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Introduction

CATIA Version 6 Kinematics

Upon completion of this course the student should have a full understanding of the following topics:

- Creating joints
- Creating simulations and replays
- Performing analysis on a kinematic mechanism
- Using laws to help simulate a mechanism
- Converting assembly constraints to joints

Kinematics

The first item that needs to be understood is the definition of kinematics. Kinematics involves an assembly of parts that are connected together by a series of joints, referred to as a mechanism. These joints define how an assembly can perform motion. When one of the joints move it causes the assembly to move. Kinematics does not involve any type of finite element analysis, which means that there are no associated loads or weights with the parts. You are simply moving the assembly through some range of motion as defined by the joints.

Sometimes kinematics gets confused with animation as well. Although kinematics does perform some actions similar to animation, it is very limited. Kinematics is meant to show the range of motion of a mechanical component. Basically, it will show how the movement of one joint affects all of the other joints defined in the mechanism.

The second concept that needs to be understood are degrees of freedom. Every part has six degrees of freedom. It can move in three directions, and it can also rotate about those three directions. In order for an assembly to be used in kinematics, it must have at least one degree of freedom. The remaining degrees of freedom are controlled with commands. This is what allows the motion of the mechanism to be defined.

The hardest part about kinematics is figuring out what joints need to be defined on an assembly in order for it to operate correctly. The actual definition of the joints is pretty easy. Kinematics requires you to think a little differently without allowing finite element analysis and animation confuse the situation.

Kinematics is used to check for clearances and interferences among moving parts, and analyze the velocities of parts as well. In addition, laws can be applied to the mechanism to force the parts to accelerate.

There are two main kinematic apps: Mechanical Systems Design and Mechanical Systems Experience. Mechanical Systems Design is primarily used to define all the joints in the kinematic mechanism. It will be the focus of the first half of this manual. Mechanical Systems Experience is primarily used after the kinematic mechanism has been defined. This app is primarily used to simulate the mechanism. It will be the focus of the second half of this manual.

Kinematics

Engineering Connection Types

There are many engineering connection types. Each type has degrees of freedom and commands associated with it. A good understanding of these will make performing kinematics much easier. The table below gives an overview of the engineering connections. Some of the connections can be created using axis systems but that will be discussed later.

Engi	ineering Connection	Degrees of Freedom	Commands Available
R	User-Defined	Depends	None
۲	Rigid	None	None
ý	Spherical	3 Rotations	None
Ŵ	Cylindrical	1 Rotation, 1 Translation	Angle and/or Length
٩	Planar	1 Rotation, 2 Translations	None
Ø	Prismatic	1 Translation	Length
8	Revolute	1 Rotation	Angle
1	Screw	1 Rotation or 1 Translation	Angle or Length
P	Point Curve	3 Rotations, 1 Translation	Length
Ø	Point Surface	3 Rotations, 2 Translations	None
\$	Gear	1 Rotation	Angle
瀫	Rack	1 Rotation or 1 Translation	Angle or Length
2	Cable	1 Translation	Length
ø	Universal	1 Rotation	None
2	Roll Curve	1 Rotation, 1 Translation	Length
8	Slide Curve	2 Rotations, 1 Translation	None
Ľ	Fix	None	None

Revolute - Null Offset

The revolute option allows you to define a joint that represents a rotation. This is useful when you need an object to turn about another object.

Open the KINE110 - Revolute Assembly document. You should see a base with three rings.



If not already there, switch to the Mechanical System Design app.

Select the Engineering Connection icon. The *Engineering Connection Definition* window appears. This window should be familiar from the Assembly Design workbench.

ngineerir	g Connection Definition							?	×
🔊 Co	onstraints	m	Force Element	🗞 Interf	erences	l n € C	ontact		
Туре:	🎕 Us	er Define	ed 🗸 🔓	Auto	matically	positior	n components		~
Туре	Mode	Pref	Support	Lower	Value	Upper			
40			Select an element						
							·····		

Select the Gyroscope Base from the tree. Notice the *Type* automatically switches to *Fix*. You must always have a fixed object in order to create a kinematic simulation.

Select OK. The engineering connection is created.

Select the Engineering Connection icon. The *Engineering Connection Definition* window appears.

Select the center line of the cylinder on the outside ring and the center line of the cutout on the base as shown below. This defines the center of rotation and aligns the two lines.



Select the *zx plane* in both parts. This defines the location of each object by aligning the two planes. You will probably have to expand the branches of the Base and 1^{st} Ring in order to select the planes. Notice the *Type* automatically updates to *Revolute*.

