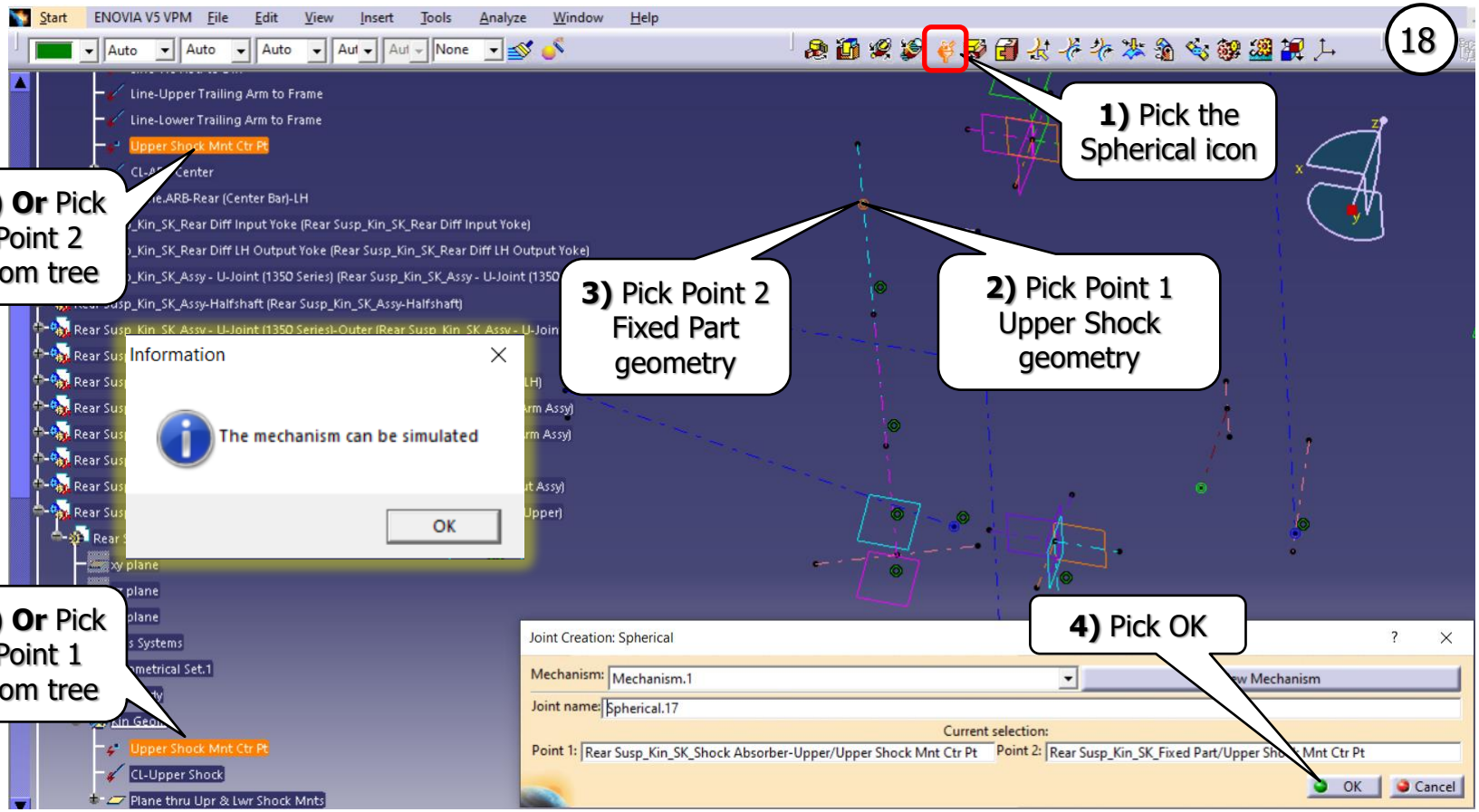
BND TechSource

- Set the Min/Max values for the Prismatic Joint.



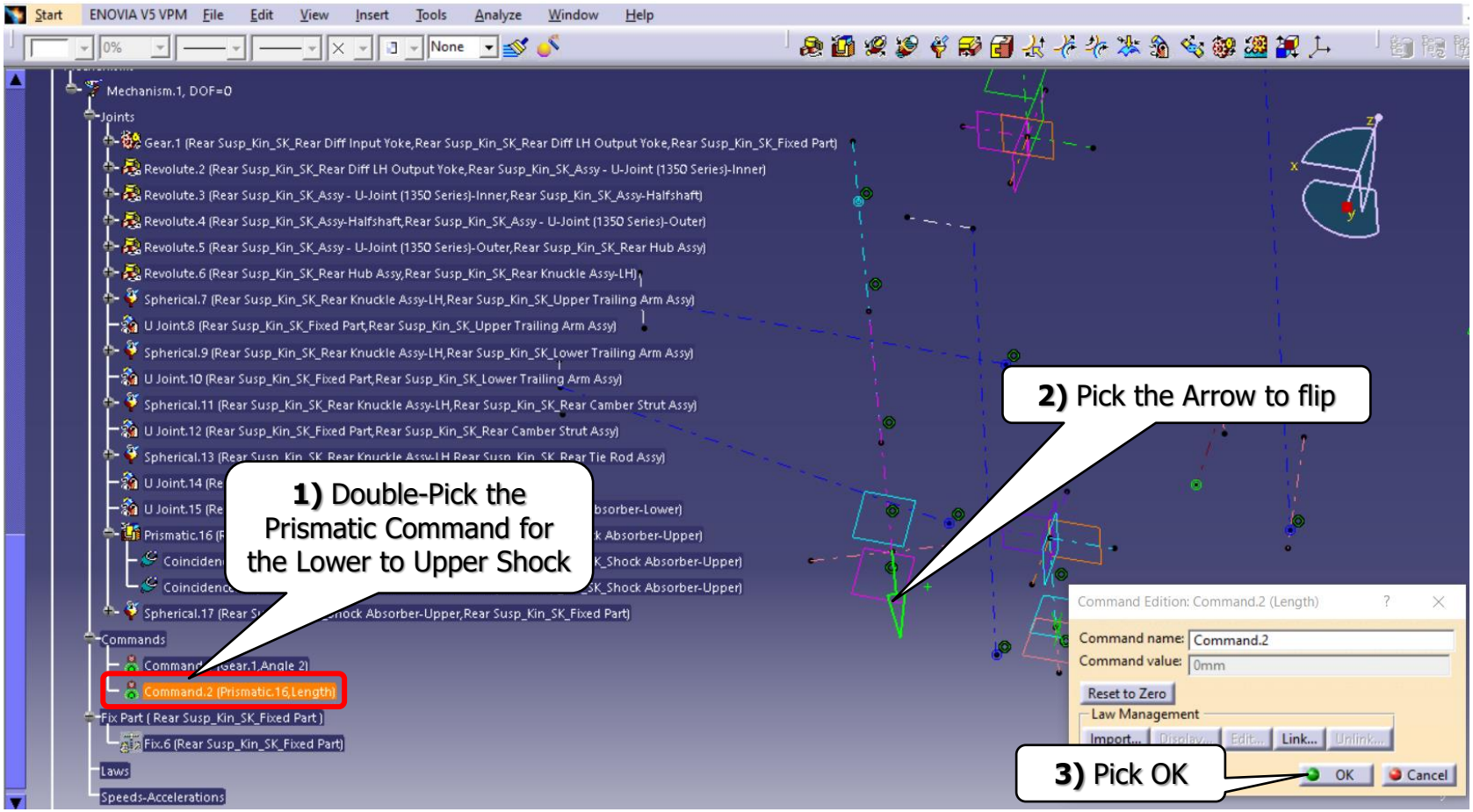
BND TechSource

- Create a Spherical Joint between the Shock Absorber-Upper and the Fixed Part.



