

DMU KINEMATICS

Computational Design Laboratory
Department of Automotive Engineering
Hanyang University, Seoul, Korea



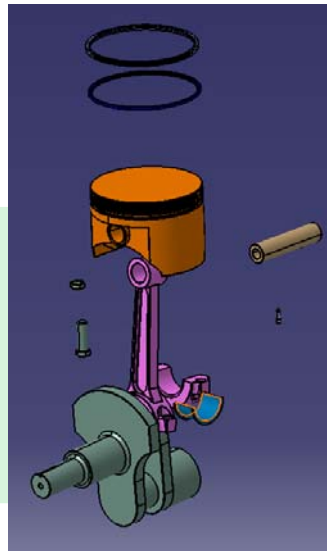
CONTENTS

- ✓ 시작하기
- ✓ DMU Kinematics Tools
- ✓ DMU Generic Animation

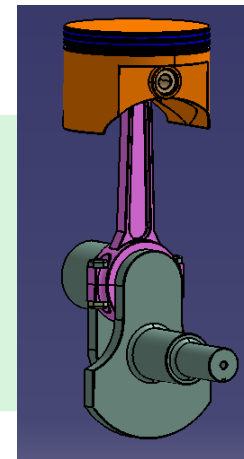
DMU KINEMATICS 진행 순서



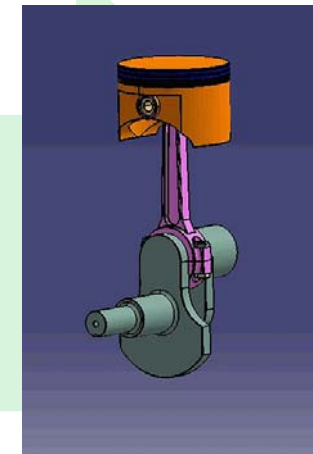
모델 불러오기



대략적 배치/수정



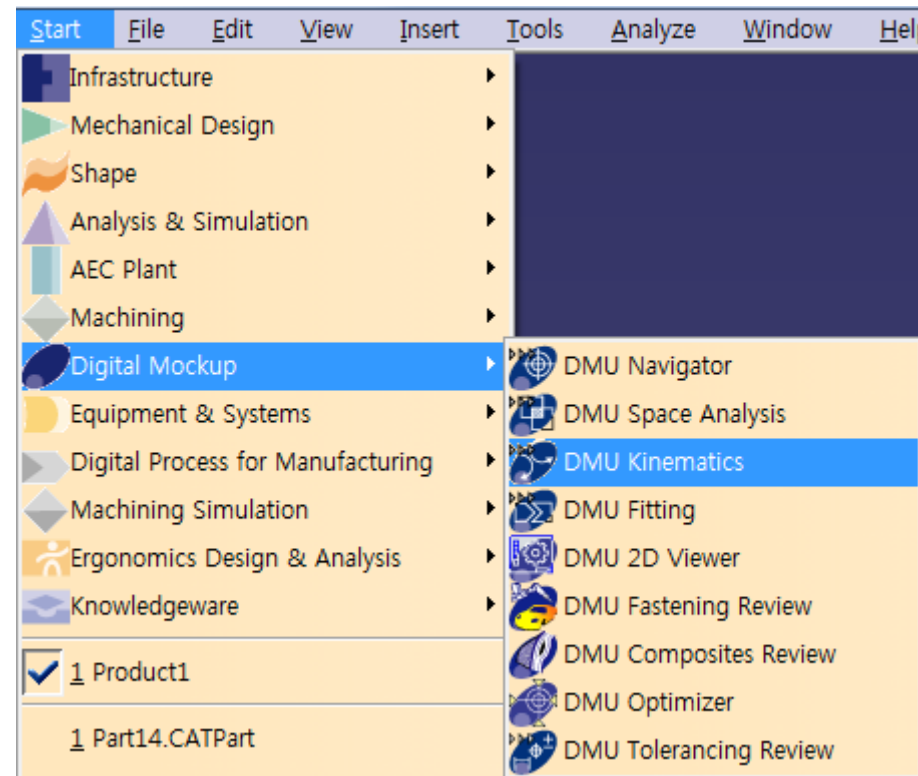
Joint 부여



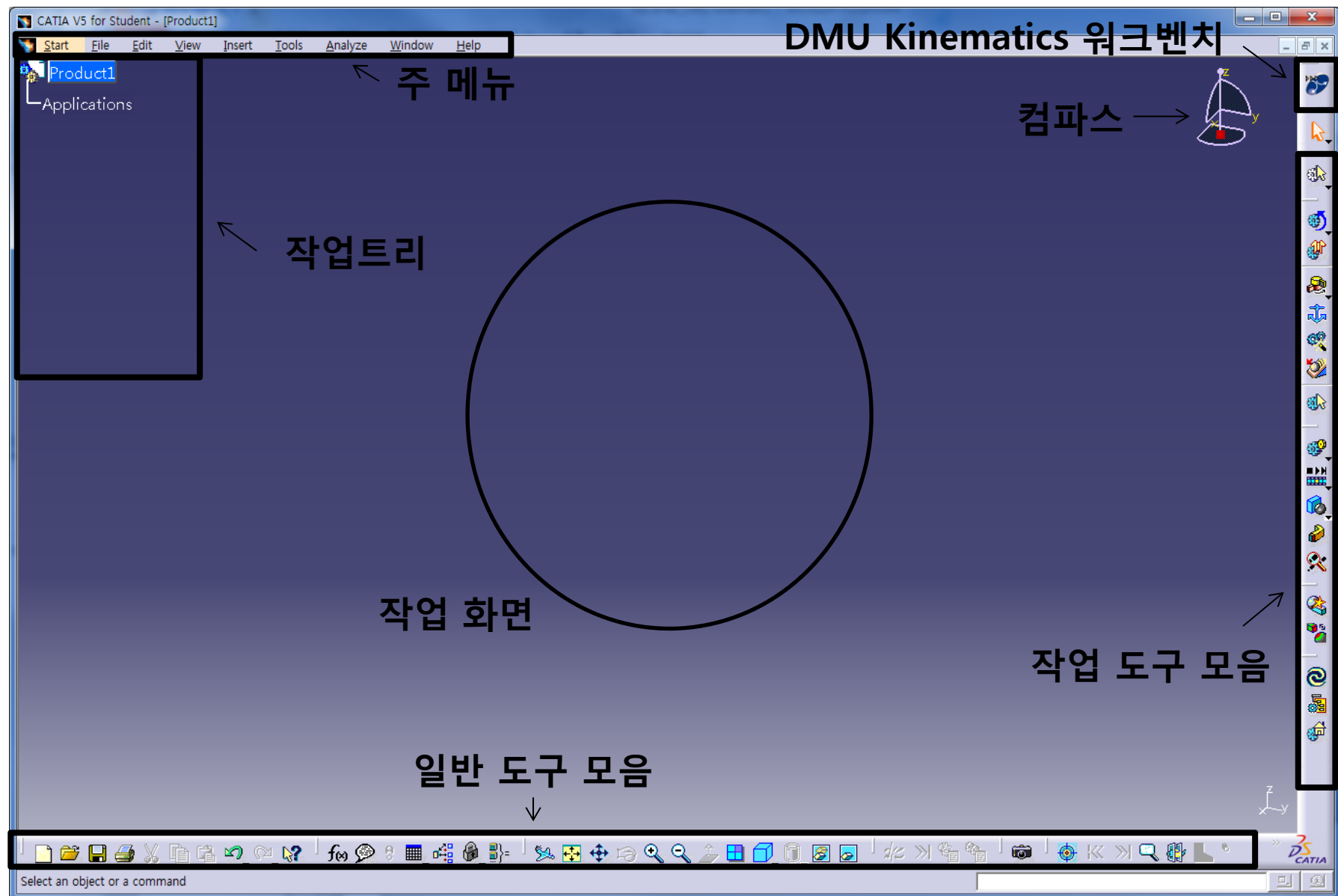
Joint 생성 후
구동 확인

DMU KINEMATICS 시작하기

Start 메뉴에서 Digital Mockup → DMU Kinematics 선택



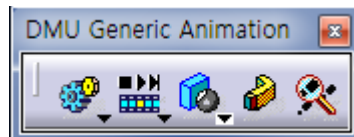
DMU KINEMATICS 작업화면



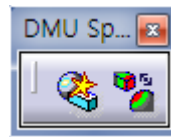
DMU KINEMATICS 툴바 종류



