Excluded Constraints in Fixed Joints

Gilles Dubourg, Feb. 26, 2024
Siemens - Digital Industries Software

Contents

1. Fixed Joints and Excluded Constraints

A fixed joint connects a motion body to a fixed position (such as ground), or to another motion body. Two Motion bodies that are connected as fixed move together as one body. A fixed joint allows zero degrees of freedom.

- Fixed joints also have an option of excluding constraints, thus adding some Degree(s) of Freedom.
- Up to 5 constraints can be excluded and at least one constraint should remain fixed.

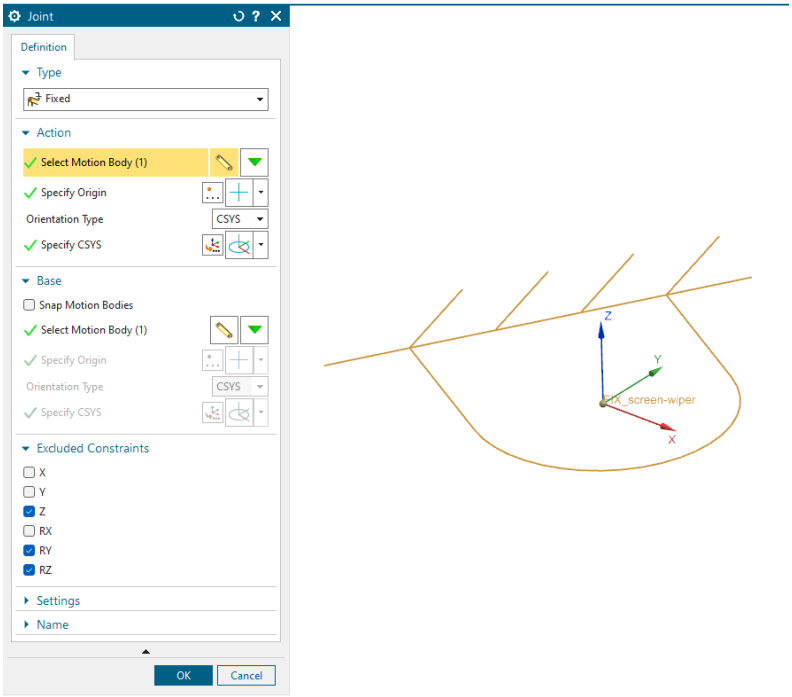


Figure 1.1: Fixed Joint dialog with some Excluded Constraints. Graphics icon. Directions are relative to the Joint CSYS displaying.

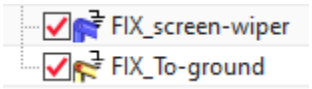


Figure 2.2: 2 Fixed joints in Motion Navigator. Blue icon is one with excluded constraints.

Refer to Simcenter 3D Motion Documentation, in chapter Joints – Simple joints.

2. Constraints meanings details

See below table. For the rotations, there is need to consider Motion Bodies Action and Base.

	Constraint Meanings			
Fixed Joint Constraint	**Undriven fixed joint, or one with zero, two or three rotational constraints excluded**	**RX checked and driven, RY and RZ unchecked**	**RY checked and driven, RX and RZ unchecked**	**RZ checked and driven, RX and RY unchecked**
X	The origin of the action is constrained to be in the y-z plane of the base.	Same as left	Same as left	Same as left
Y	The origin of the action is constrained to be in the x-z plane of the base.	Same as left	Same as left	Same as left
Z	The origin of the action is constrained to be in the x-y plane of the base.	Same as left	Same as left	Same as left
RX	The y-axis of the base is constrained to be perpendicular to the z axis of the action.	Driven, not constrained by fixed joint.	y-axis of base orthogonal to z-axis of action	z-axis of base orthogonal to y-axis of action
RY	The z-axis of the base is constrained to be perpendicular to the x axis of the action.	x-axis of base orthogonal to z-axis of action	Driven, not constrained by fixed joint.	z-axis of base orthogonal to x-axis of action
RZ	The x-axis of the base is constrained to be perpendicular to the y axis of the action.	x-axis of base orthogonal to y-axis of action	y-axis of base orthogonal to x-axis of action	Driven, not constrained by fixed joint.

Let's look at a use case.