Туре:	🖲 Revolute		~ 🔓	Automatically position components				
Туре	Mode	Pref	Support	Lower	Value	Upper		
0	Ψ <u>+</u>	2	🖌 Axis					
			🖌 Axis					
<u> </u>	<u>P</u>	↗	📁 zx plane					
			📁 zx plane					
43			Select an element					

The command will need to control the angle of the Cam in relation to the Fixture1 part, so you will need to create an Angle constraint to apply the command to.

Right select on the *Select an element* **text in the window and select** *Insert*, *Angle*, *Angle*. An angle constraint is inserted.

Select the *xy plane* **in both parts.** This will be the reference for the rotation angle. The window should appear as shown.

ingineer	ing Conn	ection D	efinition							?	×
 © 	onstraint	- 77	Force Elemen	t	🏷 Interf	ferences	♣ c	ontact			
Type: 🖊	Re 🕄	volute	~ (Auto	maticall	y positio	n compon	ents		~
Туре	Mode	Pref	Support		Lower	Value	Upper				
0	6 <mark>7-1</mark>	2	Axis								
			🛃 Axis								
<u>``</u>	<u>6</u>	∕≽	📁 zx plane								
			📁 zx plane								
4	<u>۹</u>		🔎 xy plane			0deg					
	' `		🔎 xy plane								
4			Select an elem	ient							
									OK	Ca	ncel

Notice the *Type* has an error symbol next to it. The *Mode* of the angle constraint needs to be switched to *Controlled*.

Right select on the symbol under the *Mode* **column as shown above and select** *Controlled.* The error symbol goes away.

Select OK. The engineering connection is created.

Mechanism Representation

The mechanism representation will contain all of the kinematic information for simulating movement within your assembly. It is a separate representation, similar to a 3d shape representation, that will be stored within the assembly.

Select the Mechanism Representation icon. I The Mechanism Representation window appears.

Mechanism Represent	tation			?	\times
8 Mechanism Re	presentation	8 Mechanism Pr	eferences		
Title	Mechanism Re	presentation0000000			
Name	mec-40476464	-00000001			☆
Description					
Design Range	Normal Range			~	
Collaborative Policy	Engineering D	efinition			
			ОК	Ca	ncel

Change the *Title* to <u>KINE110 - Kinematic Mechanism</u>.

Select the Mechanism Options tab.

Mechanism Representation	?	\times
8 Mechanism Representation		
 Include all kinematics connections into the mechanism Create all possible kinematics commands Link all independent submechanisms 		
ОК	Can	cel

Include all kinematics connections...Creates joints from all of the existing
engineering connections in the modelCreate all possible kinematic commandsCreates commands from any existing
controlled constraints within the existing
engineering connections

Link all independent submechanisms

Identifies and assembles existing mechanisms within any subassemblies under the product the new mechanism representation is being created in

Be sure the first two options are turned on and select *OK*. The mechanism representation is created.



All of the engineering connections were used to create joints within the mechanism. Notice there is one command.

Select the Update icon. This will update the engineering connections. It is a good idea to make sure things are updated.

Mechanism Manager

The mechanism manager allows you to get a summary of the existing mechanism, including all of the joints, commands and degrees of freedom. It can be helpful for identifying issues within the mechanism.

lechanism	Manager					?
Status — Computation	DOF with o DOF witho on status : O	commands out comma) Automati	: 0 nds: 1 c • Manual (Number of co Command de Update status	ommands: 1 pendency: No	
Joints Joints Lis Filter:	Assembly					
Included	Name Fix 1	Туре	Command 1	Command 2	Context	Assembly A 1
	Revolute.2	Revolute	Angle	-	KINE110 - Revolute	Assembly A.1
– Joints Ma	anagement -	4	Include All	– Command M Driven by:	lanagement	1 🗖 Length
			Evolude All		🗖 Angle 1	Angle 2

Notice there are no degrees of freedom with the command. This window also identifies which connections could have a command added to them.

Select the revolute in the list. Notice the Angle 1 command is checked. This is the angle command you already added to the revolute engineering connection.

1echanism	Manager					?
Status —						
	DOF with o	commands:	0	Number of co	mmands: 1	
ø	DOF witho	ut commar	nds: 1	Command de	pendency: No	
Computatio	on status : 🔿	Automatio	c 💿 Manual	Update status]	
Joints	Assembly					
Joints List	t					
Filter:				0	Only included 💿 All	
Included	Name	Туре	Command 1	Command 2	Context	
	Fix.1	Fix	-	-	KINE110 - Revolute Asse	mbly A.1
	Revolute.2	Revolute	Angle	-	KINE110 - Revolute Asse	mbly A.1
				\mathbf{N}		
Joints Ma	anagement -	_		- Command M	anagement	
🕂 [Inclu	de	- P	Include All	Driven by:	🗌 🗆 Length 1 🗖] Length (
Exclu	ide	e	Exclude All		Angle 1	Angle 2
					OK	Cance

Select OK.