만들어진 Component를 불러들여서 component간에 운동을 부여하거나 구속함.



만들어진 mechanism을 동작함.



Component간에 간섭, 거리를 확인함.

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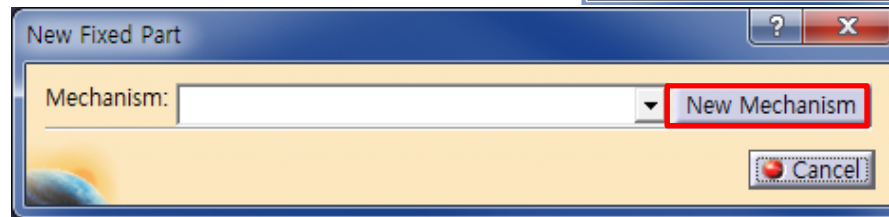
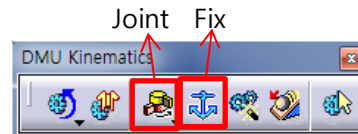
DMU KINEMATICS TOOLS

DMU Kinematics

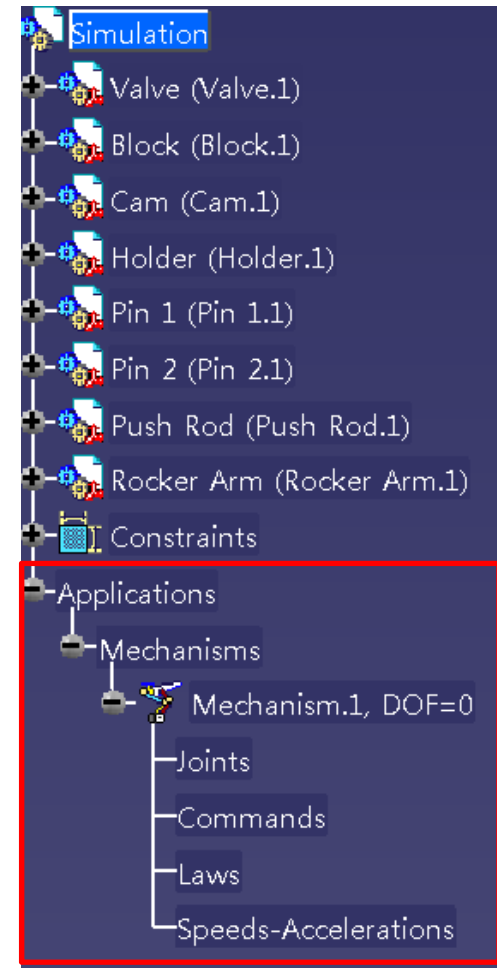
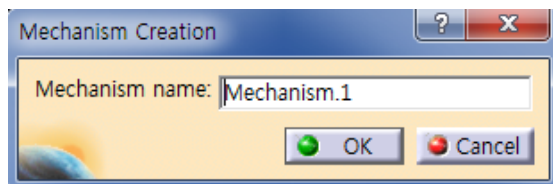
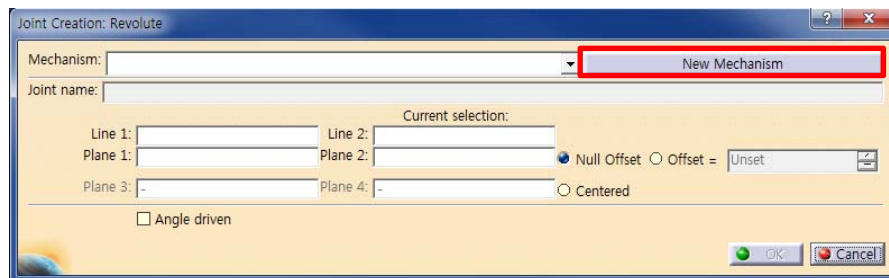


- Mechanisms 메뉴 생성

<Fix Part 혹은 Joint 선택>



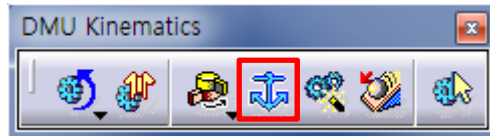
혹은



<Mechanisms 생성>

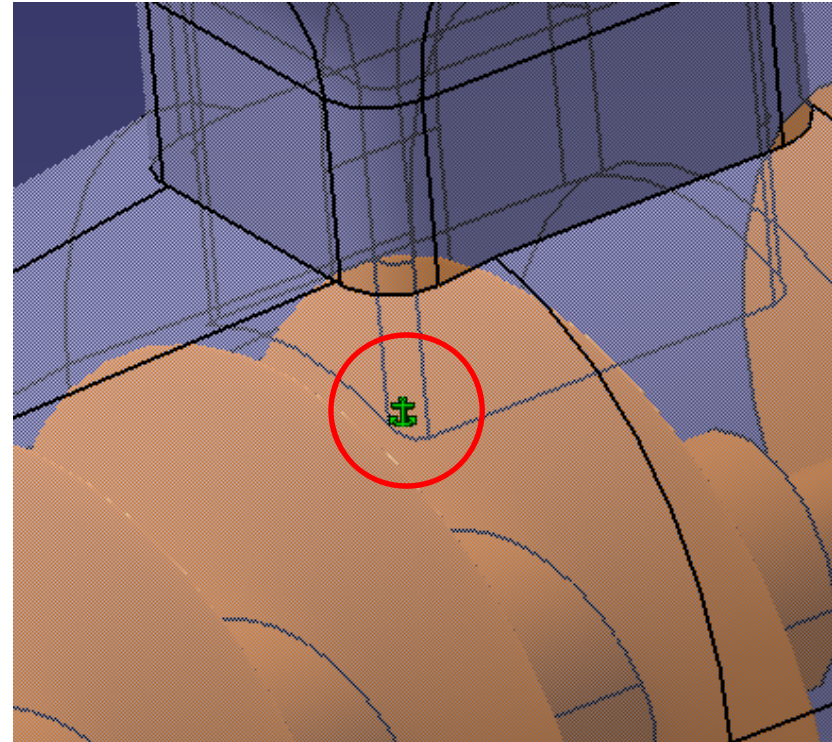
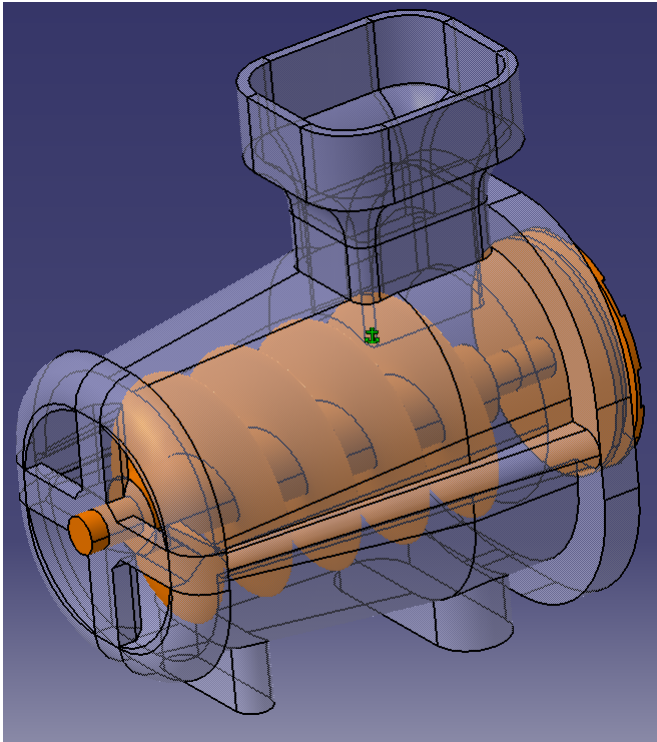
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Fixed Part 