3. Use case with Excluded Rotation constraints – wiper on screen.

3.1. Model and expected behavior.

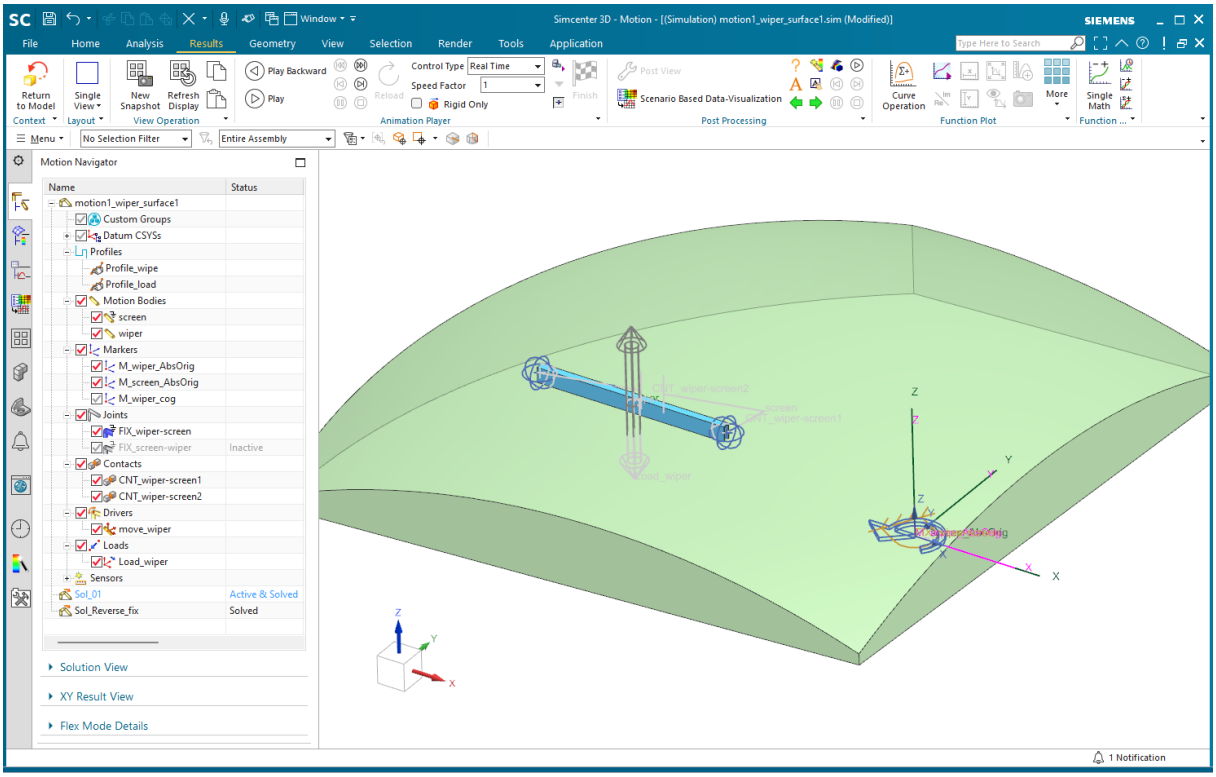
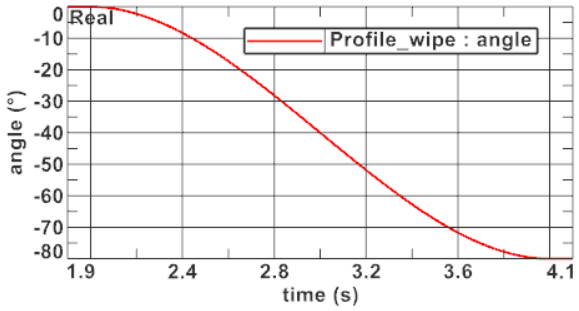


Figure 3.1: Motion model for a blade wiping a screen. Gravity is applied -Z.

A wiper blade (represented by a rigid U section beam) is wiping a screen surface (transparent green body fixed without Joint). A wiper mechanism system, with linkage, motor and holding the wiper blade is not modeled, only a vertical axis around which the blade should be rotating. Hence, a body driver is acting on the wiper body with rotation axis as displayed below (blue rotation arrow). The rotation profile is also idealized with a cubic angle variation.