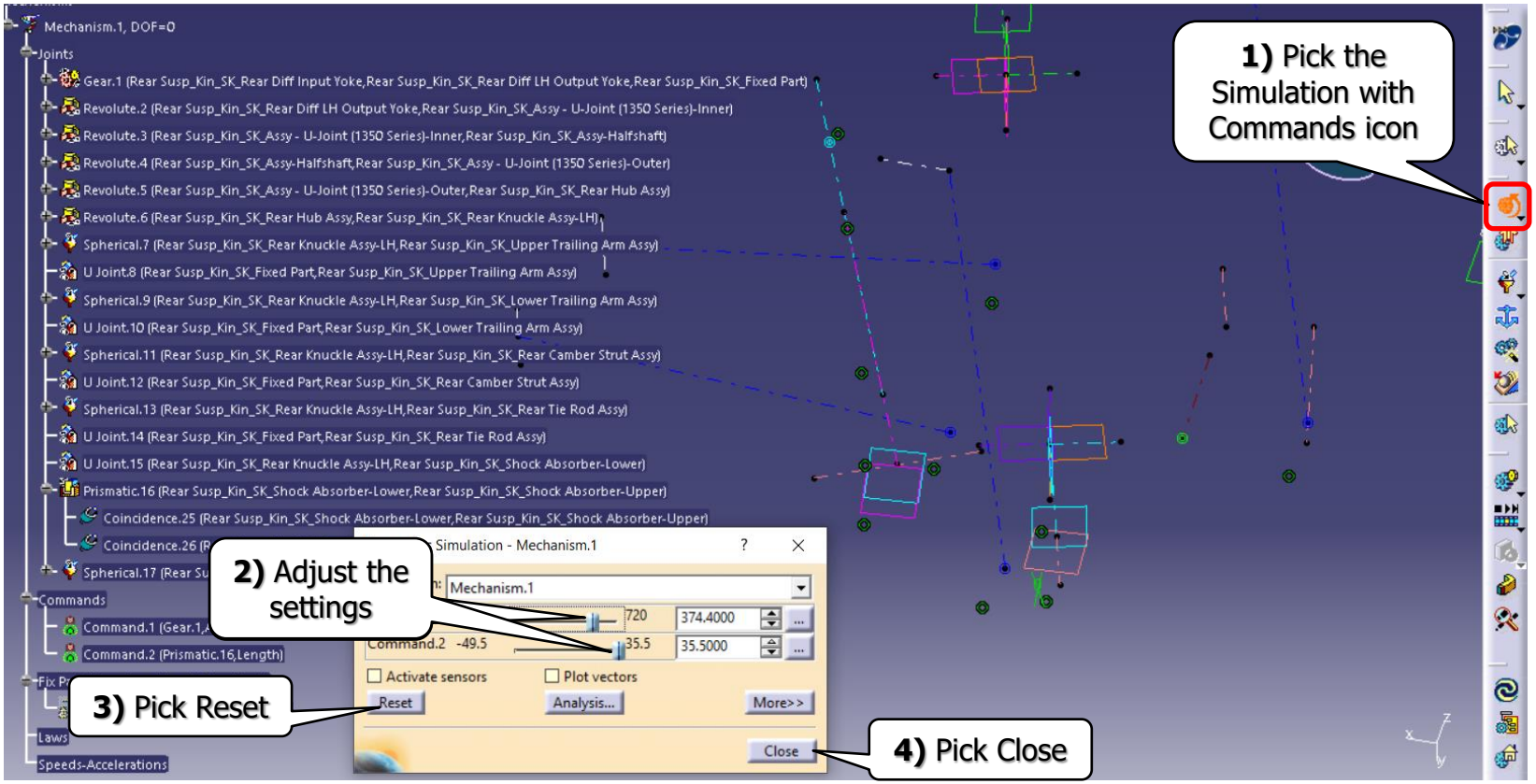
BND TechSource

- If 35.5mm is not upwards and -49.5mm not downwards:



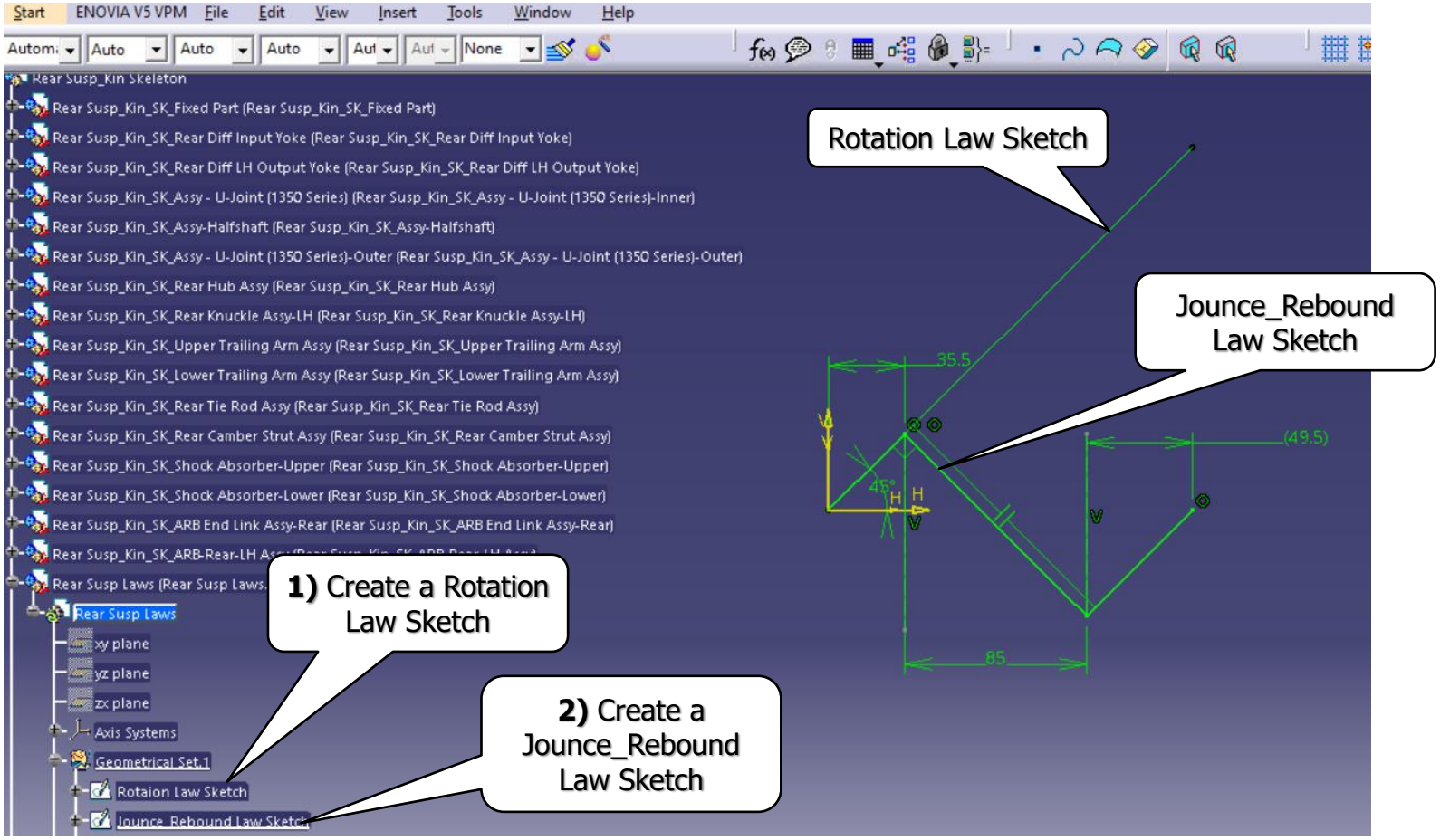
BND TechSource

- Run Simulation with Commands.



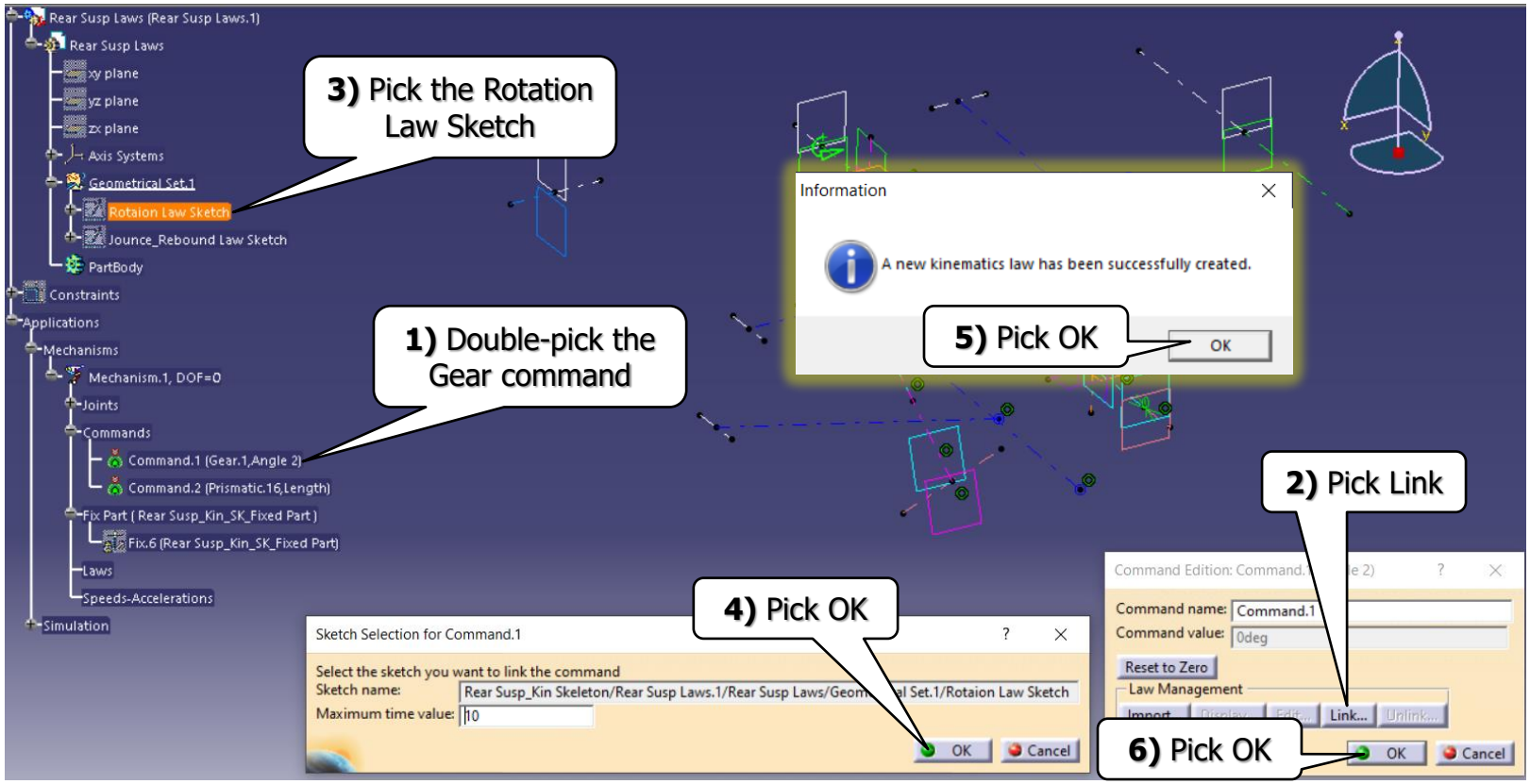
BND TechSource

- Create Laws for the mechanism commands.