- 선택한 Component를 고정 (기준이 되는 하나의 component만 가능)



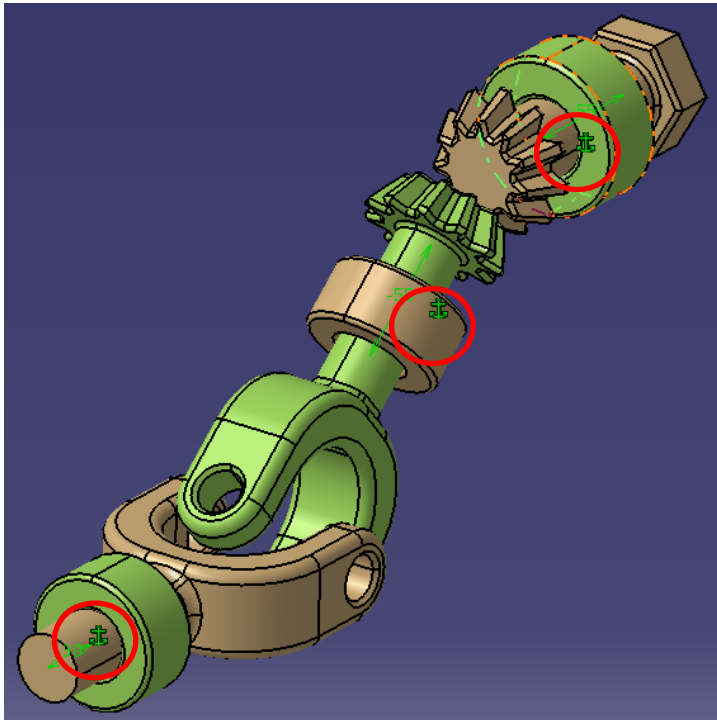
DMU KINEMATICS TOOLS

DMU Kinematics

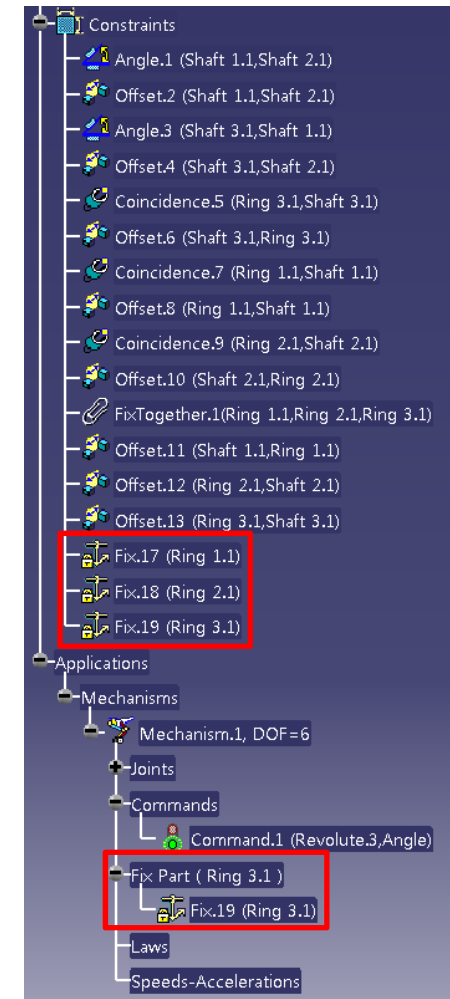


Fixed Part

- 선택한 Component를 고정 (기준이 되는 하나의 component만 가능)



<다수의 Fix를 생성해도 mechanism에는 하나만 생성됨>



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	Revolute	: 평면을 기준으로 회전하도록 joint 생성
	Prismatic	: 특정 면을 기준으로 병진 운동하도록 joint 생성
	Cylindrical	: 병진운동과 회전 운동하도록 joint 생성
	Screw	: Pitch 값을 기준으로 회전과 병진 운동하도록 joint 생성
	Spherical	: 특정한 point를 중심으로 운동하도록 joint 생성
	Planar	: 특정한 plane를 중심으로 운동하도록 joint 생성
	Rigid	: component간의 상대위치를 고정시켜주는 joint를 생성
	Point Curve	: 특정 점이 특정 곡선을 따라 움직이도록 joint 생성
	Slide Curve	: 특정 곡선이 다른 곡선을 따라 움직이도록 joint 생성
	Roll Curve	: 특정 곡선끼리 맞물려 움직이도록 joint 생성
	Point Surface	: 특정 점이 특정 곡면을 따라 움직이도록 joint 생성
	Universal	: 두 축을 연결해주기 위한 joint 생성
	CV	: 3개의 축을 연결해 주기 위한 joint 생성
	Gear	: 기어 비를 이용하여 두 개의 prismatic joint를 연결함
	Rack	: 기어 비를 이용하여 prismatic joint와 revolute joint를 연결함
	Cable	: Cable이 연결 된 것처럼 움직이도록 joint 생성
	Axis-based	: Component의 Axis를 기준으로 joint 생성

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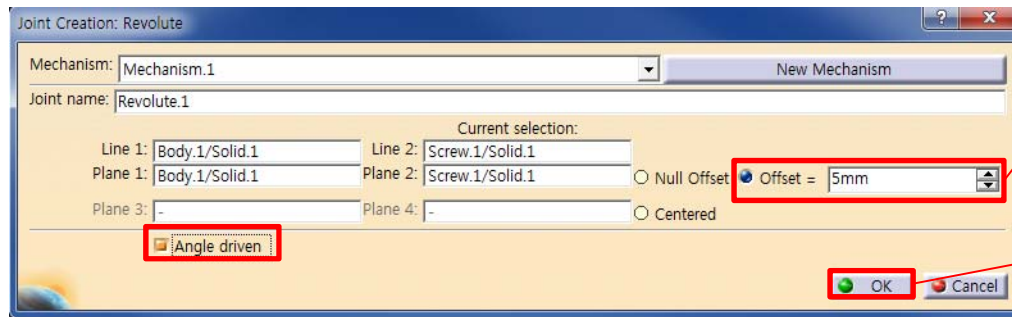
DMU Kinematics