Select the Mechanism Player icon. The Mechanism Player window appears.

Mechanism Player				?	×
Mechanism status:					
Command.1 -360	0.00	360	0deg	÷	5
Reset All					
				CI	ose

Drag the slider in the window. The ring will rotate.

Select the *Reset All* button and select *Close*. This defines one joint. You will continue to define revolute joints in order for the complete assembly to be defined.

Select the Engineering Connection icon again. The Engineering Connection Definition window appears.

Select the center line of the cylinder on the outside of the middle ring and then the center line of the hole of the outer ring as shown below. This defines the lines.



Select the *zx plane* in the 2nd Ring and *Plane.1* from *Geometrical Set.1* in the 1st Ring.

Insert an *Angle* **constraint and define the** *yz plane* **of both rings as the inputs. Switch the** *Mode* **to** *Controlled* **in the same manner as before.** This will have the revolute defined with a command.

Select OK. The window closes.

Define the revolute joint between the inner ring and the middle ring. You do this in the same manner as you did the second revolute joint.

Notice the engineering connections are created in the tree, but not populated in the mechanism.

🗄 🖧 Er	igineering Connections
⊭೮	Fix.1 (KINE110 - Gyroscope Base.1)
- €-	Revolute.2 (KINE110 - Gyroscope Base.1<->KINE110 - Gyroscope 1st Ring.1)
₽-\$}	Revolute.3 (KINE110 - Gyroscope 1st Ring.1<->KINE110 - Gyroscope 2nd Ring.1)
₫-55	Revolute.4 (KINE110 - Gyroscope 2nd Ring.1<->KINE110 - Gyroscope 3rd Ring.1)
	KINE110 - Kinematics Mechanism Joints

Select the Mechanism Manager icon. The Mechanism Manager window appears.

Commands Command.1 (Revolute.2)

🖲 Revolute.2

Joints	Assembly				
Joints Lis	t				
Filter:				0	Only included All
Included	Name	Туре	Command 1	Command 2	Context
	Fix.1	Fix	-	-	KINE110 - Revolute Assembly A.1
	Revolute.2	Revolute	Angle	-	KINE110 - Revolute Assembly A.1
	Revolute.3	Revolute	No	-	KINE110 - Revolute Assembly A.1
	Revolute.4	Revolute	No	-	KINE110 - Revolute Assembly A.1

Notice the last two revolutes are not included in the mechanism.

Turn on the checkboxes next to the last two revolutes and then select the *Update status* **button.** Notice there are now 2 degrees of freedom with commands. This is because only the first command is recognized. You will need to activate the other two commands.

- Status	DOF with commands: 2 DOF without commands: 3				ommands: 1 pendency: No
Joints Assembly Filter:				0	Only included All
Included	Name	Туре	Command 1	Command 2	Context
	Fix.1	Fix	-	-	KINE110 - Revolute Assembly A.1
	Revolute.2	Revolute	Angle	-	KINE110 - Revolute Assembly A.1
	Revolute.3	Revolute	No	-	KINE110 - Revolute Assembly A.1
	Revolute.4	Revolute	No	-	KINE110 - Revolute Assembly A.1

Select the second revolute and turn on the *Angle 1* command. This will need to be done anytime a joint is added to an existing mechanism.

Joints	Assembly				
-Joints List	t				
Filter:				0	Only included All
Included	Name	Туре	Command 1	Command 2	Context
	Fix.1	Fix	-	-	KINE110 - Revolute Assembly A.1
	Revolute.2	Revolute	Angle	-	KINE110 - Revolute Assembly A.1
	Revolute.3	Revolute	Angle	-	KINE110 - Revolute Assembly A.1
	Revolute.4	Revolute	No	-	KINE110 - Revolute Assembly A.1
				•	
					\
– Joints Ma	anagement -			-Command M	lanagement
🕂 🔤	ide	- ÷	Include All	Driven by:	🔽 🗆 Length 1 🔲 Length 2
Exclu	ide	-	Exclude All		Angle 1 🗌 Angle 2

Turn on the *Angle 1* for the last revolute as well.

Select the *Update status* button. The degrees of freedom update.

Г	Status —				
		DOF with commands:	0	Number of commands:	3
		DOF without commands:	3	Command dependency:	No
C	Computation status : O Automatic Manual Update status				

Select OK.

Select the Mechanism Player icon. The Mechanism Player window appears.

Mechanism Player				?	×
Mechanism status:	5				
Command.1 -360	0.00	360	0deg	-	2
Command.2 -360	0.00	360	0deg	-	5
Command.3 -360	0.00	360	Odeg	÷	2
Reset All					
				Cl	ose

Drag each of the sliders in the window. The rings should all rotate now.



Select the *Reset All* **button and select** *Close***.** This defines one joint. You will continue to define revolute joints in order for the complete assembly to be defined. Your first kinematic mechanism has been defined.