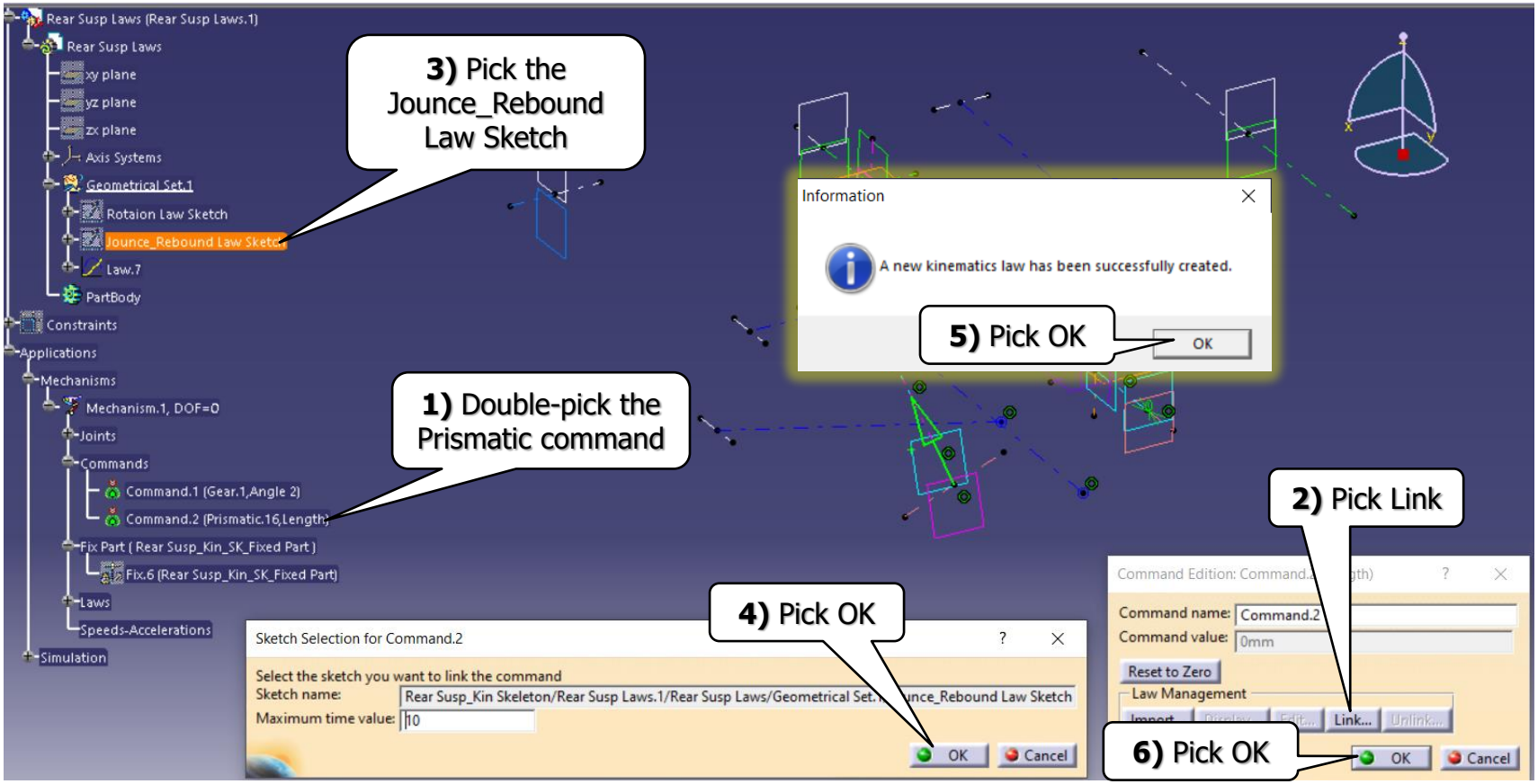
BND TechSource

- Attach the Laws to the mechanism Simulation.



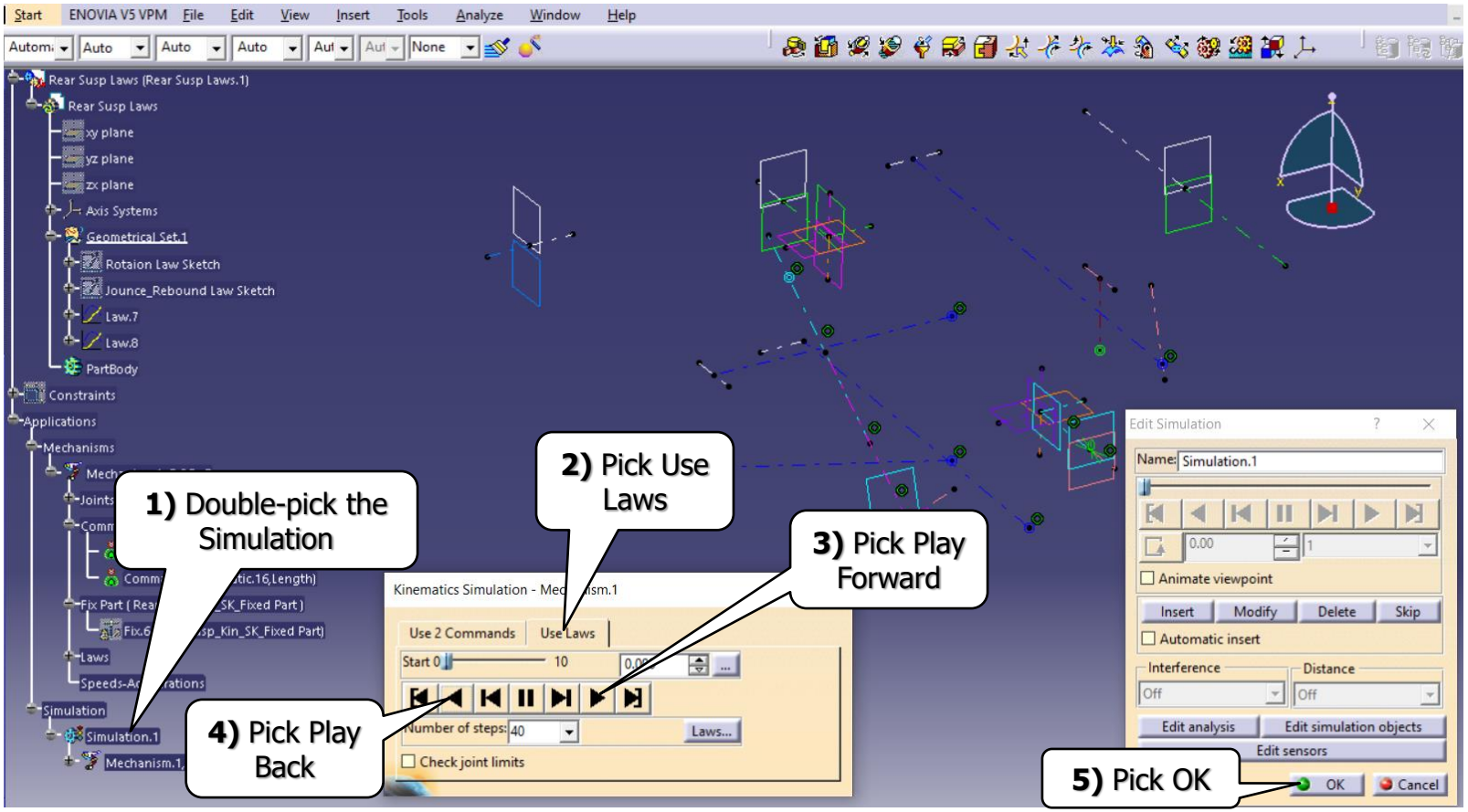
BND TechSource

- Attach the Laws to the mechanism Simulation.