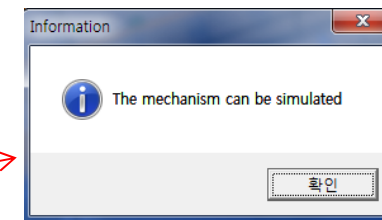
Revolute Joint

- 두 component가 평면을 기준으로 회전하도록 joint 생성

<Line, Plane 선택>

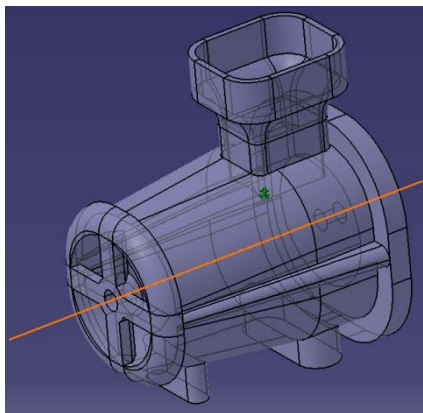


Offset 선택 시, 선택한 plane 사이의
거리가 자동으로 입력됨

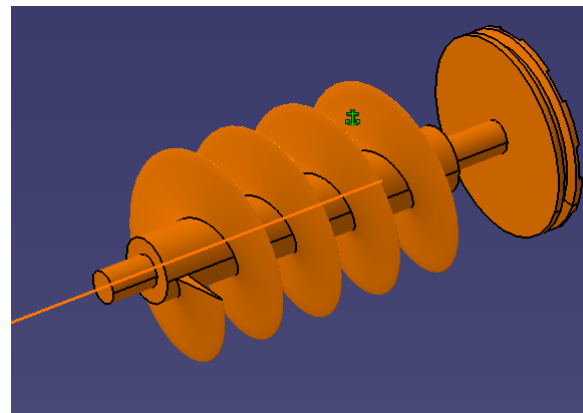


Mechanism이 실행 가능한 경우

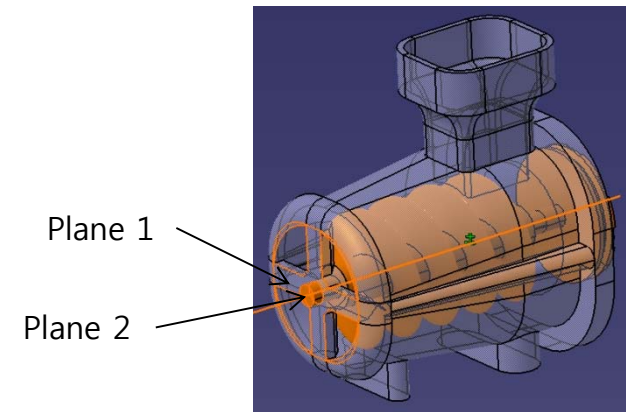
<Line 1>



<Line 2>



<Plane>



DMU KINEMATICS TOOLS

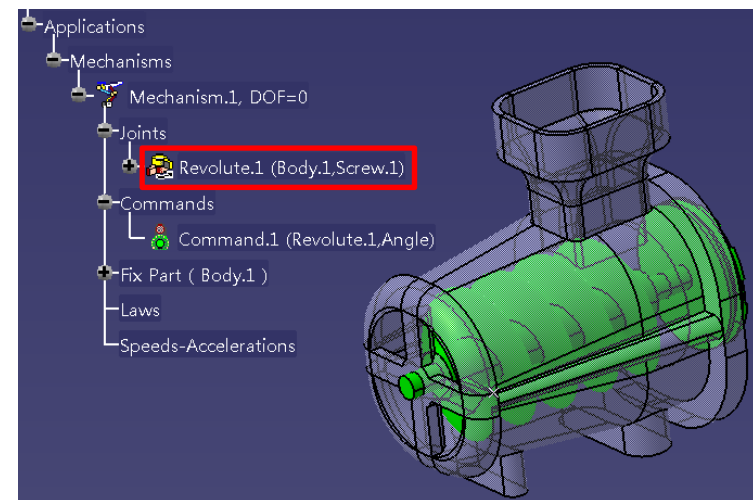
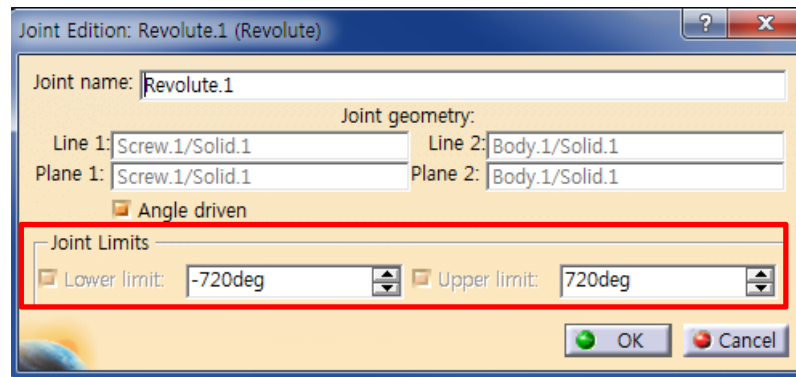
DMU Kinematics



Revolute Joint 

- 두 component가 평면을 기준으로 회전하도록 joint 생성

Joint 생성 후, 생성한 Joint를 더블 클릭하여 Joint Limits 조절 가능



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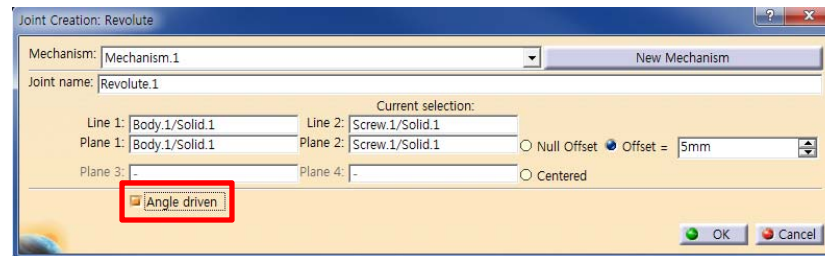
DMU Kinematics



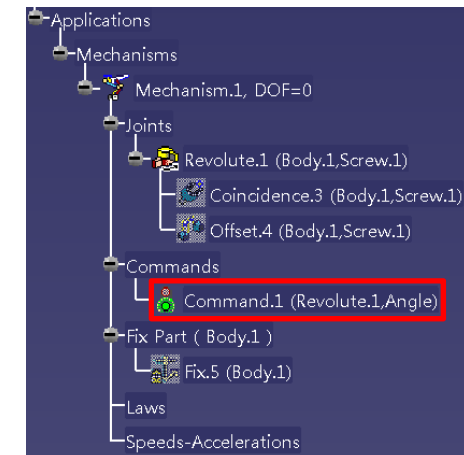
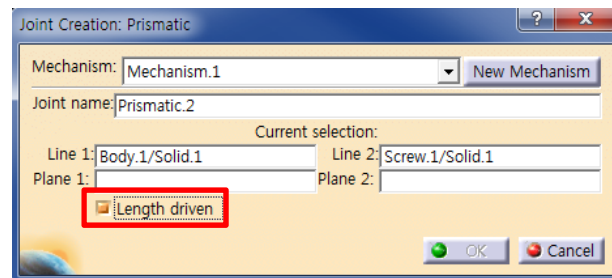
Angle driven/Length driven

- 체크 할 경우 작업 트리에 Command로 생성되며 (오른쪽 그림의 Command.1), 시뮬레이션 툴에서 사용자가 조절 가능한 Command로 나타남. Mechanism 구성 시 최소한 하나의 Command는 필요하며, 체크하지 않을 경우 다른 Joint 운동에 의존하여 움직임.