Your final mechanism should appear similar to the one shown below.



Save and close your document.

Mechanism Operations

This section will discuss a number of operations with regards mechanism manipulation and analysis.

Dressup

The dressup feature allows you to add another object to your mechanism without having to make it part of the actual mechanism. This is very useful when you already have a mechanism defined in a sub-assembly and you include that into a larger assembly. To be able to use the mechanism contained in the sub-assembly and be able to attach other parts to that mechanism, you must use the dressup feature.

Open the KINE300 - Dressup model. The model should appear as shown.



The trunion was initially designed with simple wireframe geometry and is represented by the KINE300 - Turnion Design Geometry model. Now the final trunion part will be added into the kinematic mechansim using a dressup.

Select the Mechanism Player icon. The commands should appear as shown.

Mechanism Player				?	×
Mechanism status: 🎻					
Command.3 5.49274	9.43	13.3668	9.43in	\$	2
Command.4 95	180.00	180	180deg	≙ ▼	5
Reset All					
				C	ose

Drag *Command.4* to the left. The assembly should move as shown. Notice the actual trunion part doesn't move because it isn't part of the mechanism yet.



Select the Reset All button and close the Mechanism Player window.

Select the Dressup icon. It is in the sub menu of the Mechanism Manager icon. The *Dressup* window will appear.

Attach	ed pro	ducts
	Attach	Attached pro

Mechanism Specifies the mechanism that you are dressing up

Mechanism products Shows the products available to attach a dressup

Attached products Defines the product(s) that will be attached with the dressup

Select *KINE300 - Trunion Design Geometry*. This is the part that you wish to attach other objects to.

Select the *KINE300 - Trunion* part in the specification tree. It should appear in the *Dressup* window.

Dressup	?	×
Mechanism: KINE300 - Mechanism A.1		
Mechanism products	Attached	products
KINE300 - Skin A.1(KINE300 - Skin.1)		
KINE300 - Mount A.1(KINE300 - Mount.1)		
KINE300 - Piston A.1(KINE300 - Piston.1)		
KINE300 - Cylinder A.1(KINE300 - Cylinder.1)		
KINE300 - Link A.1(KINE300 - Link.1)		
KINE300 - Wheel Assembly A.1(KINE300 - Wheel Assembly.1)		
KINE300 - Actuator Shaft A.1(KINE300 - Actuator Shaft.1)		
KINE300 - Actuator Cylinder A.1(KINE300 - Actuator Cylinder.1)		
KINE300 - Actuator Mount A.1(KINE300 - Actuator Mount.1)		
KINE300 - Trunion Design Geometry A.1(KINE300 - Trunion Design Geometry.1)	KINE300 - 1	Trunion
	ок	Cancel

Select OK. There should now be a *Dressup* branch under the mechanism.



Notice the dressup basically creates a rigid connection between the parts.

Simulate the mechanism. Notice the trunion now moves with the rest of the assembly.



Select the *Reset All* button and select *Close*.

Select the Dressup icon. The *Dressup* window will appear.

Dressup	? ×
Mechanism: KINE300 - Mechanism A.1	
Mechanism products	Attached products
KINE300 - Skin A.1(KINE300 - Skin.1)	
KINE300 - Mount A.1(KINE300 - Mount.1)	
KINE300 - Piston A.1(KINE300 - Piston.1)	
KINE300 - Cylinder A.1(KINE300 - Cylinder.1)	
KINE300 - Link A.1(KINE300 - Link.1)	
KINE300 - Wheel Assembly A.1(KINE300 - Wheel Assembly.1)	
KINE300 - Actuator Shaft A.1(KINE300 - Actuator Shaft.1)	
KINE300 - Actuator Cylinder A.1(KINE300 - Actuator Cylinder.1)	
KINE300 - Actuator Mount A.1(KINE300 - Actuator Mount.1)	
KINE300 - Trunion Design Geometry A.1(KINE300 - Trunion Design Geometry.1)	KINE300 - Trunion A.1(KINE300 - Trunion.1)
	OK

Right select on the trunion in the Attached products column. A contextual menu appears.

<u>R</u>emove Link <u>D</u>elete Joint <u>C</u>enter Tree

Remove Link	Deletes the dressup link from the mechanism, but retains the underlying rigid joint

Delete Joint Deletes both the dressup link and the underlying rigid joint.

Select Cancel.

The dressup option provides and easy way to attach additional parts or products to objects already in a mechanism. This is especially helpful if a kinematic mechanism was done with simple wireframe geometry for conceptual design.

Save and close your document.