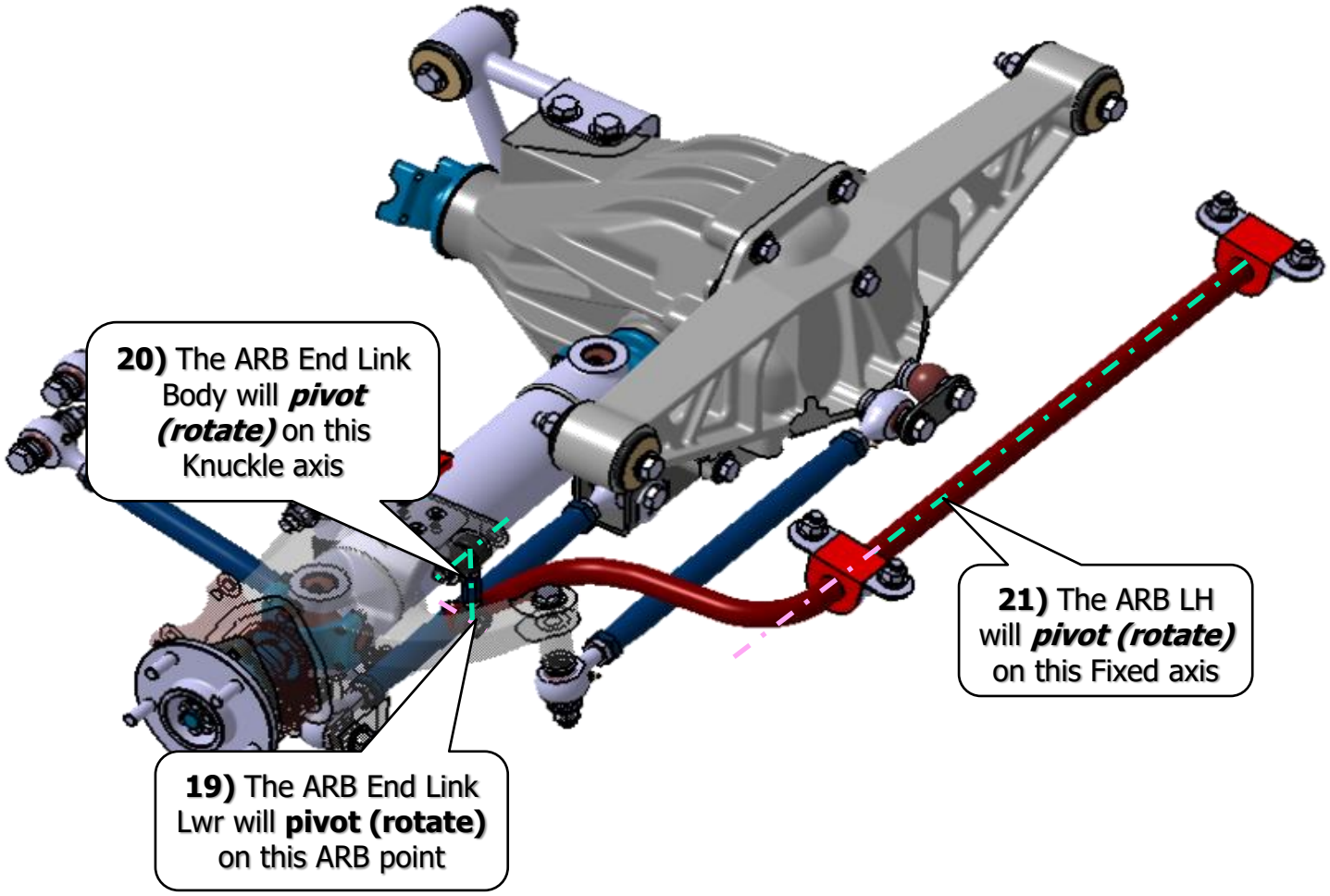
BND TechSource

- Run the Simulation with Laws.



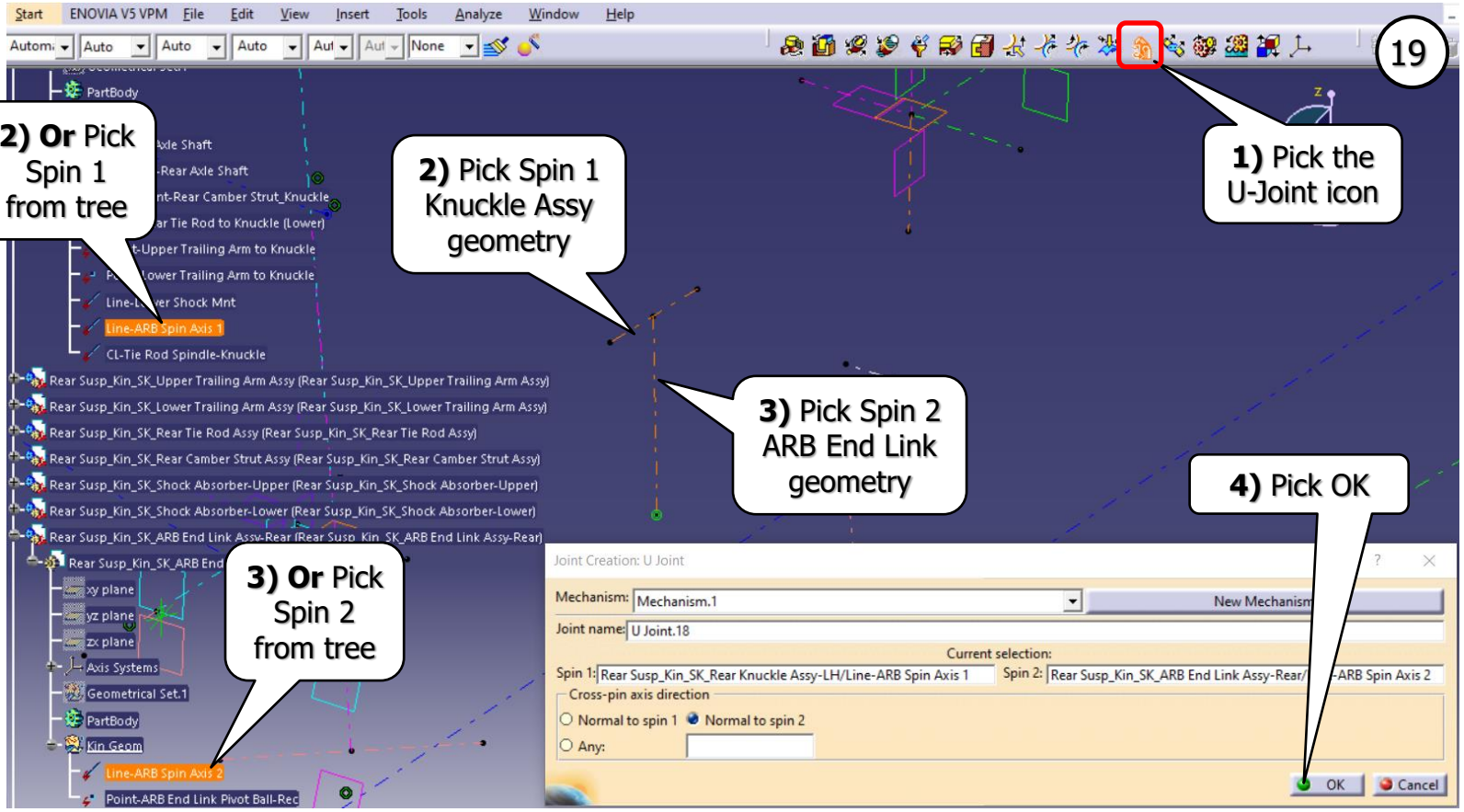
BND TechSource

- To finish the simulation, add the ARB into the mechanism.