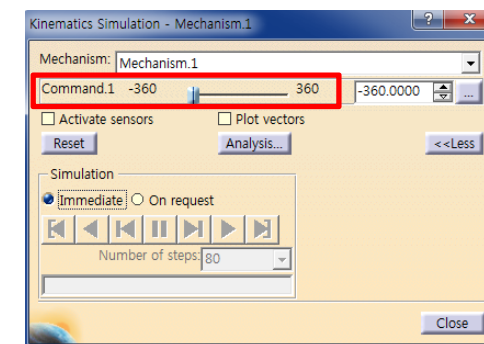
Revolute Joint의 Angle driven



Prismatic Joint의 Length driven



Joint 생성 후 작업트리



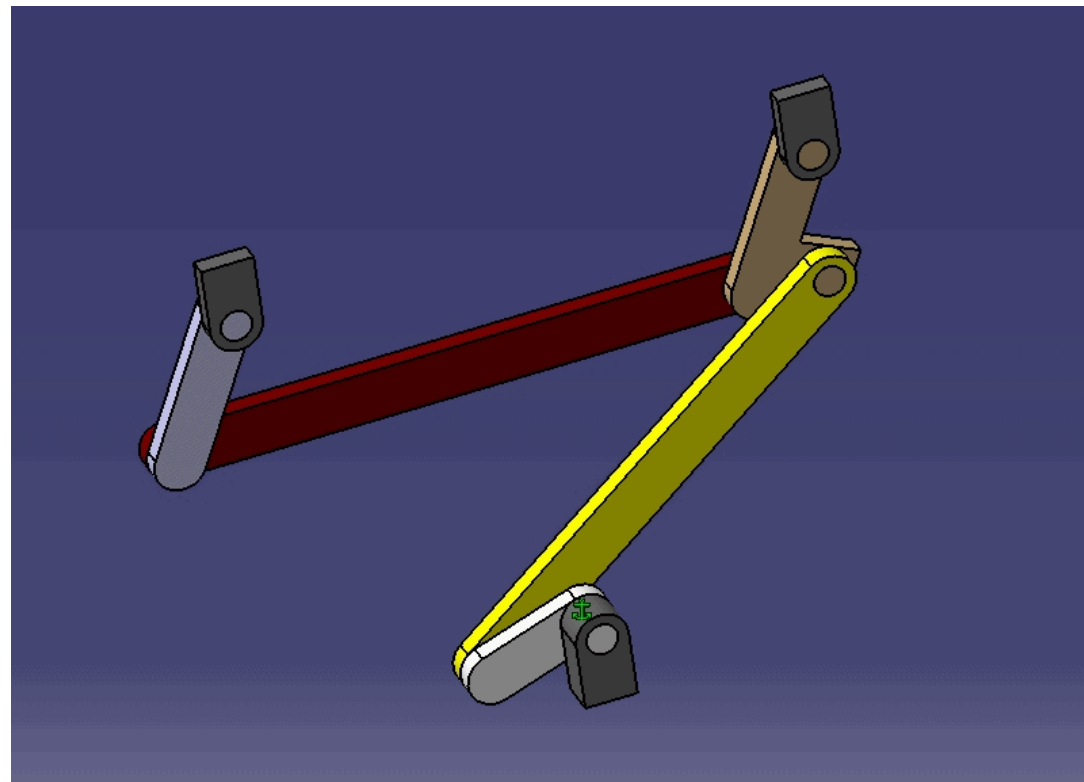
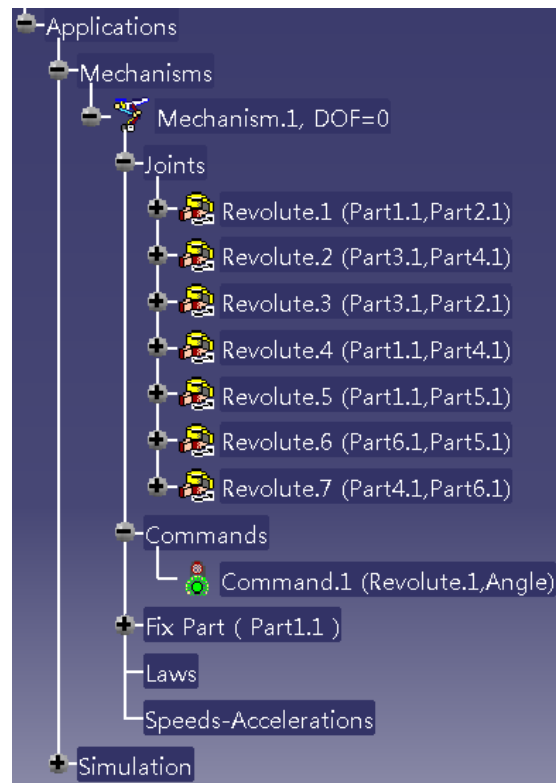
Simulation with Commands

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Wiper Mechanism (Revolute Joint)



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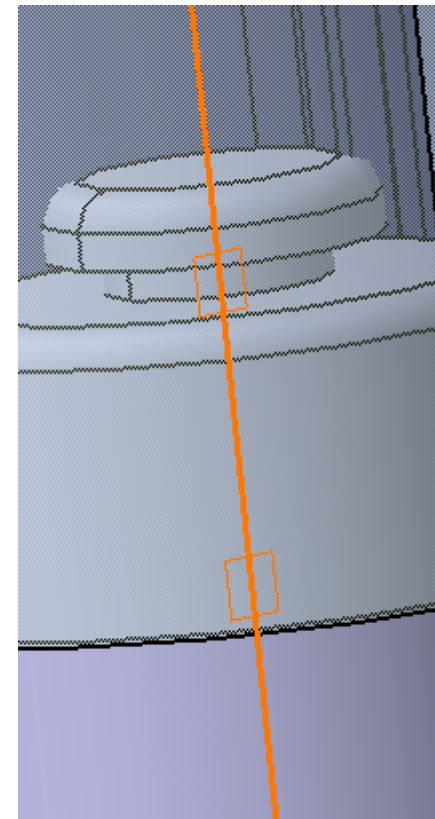
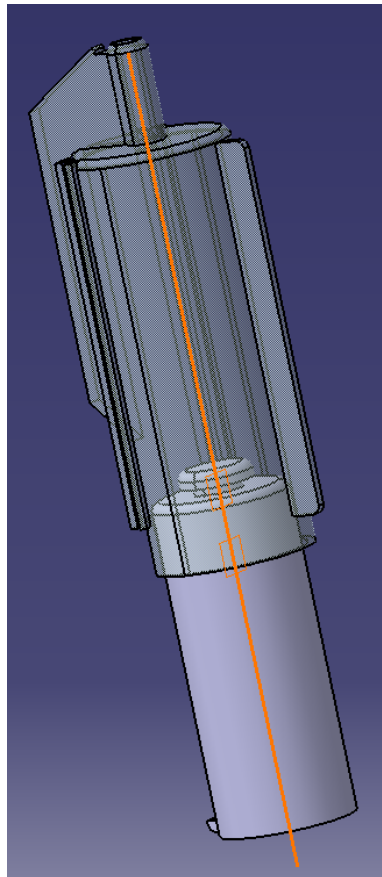
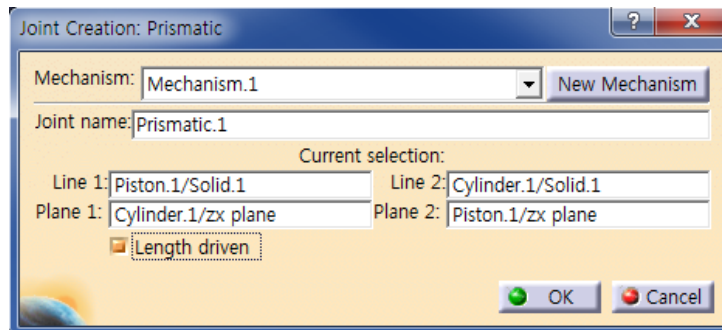
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Prismatic Joint 