Kinematic Simulations

Up until now you have been simulating your mechanisms using the mechanism player. You can also create a simulation that can be used to better visualize the kinematic movements. A kinematic simulation consists of a Model, Scenario and Result. Each node in the tree has a different function and will be discussed. The model represents the product you are using for the kinematic simulation. The scenario defines the definition of the kinematic movement including excitations and probes. Scenarios can be used in conjunction with assembly sequences that will allow you to put multiple scenarios together and vary their duration. The results node will contain simulation results and any snapshots of specific simulation steps.

Creating a Kinematic Simulation

This section will discuss creating a kinematic simulation that can be used to better visualize the kinematic movements, as well as analyze them.



Open the KINE400 - Kinematic Simulation model. It should appear as shown.

Switch to the Mechanical Systems Experience workbench. The *Mechanical Systems Experience* window appears.

Mechanical Systems	?	×
Simulation Object C	reation	
Product:		
KINE400 - Kinematic Sir	mulatio	n A.1
 □ Create a mechanism ✓ Create a kinematics s 	Cenario	, i
ОК	Ca	ncel

Product	Specifies the product to use for the model node of the simulation
Create a mechanism	Creates a new mechanism if one doesn't already exist
Create a kinematics scenario	Specifies a kinematics scenario will be created

Turn off both check boxes and select OK. The Kinematics Simulation window appears.

Kinematics Simulation ?			
Kinematics Sir	nulation		
Title	Kinematics Simulation000000044		
Name	sim-73888265-00000044		☆
Description			
Collaborative Policy	Engineering Evaluation]
	(OK)	Ca	incel

Key in <u>KINE400 - Kinematic Simulation</u> for the *Title* and select *OK*. The kinematic simulation is created.



This is the easiest method for creating a kinematic simulation.

Right select on the *Model* branch in the tree. A contextual menu appears.

₿‡	Center tree on Preselected O	bjects	
	<u>R</u> eframe On		
۲	<u>H</u> ide/Show		
	<u>P</u> roperties	Alt+Enter	
	<u>O</u> pen Sub-Tree		
	<u>D</u> isplay		•
S	Choo <u>s</u> e a Model		
Š	Replace Model By Revision		

Notice you can use the *Choose a Model* option in order to populate the *Model* branch if you had created the kinematic simulation without having a product open first. You also have the option to *Replace Model By Revision* if you had a new revision of the product.

Select in space. Now you are ready to create a scenario for the simulation.

Kinematic Scenarios

This section will discuss creating a scenario with specific excitations and probes. There are two types of scenarios: kinematic and dynamic. The kinematic type will be discussed here.

Select the Kinematic Scenario icon. X The *Kinematics Scenario* window appears.

Kinematics Scenario	?	×
Name: Scenario.1 Mechanism: KINE400 - Mechanism A.1		8
Excitations Probes Parameters		
Select excitations used for the scenario:		
Cancel	Previe	w

Name Specifies a name for the scenario

Mechanism Specifies the mechanism to be used for the scenario

Excitations Allows you to specify which excitations will be used for the scenario

Probes Allows you to specify which probes will be used for the scenario

Excitations	Probes	Parameters]
Select probes	used for the	e scenario:	
Available		Refe	renced

Parameters Defines the simulation parameters for the scenario

Excitations	Probes	Parameters	
Simulation	n Parameters		
Start time:	0s		
End time:	10s		
Time step:	1s		

Select OK. There are no excitations or probes to select yet. The scenario is created.

🜔 KINE4	400 - Kinematic Simulation
ф 🎨 м	odel
₫-1	KINE400 - Kinematic Simulation A.1
📥 🐉 🚾	enario
	<u> Scenario.1 - Kinematics Scenario</u>

Select Undo until the scenario disappears. Select Undo until the scenario disappears. Select Undo until the scenario icon unless you already have excitations you can select from. In this case you haven't created any excitations yet, so it will be more efficient to create the scenario while recording the excitation.

Recording a Scenario

You can manually or automatically record a scenario of your kinematic mechanism moving to create a recorded excitation. If you do not already have a kinematic scenario, this icon will create one in the process.

Select the Kinematic Excitation Recorder icon. The *Kinematics Scenario* window appears again. Notice it looks the same, except there is no *Excitation* tab.

Kinematics S	cenario	?	×
Name: Mechanism:	Scenario.1 KINE400 - Mechanism A.1		B
Probes	Parameters		
Select prob	es used for the scenario:	rad	
Available		ceu	
	OK Cancel	Preview	v

Select the Parameters tab and set the values as shown.

Probes	Parameters
Simulat	ion Parameters
Start time	e: Os
End time:	6s
Time step	n: 1s

In this case, the recording will have a duration of 6 seconds with the position of the mechanism being recorded each second.

Change the *Name* to <u>Recorded Scenario</u> and select *OK*. The *Excitation Recorder* window appears.