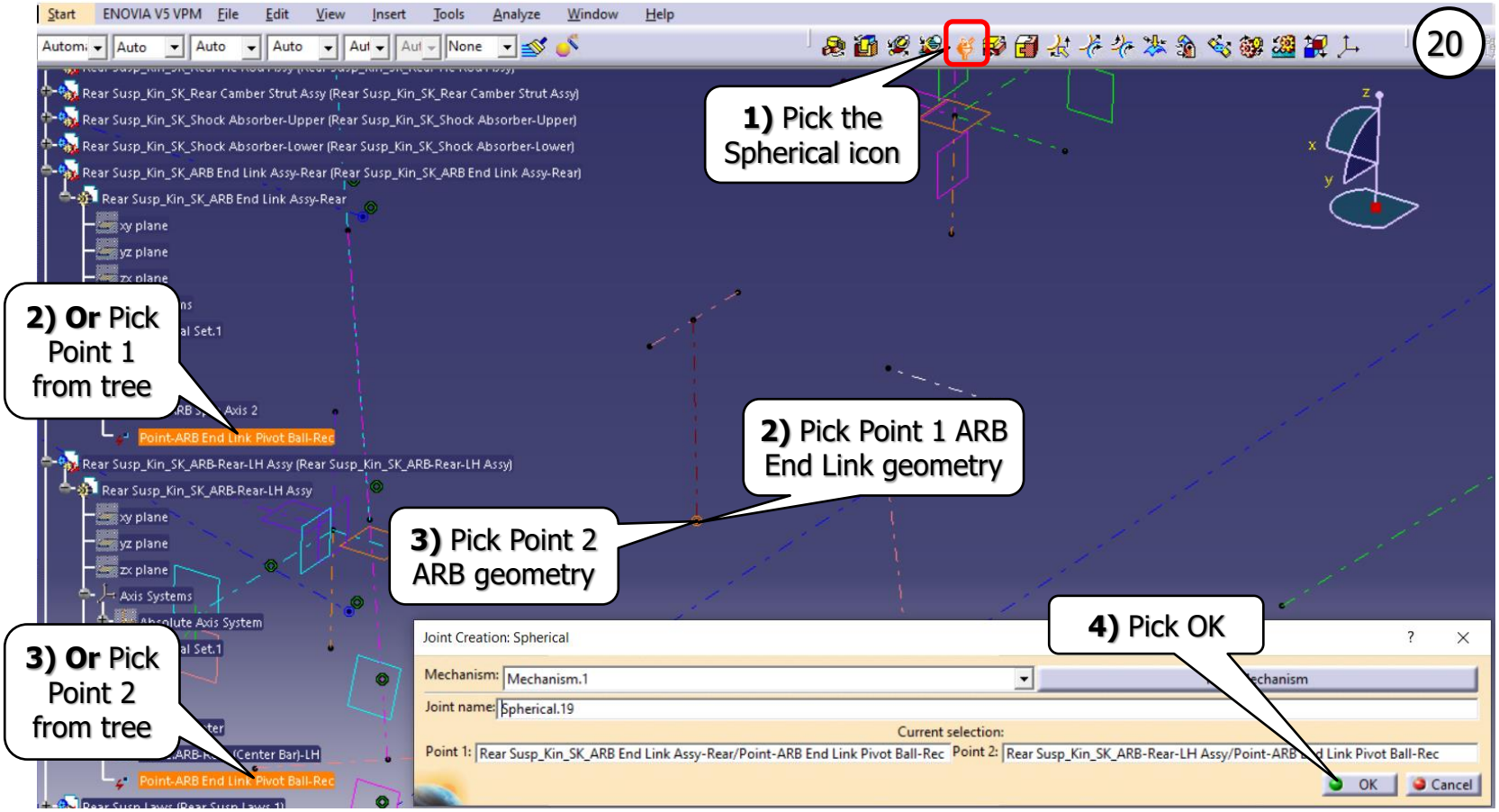
BND TechSource

- To avoid binding in the mechanism*, create a Universal Joint between the Knuckle Assy and the ARB End Link.



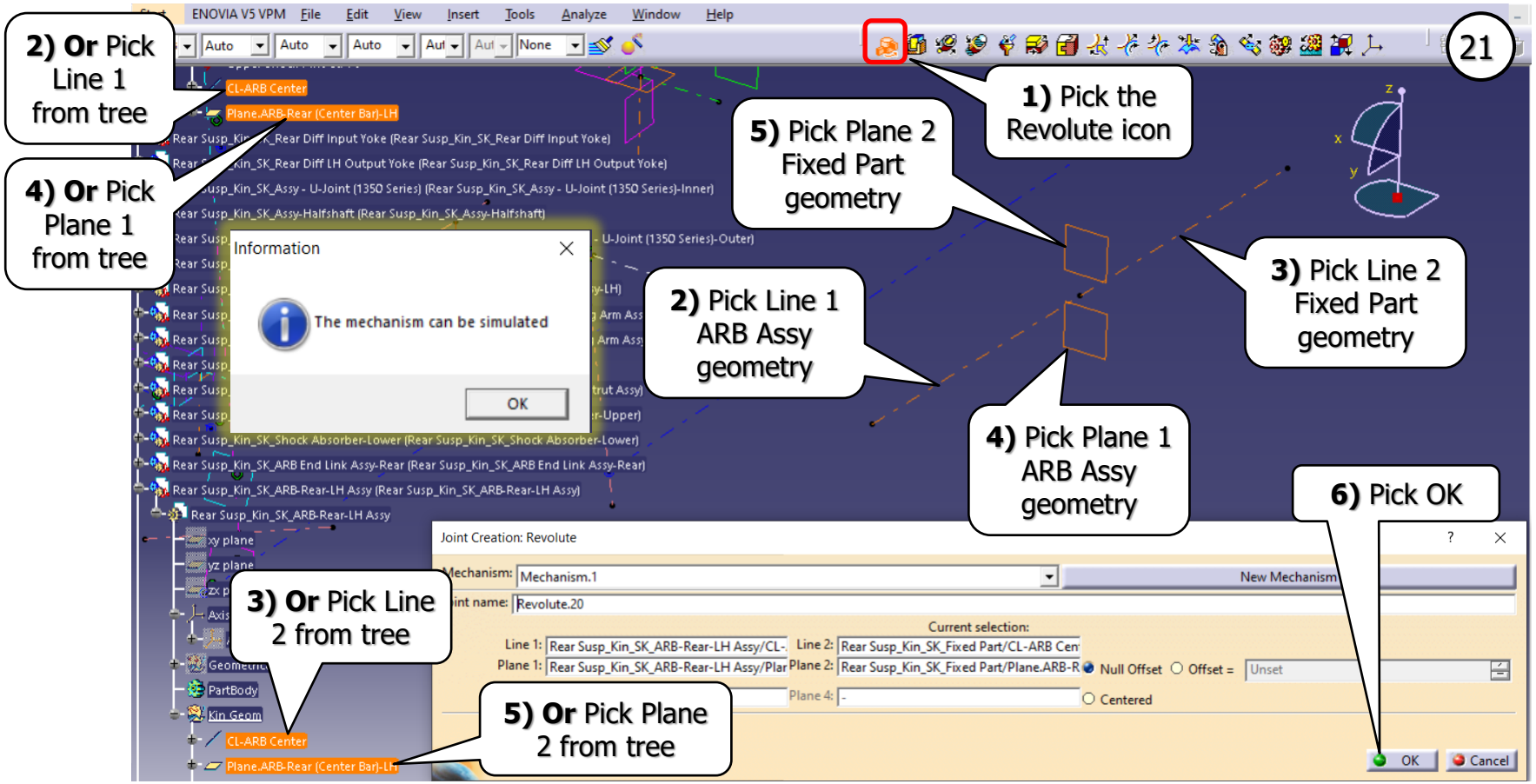
BND TechSource

- Create a Spherical Joint between the ARB End Link and the ARB Assy.



BND TechSource

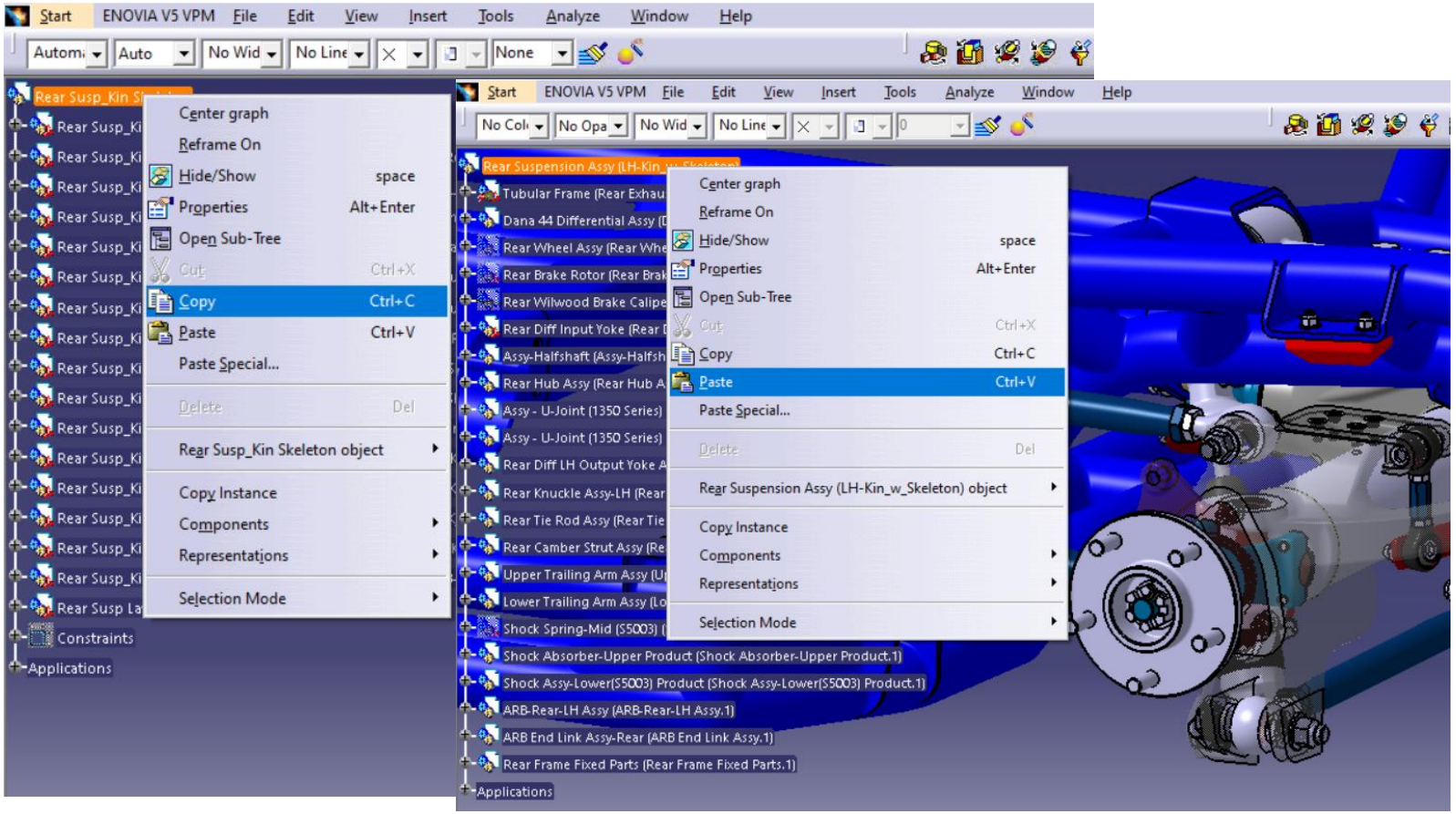
- Create a Revolute Joint between the ARB Assy and the Fixed Part.