- 두 component가 특정 면을 기준으로 병진 운동하도록 joint 생성

<Line, Plane 선택>

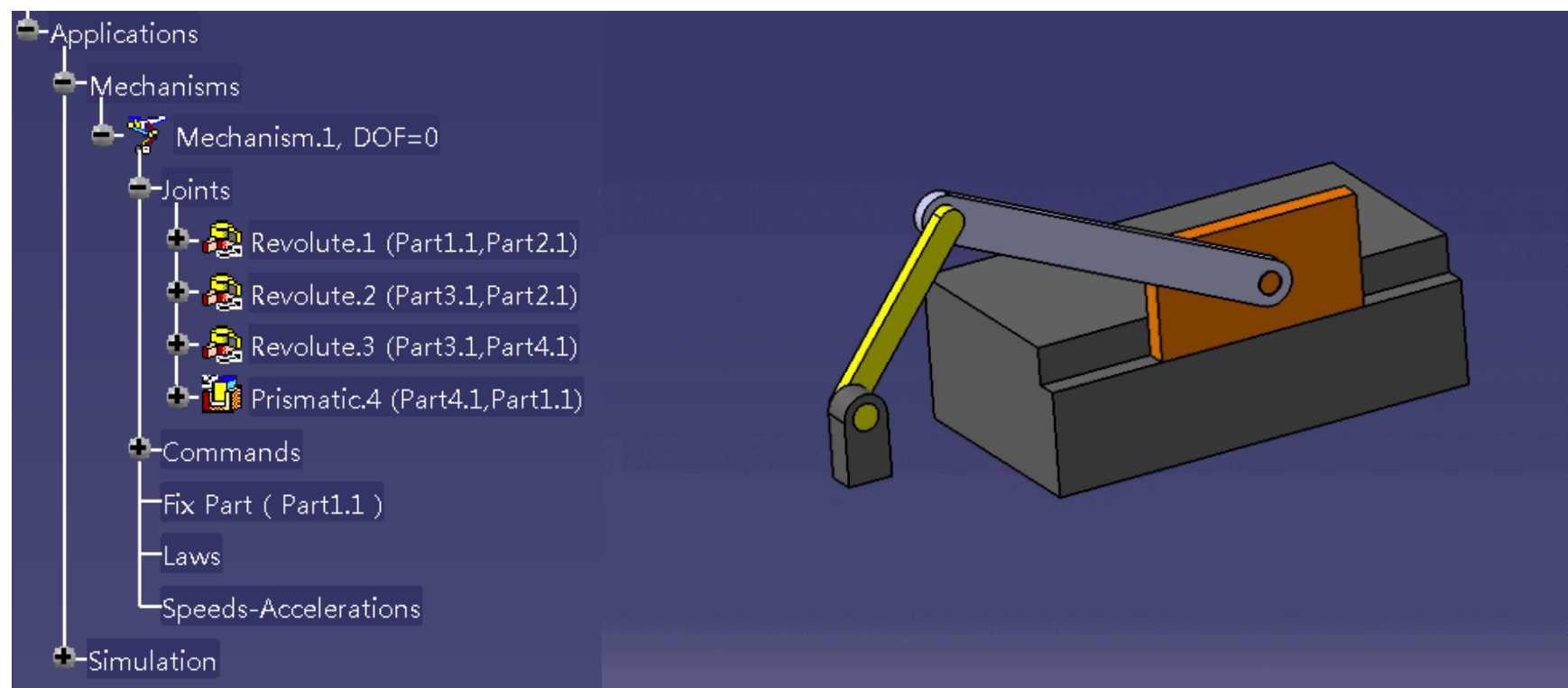


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Crank-Slider Mechanism (Revolute Joint + Prismatic Joint)



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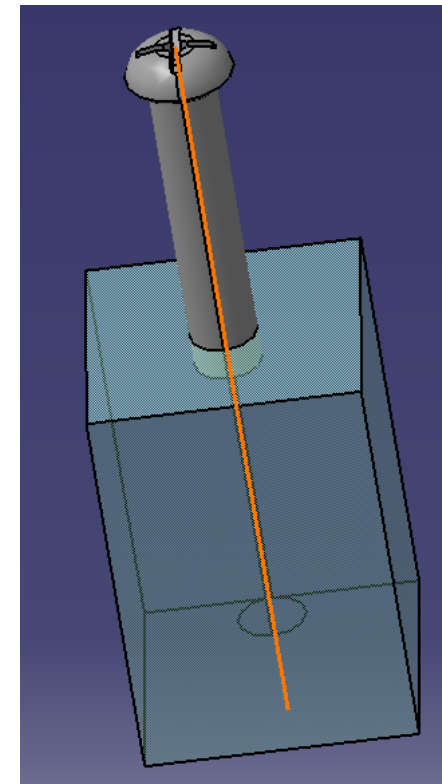
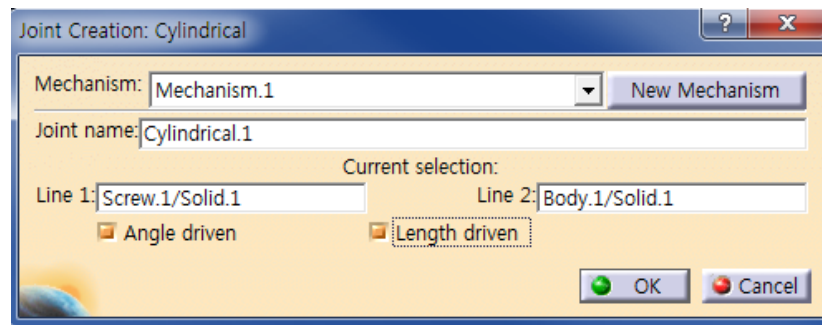
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Cylindrical Joint 

- 두 component가 병진운동과 회전 운동하도록 joint 생성

<Line 선택>



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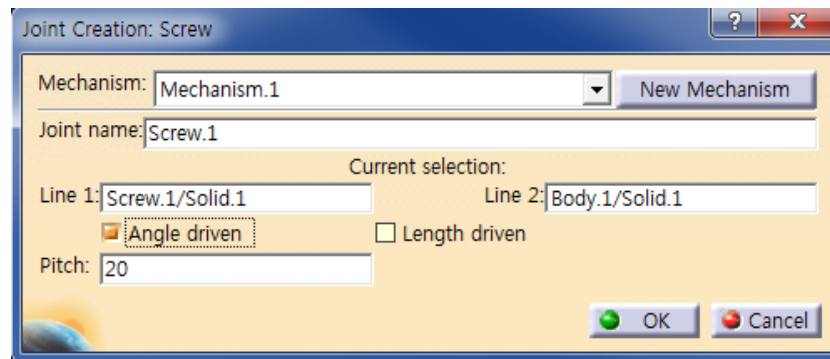
DMU Kinematics