Excitation Recor	der						?	×
Mechanism stat	tus: 🐼							
Record	- Commands							
	LG Open/Close	275		360.00	360	360deg		<u>-</u>
	LG Extend/Retract	5		12.50	12.5	12.5in		-
	Right Door Open/Close	0		90.00	90	90deg		-
Automatic	Left Door Open/Close	270	270.00		360	270deg		-
						ОК	Can	cel

This window lists all of the commands available within the selected mechanism. You may manually record the mechanism movements you want or you can turn on the Automatic option and simply drag the sliders for the recording.

Be sure the *Automatic* **option is turned off and select the Record icon.** This will record the current position of the commands as the first step.

For the *LG Open/Close* command, key in 345 or drag the slider to approximately 345. This will be the position for the command in the second step.

Key in 11.5 or drag the slider to the approximate value for the *LG Extend/Retract* command.

Select the Record icon. • This is the positioning for the second step.

Repeat this process for the pairs of values below. This should have each of the positions recorded for the entire excitation.

LG Open/Close	330	315	300	285	275
LG Extend/Retract	10.5	9.5	8.5	7.5	7.0

Notice the *Experience Player* toolbar is available in the lower left hand corner of the display.

Select the Skip to Beginning icon.

Select the Play icon. The simulation plays.

Change the time drop down to be *x* 0.1*s*.

Reset	
x 0.1	
x 0.2	
x 0.5	
1s	
x 2	
x 5	
x 10	
x 0.1	~

Select the Skip to Beginning icon.

Select the Play icon.

The simulation plays slower.

Select OK in the Excitation Recorder window. The scenario and excitation are created.



Now a second scenario will be created using the automatic record.

Select the Kinematic Excitation Recorder icon. The *Kinematics Scenario* window appears.

Select the *Parameters* tab and set the values as shown.

Probes	Parameters
Simulat	on Parameters
Start time	:: Os
End time:	6s
Time step	n: 1s

In this case, the recording will have a duration of 6 seconds with the position of the mechanism being recorded each second.

Change the *Name* to <u>Auto Recorded Scenario</u> and select *OK*. The *Excitation Recorder* window appears.

Excitation Reco	rder						?	×
Mechanism sta	tus: 🍼							
Record	Commands							
	LG Open/Close	275		360.00	360	360deg		
	LG Extend/Retract	5		12.50	12.5	12.5in		
	Right Door Open/Close	0		90.00	90	90deg		÷
Automatic	Left Door Open/Close	270	270.00		360	270deg		
						ОК	Car	ncel

Change the *LG Extend/Retract* **to be 8.5 and select the Record icon.** This will be the first step.

Turn on the *Automatic* **option and drag the** *LG Open/Close* **command in approximately 15 degree increments, releasing it each time.** Each step will be recorded automatically.

Change the time drop down to be x 0.1s.

Reset
x 0.1
x 0.2
x 0.5
1s
x 2
x 5
x 10
x 0.1 🗸 🗸 🗸

Select the Skip to Beginning icon.

Select the Play icon. The simulation plays.

Select OK in the Excitation Recorder window. The scenario and excitation are created.



Editing a Recorded Scenario

You can edit a recorded scenario in order to adjust the command values if needed.

Right select on the *Recorded Excitation.1* **for the** *Recorded Scenario.* A contextual menu appears.



Select the *Edit Table* option. The *Recorded Excitation Table* window appears.

Rec	Recorded Excitation Table - 🗆 🗙							
Na	Name: Recorded Excitation.1							
	Time (s)	LG Open/Close (deg)	LG Extend/Retract (in)	Right Door Open/Close (deg)	Left Door Open/Close (deg)			
1	0	360	12.5	90	270			
2	1	345	11.5	90	270			
3	2	330	10.5	90	270			
4	3	315	9.5	90	270			
5	4	300	8.5	90	270			
6	5	285	7.5	90	270			
7	6	275	7	90	270			
					OK Cancel			

Change the *Name* to <u>Manually Recorded Excitation.1</u>.

Select row 6, then right select in the table. A contextual menu appears.

Rec	Recorded Excitation Table - 🗌 🗙							
Na	me: Manu	ally Recorded Excitation	n.1					
Г	Time (s)	LG Open/Close (deg)	LG Exter	nd/Retract (in)	Right Door Open/Close (deg)	Left Door Oper	n/Close (d	leg)
1	0	360	12.5		90	270		1
2	1	345	11.5		90	270		
3	2	330	10.5		90	270		
4	3	315	9.5		90	270		
5	4	300	8.5		90	270		
б	5	285	7.5	Add David		270		
7	6	275	7	Add Row		270		
				Delete Rows				
				D <u>e</u> lete All Ro	ws			
			_	_				
						OK	Cano	cel

You can add or delete rows from the table. You can also simply modify the existing values.