Step 4: Link the Kinematic Skeleton to the Main parts assembly via Mechanism Dressup

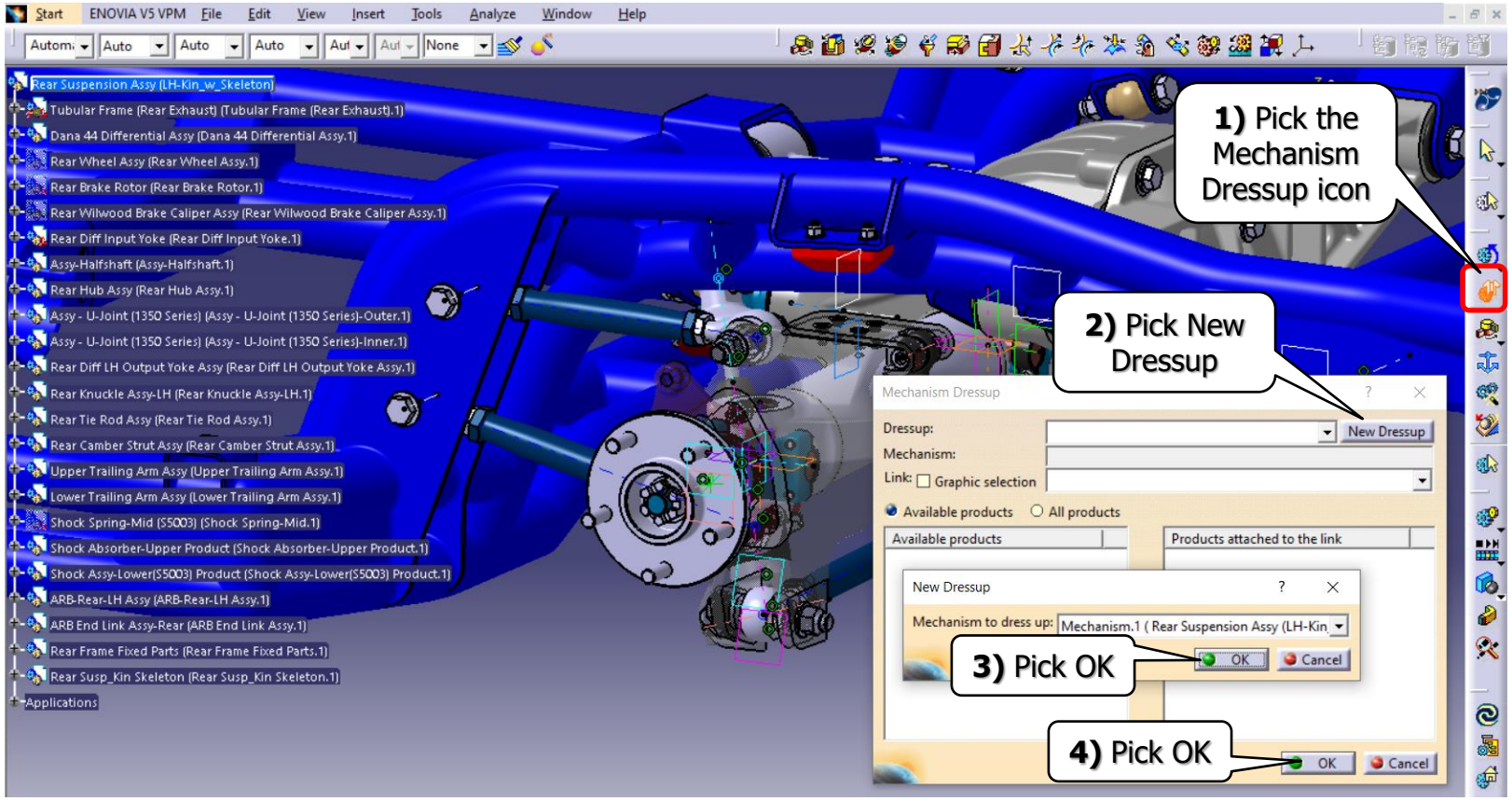
BND TechSource

- Copy the Skeleton product and paste it into the Suspension parts assembly.



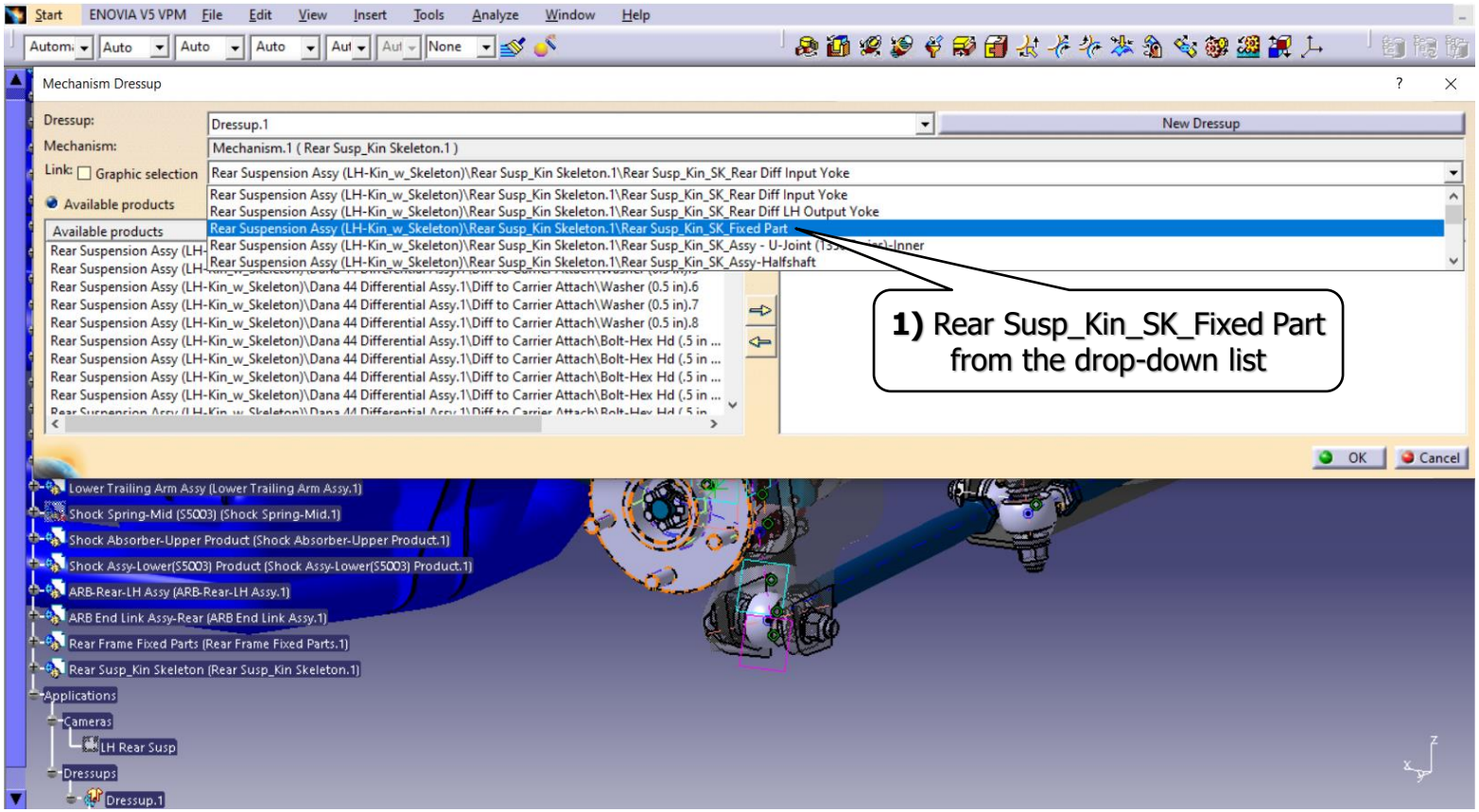
BND TechSource

- Link the parts to the Kinematic Skeleton using Mechanism Dressup.