Screw Joint 

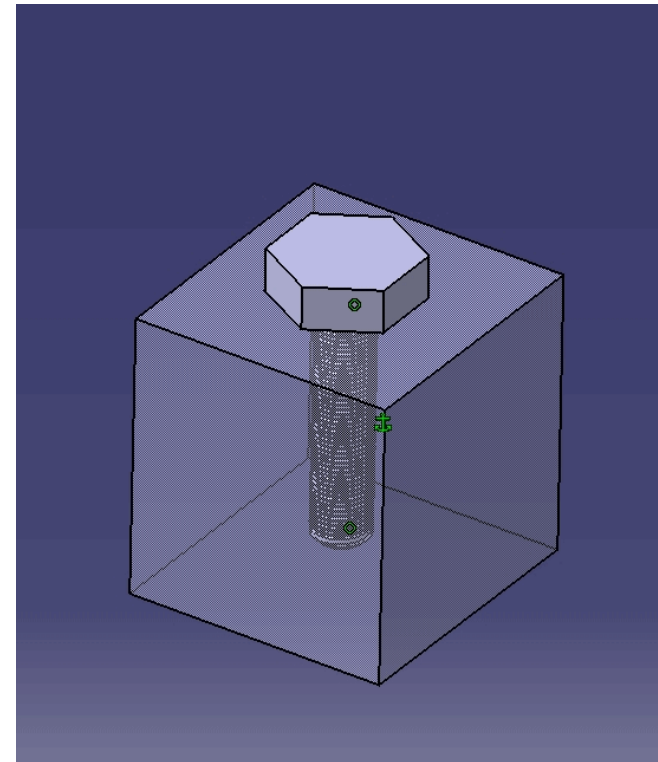
- 두 component가 pitch 값을 기준으로 회전과 병진 운동하도록 joint 생성

<Line 선택, Pitch값 입력>



Angle driven & Pitch : 지정해준 각도만큼 회전하며, 360도 회전할 때 지정한 pitch 값 만큼 이동함.

Length driven & Pitch : 지정해준 길이만큼 움직이며, 입력한 pitch 값 만큼 이동할 때 360도 회전함.



DMU KINEMATICS TOOLS

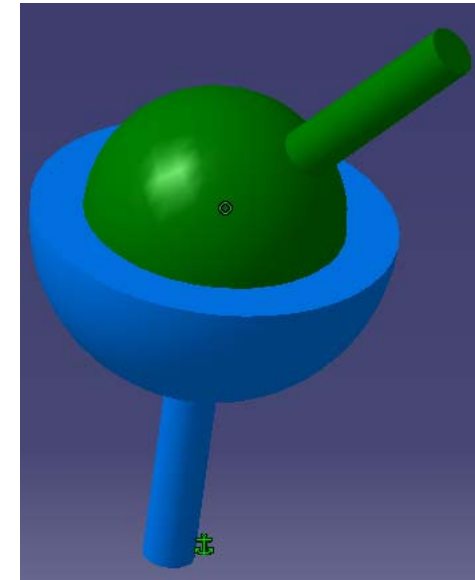
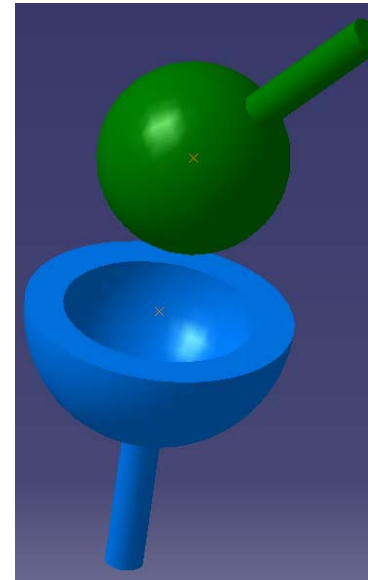
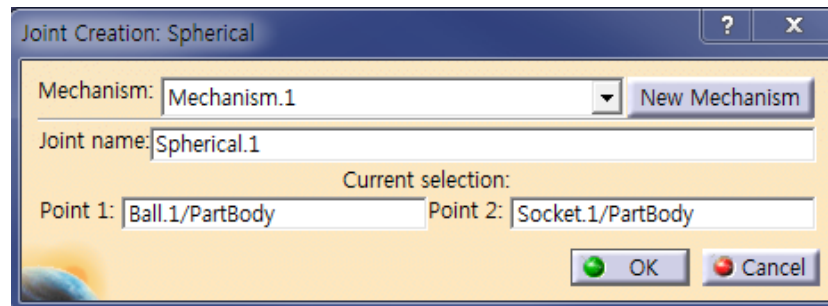
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Spherical Joint 

- 두 component가 특정한 point를 중심으로 운동하도록 joint 생성

<Point 선택>



DMU KINEMATICS TOOLS

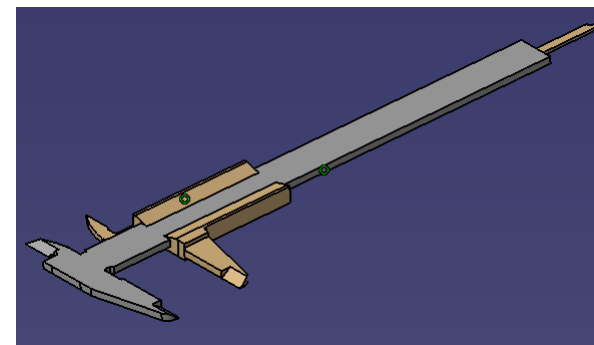
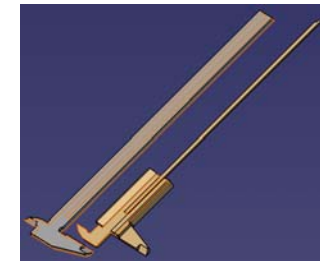
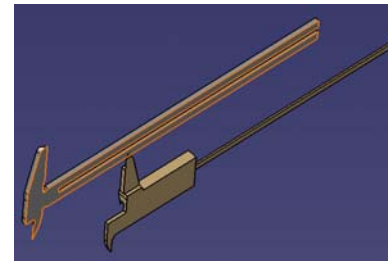
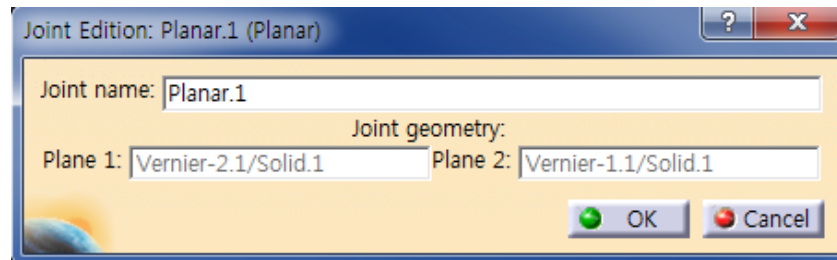
DMU Kinematics