Select on the 7.5 value in the *LG Extend/Retract* column. You should be able to edit the value. You may have to select on it twice.

	Time (s)	LG Open/Close (deg)	LG Extend/Retract (in)	Right Dc
1	0	360	12.5	90
2	1	345	11.5	90
3	2	330	10.5	90
4	3	315	9.5	90
5	4	300	8.5	90
6	5	285	7.5	90
7	6	275	7	90

Change it to 8.0 and select off of it to set it. This will update the position of the command for that step.

Select OK.

Right select on the *Recorded Excitation.1* **for the** *Auto Recorded Scenario* **and select** *Edit Table.* The *Recorded Excitation Table* appears.

Red	orded Exci	tation Table			- 🗆 🗙			
Na	Name: Recorded Excitation.1							
	Time (s)	LG Open/Close (deg)	LG Extend/Retract (in)	Right Door Open/Close (deg)	Left Door Open/Close (deg)			
1	0	360	8.5	90	270			
2	1	346.825	8.5	90	270			
3	2	331.95	8.5	90	270			
4	3	314.1	8.5	90	270			
5	4	300.075	8.5	90	270			
6	5	286.05	8.5	90	270			
7	6	275	8.5	90	270			
					Cancel			

Notice all of the values in the *LG Open/Close* column are random since they were automatically recorded using the slider.

Update the values as shown.

Recorded Excitation Table - 🗌 🗙							
Na	Name: Recorded Excitation.1						
	Time (s)	LG Open/Close (deg)	LG Extend/Retract (in)	Right Door Open/Close (deg)	Left Door Open/Close (deg)		
1	0	360	8.5	90	270		
2	1	345	8.5	90	270		
3	2	330	8.5	90	270		
4	3	315	8.5	90	270		
5	4	300	8.5	90	270		
6	5	285	8.5	90	270		
7	6	275	8.5	90	270		
	OK Cancel						

Change the *Name* to be <u>Auto Recorded Excitation.1</u> and select *OK*.

This illustrates how you can record an excitation for a scenario.

Save and close the document.

Results

This section will discuss a number of operations with regards mechanism manipulation and analysis.

Preview Scenario

The preview scenario option allows you to review the behavior of a mechanism.

Open the KINE450 - Results model. The model should appear as shown.



Select the Esc key. This provides a quick easy way to play a scenario.

Compute and Generate Results with Local Update

The compute and generate results with local update option allows you create a result computation of the current scenario. If results have already been generated, this option can also be used to update them if any local modifications have been made to the scenarios involved.

Right select on the *Landing Gear Scenario* and select *Set as Current*. This scenario will be used for this exercise.



Select the Compute and Generate Results with Local update icon. 🕑 You

should see the scenario play and you may receive a warning.

Incid	Incident Diagnosis					?	×
	Scenarios Landing Gear Scen	Errors 0	Warnings 1	Informations 0			
War The The	Warning: The solver reached a limit for an engineering connection at time t=10.000s. The lower limit of 275.000 deg for Revolute.3 is reached						7
						CI	ose

Close the *Incident Diagnosis* **window.** This is just stating a limit was reached during the simulation.

You now have a *Result* branch in the tree as well.



The *Result* branch is active and you should see that you have a new toolbar.



To illustrate a change being made locally, a swept volume will be created.

Select the Swept Volume icon. The *3D Shape* window appears.

Select *OK* to create the new 3d shape. The name doesn't matter as this won't be saved in this exercise. The *Swept Volume* window appears.

Swept Volume		?	×	
Simulation: Element(s) to sweep: Reference product: Number of steps: Parameters Filter positions Precision: 0.008i Grain: 0.787in	Result of La 8 selected e KINE450 - K 11	i Iement	Ge tic	
Sweep All				
Sweep all moving	g products			
Enable simplification Accuracy: 0.008in Improved performance				
	OK	Car	ncel	

This window will be discussed in detail later.

Select OK. The swept volume is generated and should appear in the new 3d shape model.



Switch back to the *KINE450 - Results* model.

Double select on the *Landing Gear Scenario* **in the tree.** The *Kinematics Scenario* window appears. You may have to double select twice.

In the *Parameters* tab, change the *End time* to 5s and select *OK*. This will limit the scenario to only the first half of the simulation.

Excitations Probes	Parameters
-Simulation Parameter	s
Start time: 0s	
End time: 5s	
Time step: 1s	

Notice the result is no longer up to date.



Select the Compute and Generate Results with Local update icon. (D) You

should see the scenario play, but only half way this time.

Switch to the 3d shape tab with the swept volume. Notice it has been updated.



Now you will make a change at the model level and see how the global update option works.

Compute and Generate Results with Global Update

The compute and generate results with local update option allows you create a result computation of the current scenario. If results have already been generated, this option can also be used to update them if any local modifications have been made to the scenarios involved.