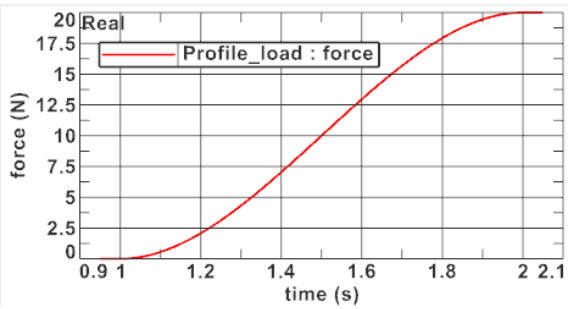


Figure 3.2 and 3.3: Rotation angle for the wiper driver. Load applied on the wiper such as to maintain it on the screen

The wiper blade contact to the screen is modeled with only 2 contacts Sphere to CAD, each at one end. A load is applied at the center of the wiper blade representing the action of a wiper and arm system maintaining the blade on the screen.

Motion of the wiper blade: It drops on the screen due to its mass and gravity; the load is applied (1-2 sec), then it's driven (2-4 sec). Pictures below. Magenta Marker belongs to the wiper, green marker to the screen.

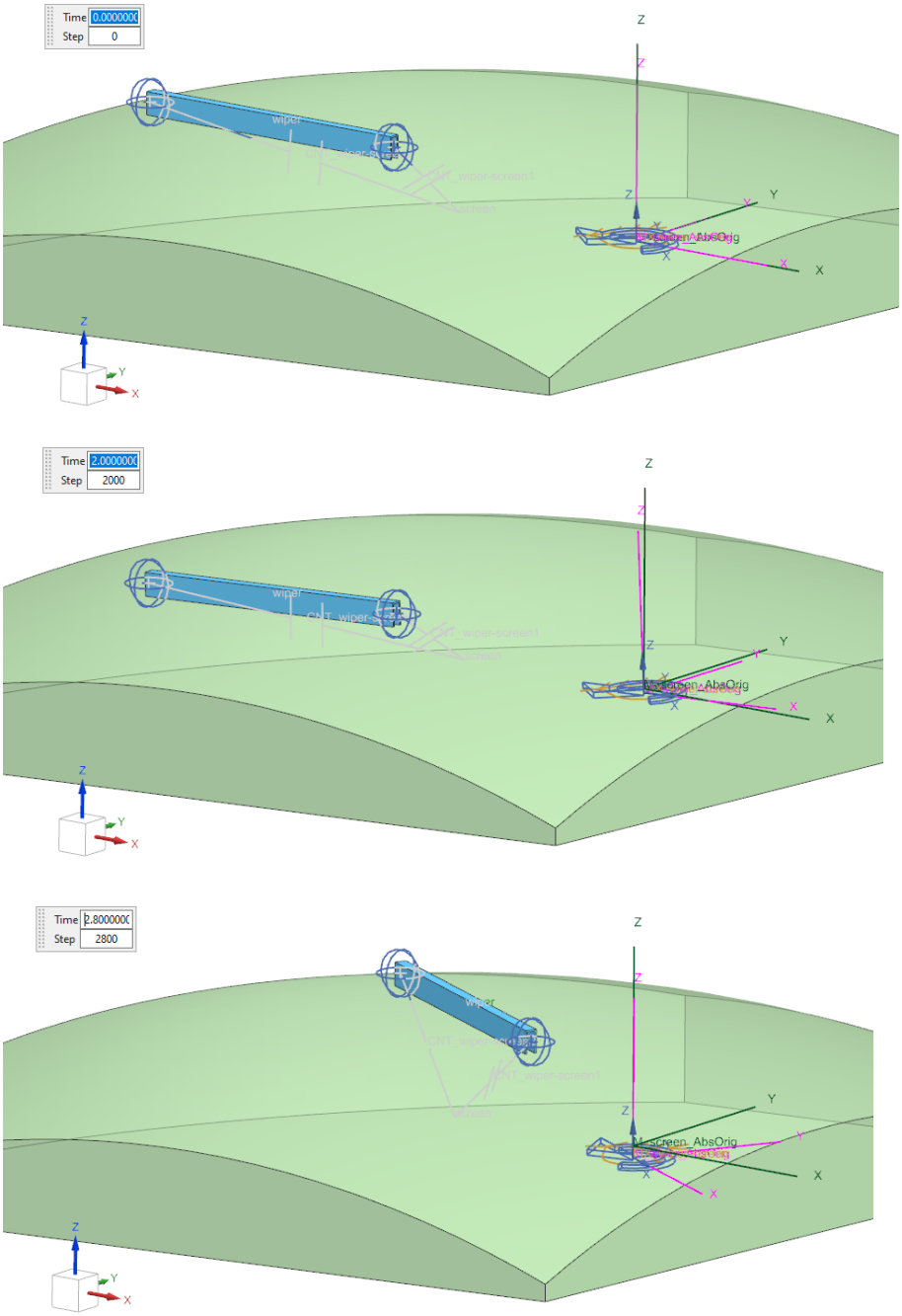


Figure 3.4: Wiper blade behavior; drop on screen and rotation driven wiping.