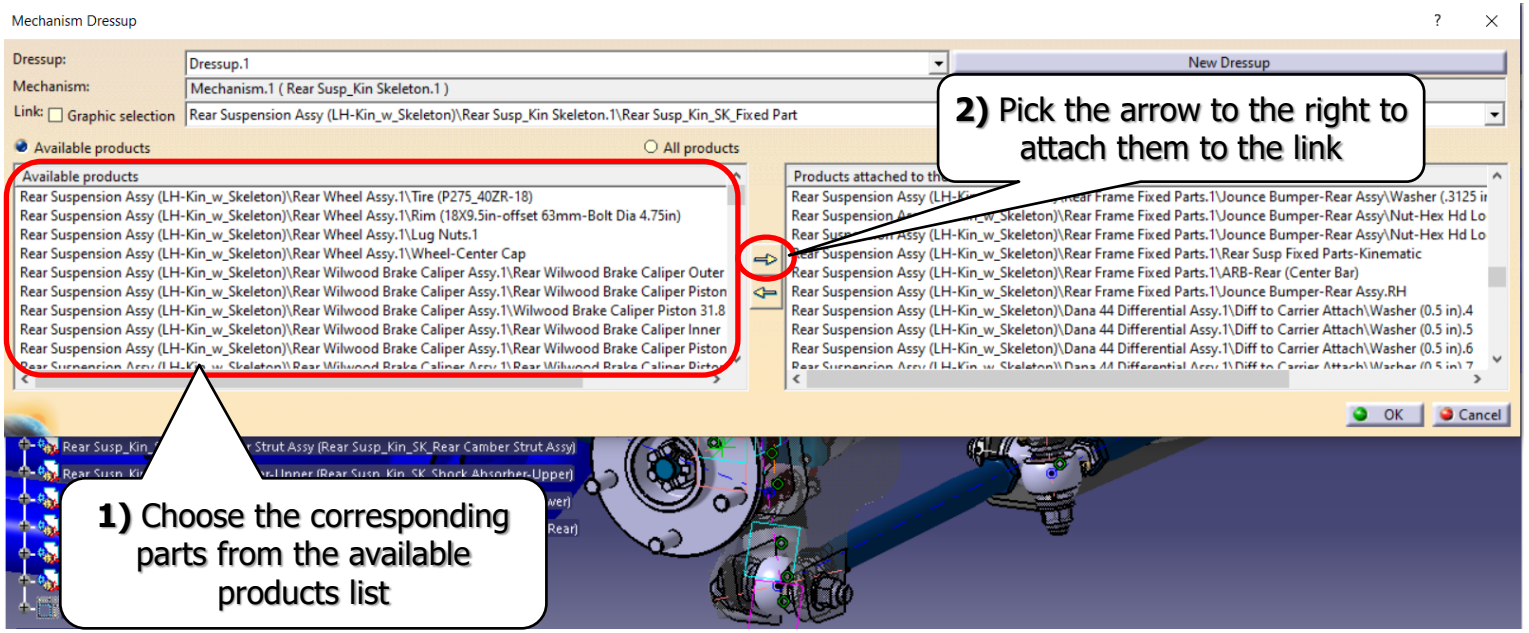
BND TechSource

- Step A: Choose Rear Susp_Kin_SK_Fixed Part from the drop-down list.



BND TechSource

- Step B: Choose the parts from the available products list and pick the arrow to the right to attach them to the link.

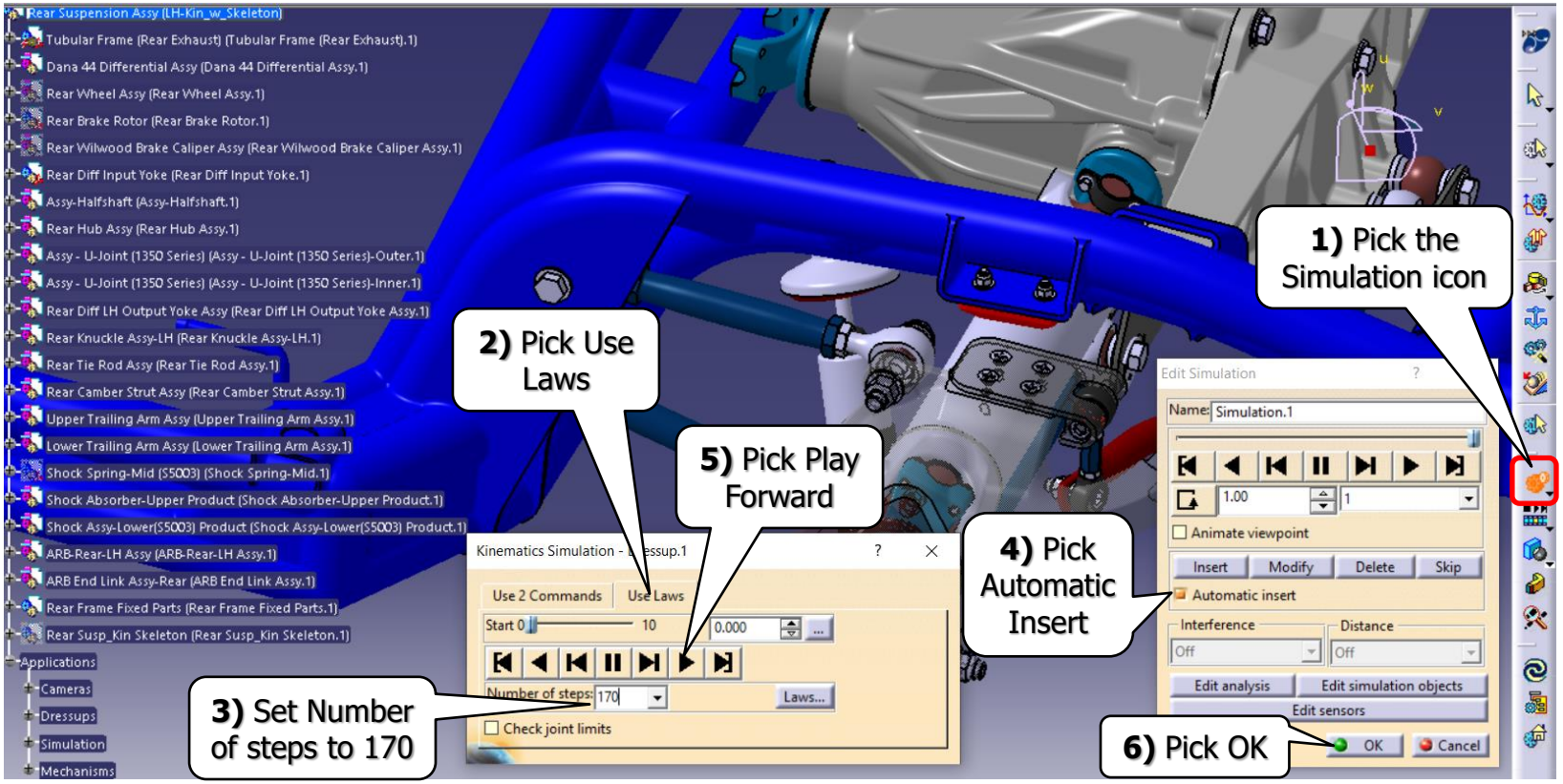


- Repeat Steps A & B until all the links on the drop-down list have been attached to the available products.