Edit Sketch.1 as shown in the KINE450 - Tire model.



Change the 10in length constraint to be 9 inches.



Exit the sketch.

Right select on *Groove.1* **in the tree and select** *Groove.1 object*, *Deactivate*. The *Deactivate* window appears.

Deactivate		?	×
Selection:	Groove.1		
🗌 Deactiv	ate all children		
🗹 Deactiv	ate aggregated e	elemer	nts
	OK	Ci	ancel

Select OK. The groove operation is deactivated and the grooves are removed from the tries.



Double select on the *Landing Gear Scenario* in the tree. The *Kinematics Scenario* window appears. You may have to double select twice.

In the *Parameters* tab, change the *End time* to 10s and select *OK*. This will set the scenario back to play the full simulation.

Excitations	Probes F	arameters	
-Simulation Par	ameters —		
Start time: 0s			
End time: 10s			
Time step: 1s			

Select the Update icon.



Select the Compute and Generate Results with Global update icon. If You should see the scenario play and you may receive a warning.

Close the *Incident Diagnosis* **window.** This is just stating a limit was reached during the simulation.

Switch to the 3d shape tab with the swept volume. Notice it has been updated, including the change the tire design.



View Scenario Results

The view scenario results option allows you to review the results of a kinematic scenario including probe and excitation parameters. The results can be viewed in plot or table format and can also be exported.

Double select on the *Scenario* **branch in the tree.** You should be returned to the Mechanical Systems Experience app.

Right select on the Assembly Sequence Scenario and select Set as Current.

Select the Compute and Generate Results with Global update icon. 💕 You should see the scenario play and you may receive a warning. You could have used either the local or global update option in this case, since it is creating a new result for the scenario.

Close the *Incident Diagnosis* **window.** This is just stating limits were reached during the simulation. Another result appears in the *Result* branch.

> Ġ- 💷 Result of Landing Gear Scenario Result of Assembly Sequence Scenario

Select the View Scenario Results icon. The View Result window appears.

View Res	ult of Assembly Sequence Scenario — 🛛	×
Specifi	cations Plot Table	
Filter:	All	
Show	Parameters	
	Assembly Sequence Scenario/LG Open/Close Law/Result/Angle	
	Assembly Sequence Scenario/LG Extend/Retract Law/Result/Length	
	Assembly Sequence Scenario/Right Door/Result/Angle	
	Assembly Sequence Scenario/Left Door/Result/Angle	
Select	All Deselect All New Curve	Save

Specifications Displays the available probe and excitation parameters for the scenario

New Curve Allows additional plots to be created between the existing parameters

Save Saves the plot results in the tree



Plot

Displays the plots of the selected parameters

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View Result of Assembl	y Sequence Scenario	_	
	/		

Time (s)	Angle	Length [Angle	Angle	
0	0	0	0	0	
1	350	12.5	0	0	
2	340	12.5	0	0	
3	330	11.875	0	0	
4	320	10.5	0	0	
5	310	9.125	0	0	
6	300	8.5	0	0	
7	290.433	8.5	0	0	
8	282.322	8.5	0	0	
9	276.903	8.5	0	0	
10	275	8.5	0	0	
11	275	8.5	75	285	
12	275	8.5	60	300	
13	275	8.5	45	315	
14	275	8.5	30	330	
15	275	8.5	15	345	
16	275	8.5	0	360	

Table

Displays the values of the parameters in table format

Export to Database

Exports the table to a spreadsheet saved in the database

Export to File

Exports the table to a spreadsheet saved locally

Select the *Plot* tab, then right select in the plot. A contextual menu appears.



These options will allow you to modify what the plot looks like.

Select the *Specifications* **tab and then select the** *New Curve* **button.** The *X* & *Y Selection* window appears.

X	& Y Selection	?	×
X:	Angle [Result/LG Open/Close Law/Assembly Sequence Scenario	o] (Degr	iee 🗸
Y:	Angle [Result/LG Open/Close Law/Assembly Sequence Scenario	o] (Degr	ree 🗸
	OK	Can	cel

Select the drop down for the *X* and select the first *Angle* parameter.

Select the drop down for the *Y* and select the *Length* parameter.

Select OK. The new option for the two parameters vs one another appears in the list.

Show	Parameters	
	Assembly Sequence Scenario/LG Open/Close Law/Result/Angle	
	Assembly Sequence Scenario/LG Extend/Retract Law/Result/Length	
	Assembly Sequence Scenario/Right Door/Result/Angle	
	Assembly Sequence Scenario/Left Door/Result/Angle	
	Assembly Sequence Scenario/LG Open/Close Law/Result/Angle - A	

Select the *Plot* tab. Notice the new curve.



Close the window.

Close all documents without saving.