During the wiping movement, the desired behavior is for the wiper blade to follow the screen surface while having no rotation around its main axis. No rotation along the axis perpendicular to the U section. Hence a fixed joint with excluded constraints is defined for the wiper blade body, in particular RX remains constrained.

3.2. Fixed joint with Action Body wiper blade (Solution Sol_01)

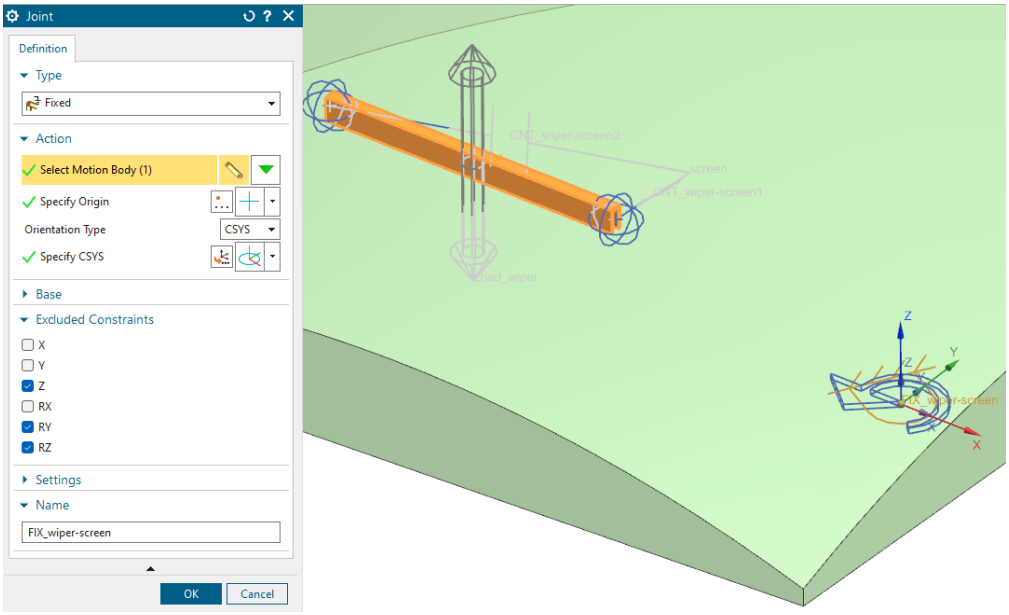


Figure 3.5: Fixed joint with unconstrained directions ***– Action is wiper****, base is screen.*

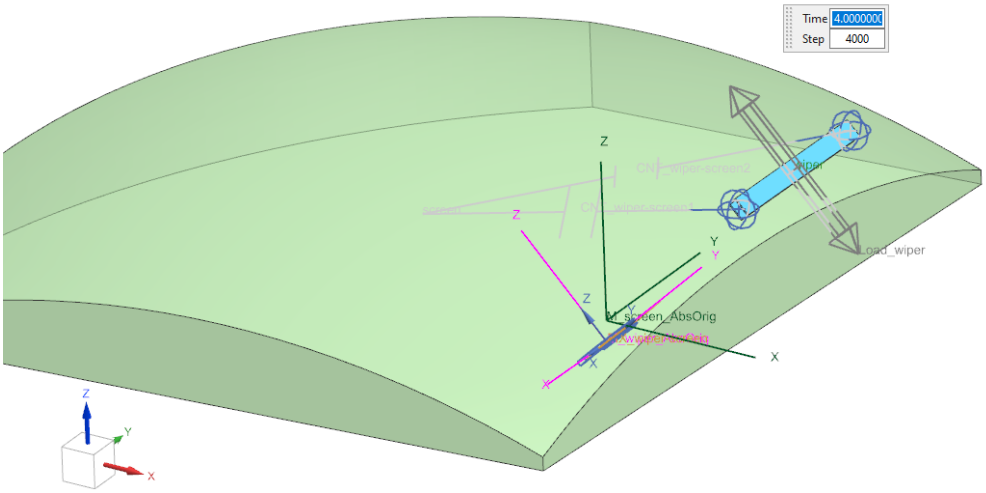


Figure 3.6: ***Action wiper****; there is rotation of the wiper along its main axis. Undesired.*