Step 5: Create and Save a Kinematic Simulation

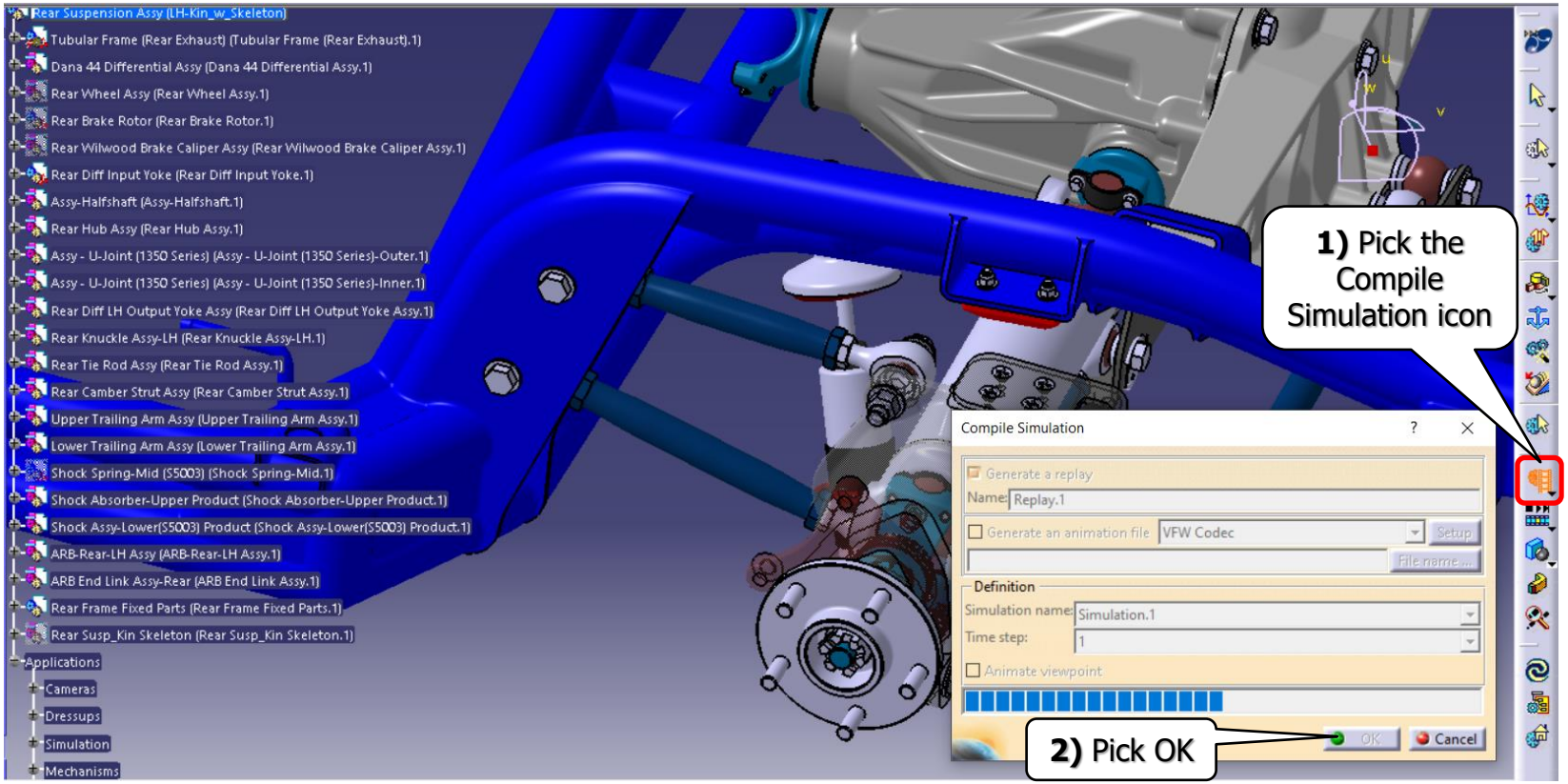
BND TechSource

- At this point we can create a Simulation using Laws to record all parts are now moving according to the kinematic mechanism.



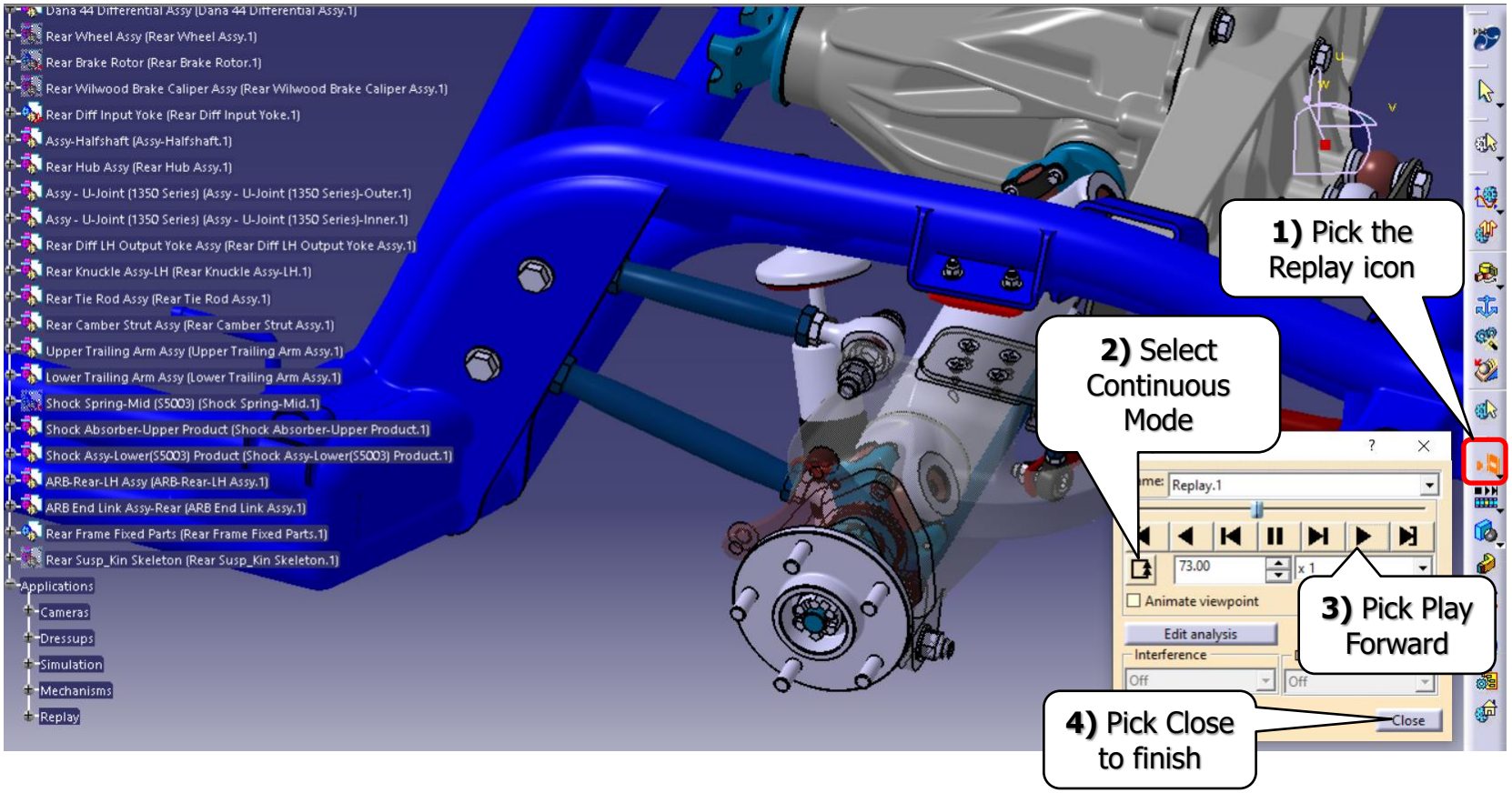
BND TechSource

- Compile a Replay of the Simulation.



BND TechSource

- Replay the Simulation.

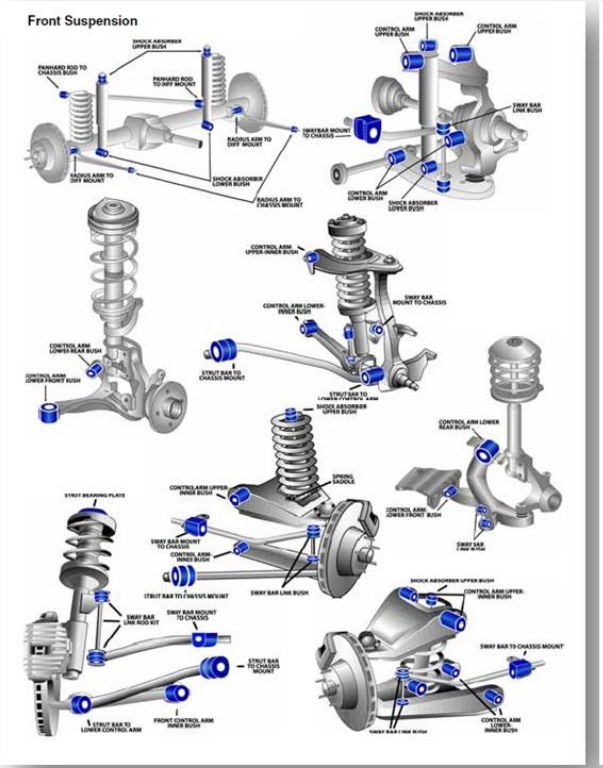


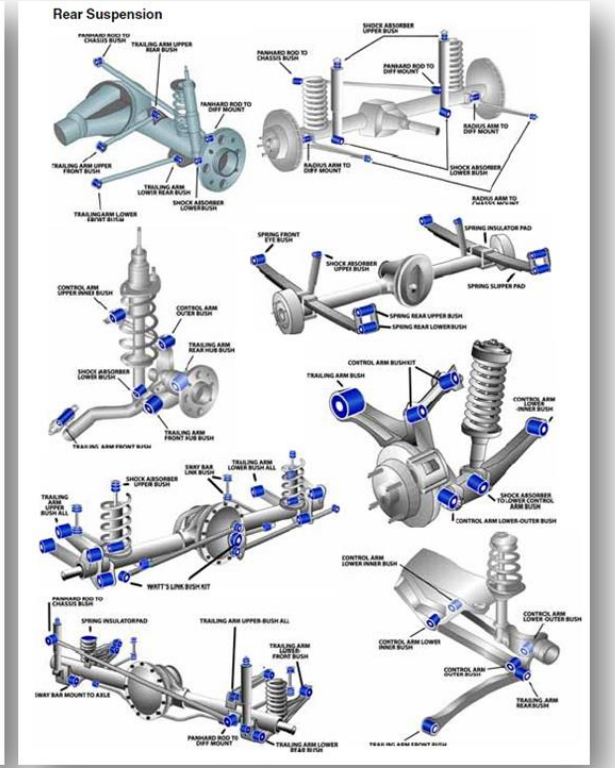
BND TechSource

* *Binding the mechanism:*

- Bushing Deflection (suspension compliance)

There are many rubber bushings within a vehicle suspension to consider when analyzing suspension compliance.
CATIA DMU Kinematics does not include bushing deflection (compliance). To emulate the compliance with CATIA, we use a U-Joint at one end and a Spherical joint at the other (instead of two revolute joints). This allows for a small bit of extra movement within the mechanism to avoid binding.





BND TechSource

- Conclusion:

  This is an example of how to create a CATIA DMU Kinematic simulation for a Rear Independent 5-link suspension.

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

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

  Please ***subscribe*** to our YouTube channel!