3.3. Fixed joint with Action Body Screen (Solution Sol_Reverse_fix)

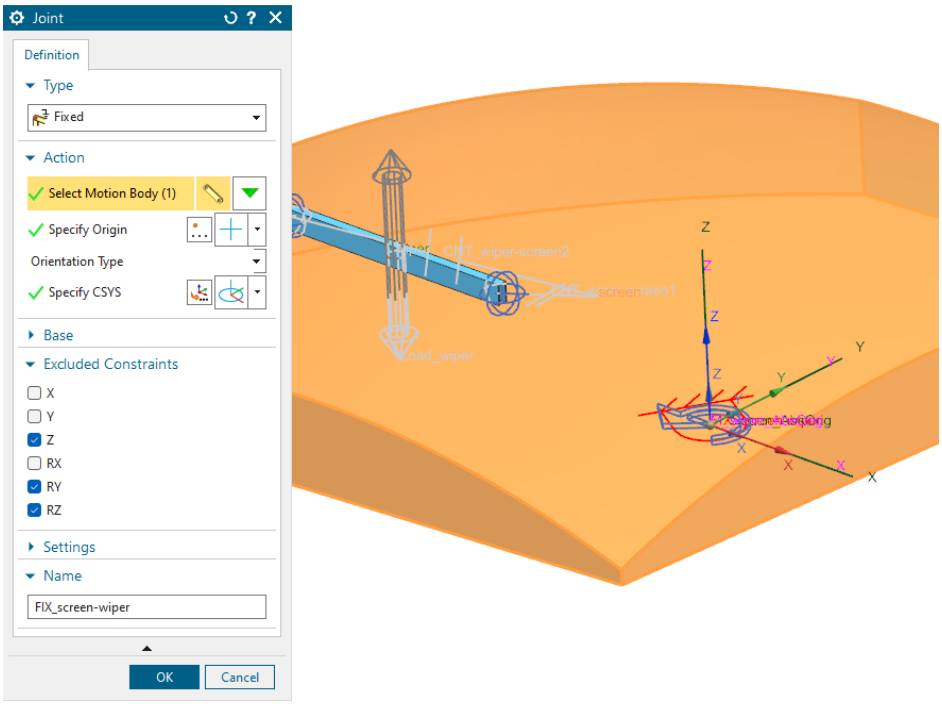


*Figure 3.7: Fixed joint with unconstrained directions – **Action is screen**, base is wiper.*

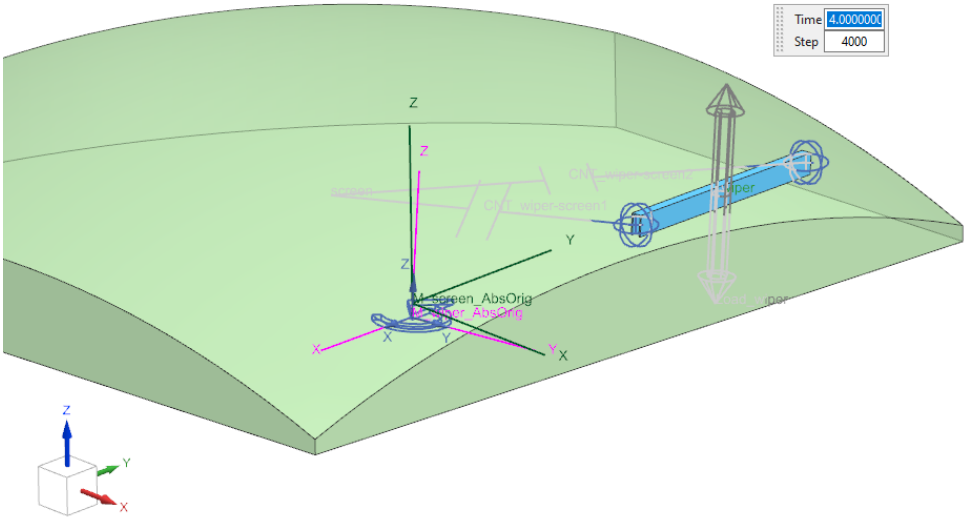


*Figure 3.8: **Action screen**; there is no rotation of the wiper along its main axis. Desired.*

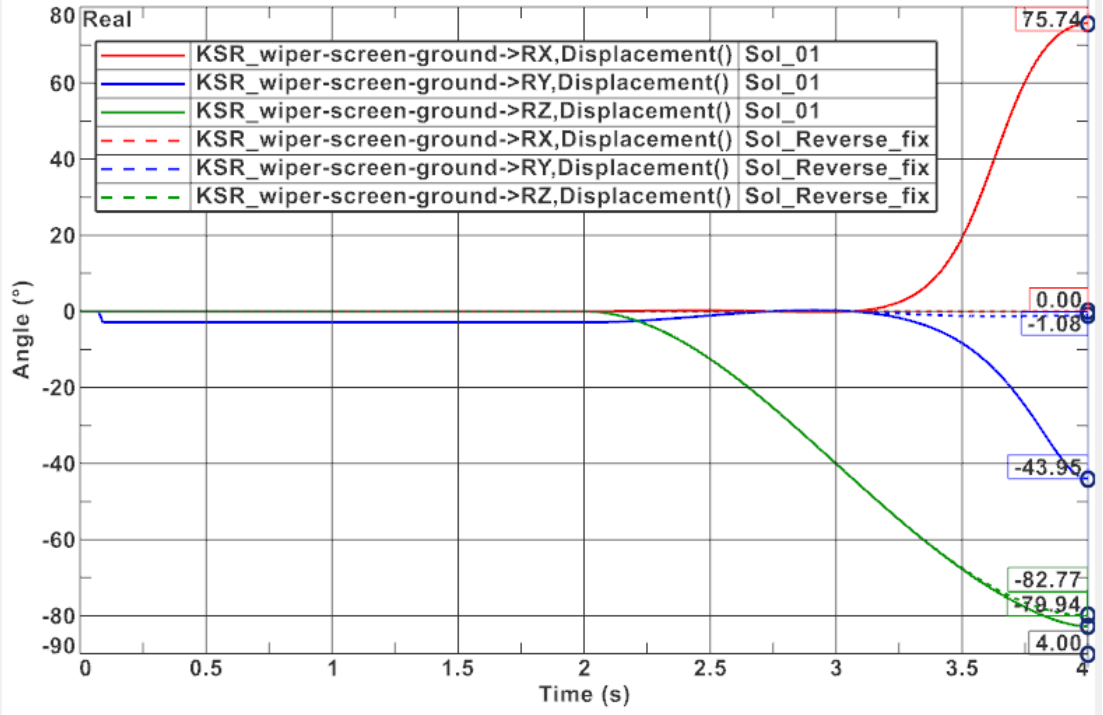


Figure 3.9: Comparison of the wiper marker rotations Sol_01 Action wiper VS. Sol_Reverse_fix action screen

3.4. Explanation

In this example, RY and RZ is checked. According to the table in chapter 2, this corresponds to this below cell which describes the active rotational condition of the fixed joint. The y-axis of base is made to be orthogonal to the z- axis of action.

	Constraint Meanings			
Fixed Joint Constraint	**Undriven fixed joint, or one with zero, two or three rotational constraints excluded**	**RX checked and driven, RY and RZ unchecked**	**RY checked and driven, RX and RZ unchecked**	**RZ checked and driven, RX and RY unchecked**
X	The origin of the action is constrained to be in the y-z plane of the base.	Same as left	Same as left	Same as left
Y	The origin of the action is constrained to be in the x-z plane of the base.	Same as left	Same as left	Same as left
Z	The origin of the action is constrained to be in the x-y plane of the base.	Same as left	Same as left	Same as left
RX	**The y-axis of the base is constrained to be perpendicular to the z axis of the action.**	Driven, not constrained by fixed joint.	y-axis of base orthogonal to z-axis of action	z-axis of base orthogonal to y-axis of action

The two scenarios are explained below.

Solution	Scenario	Explanation
Sol_01	Undesired motion (action=wiper, base=screen)	The meaning of RX is: the z-axis of the attachment on the wiper is orthogonal to the y-axis of the attachment on the screen. Initially this constraint prevents “roll” of the wiper. Because this y-axis remains in the same place during the solution, when the wiper reaches its full sweep, the RX constraint becomes a wiper “pitch” constraint about global x, instead of a condition on the “roll” motion of the wiper, about global y.
Sol_Reverse_Fix	Desired motion (Action=screen, base=wiper)	The meaning of RX is: the z-axis of the attachment on the screen is orthogonal to the y-axis of the attachment on the wiper. As the wiper sweeps through 90 degrees, the y-axis of the wiper rotates with it, and continues to prevent “roll” motion of the wiper for the whole simulation.