Planar Joint 

- 두 component가 특정한 plane를 중심으로 운동하도록 joint 생성

<Plane 선택>



DMU KINEMATICS TOOLS

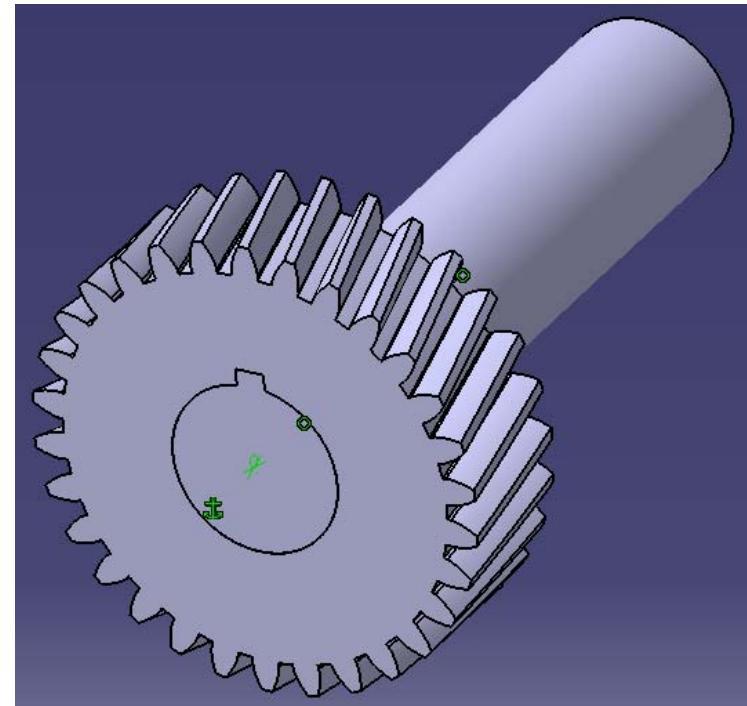
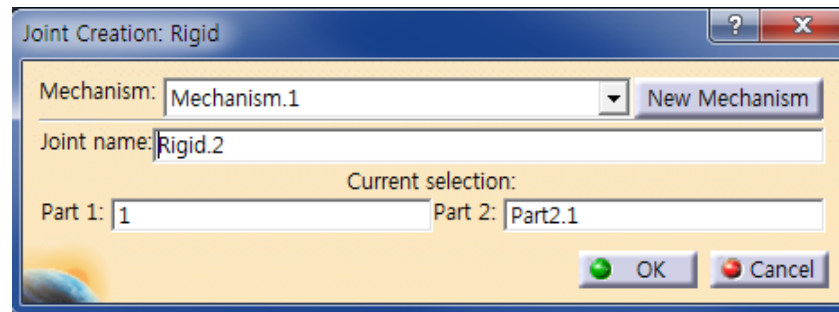
DMU Kinematics



Rigid Joint 

- 두 component의 상대위치를 고정시켜주는 joint를 생성

<Component 선택>



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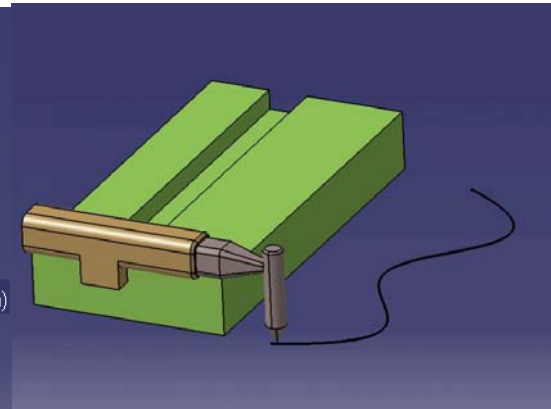
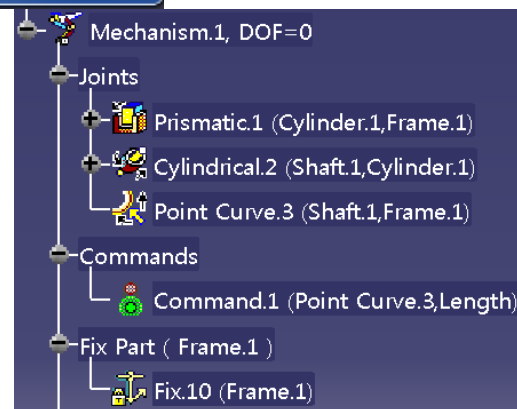
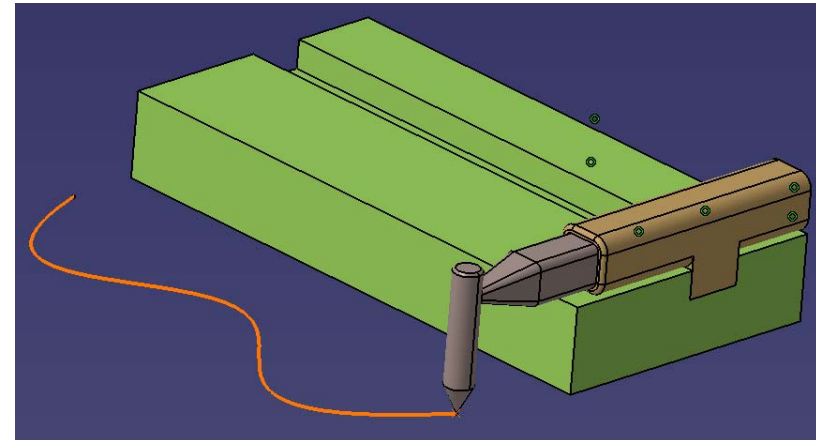
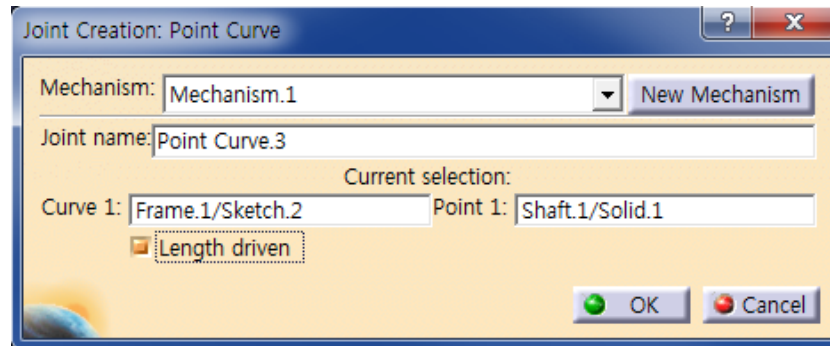
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Point Curve Joint 

- 특정 점이 특정 곡선을 따라 움직이도록 joint 생성

<Curve, Point 선택>



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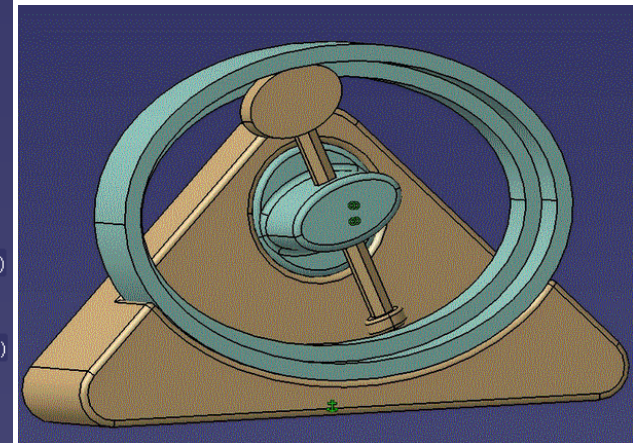
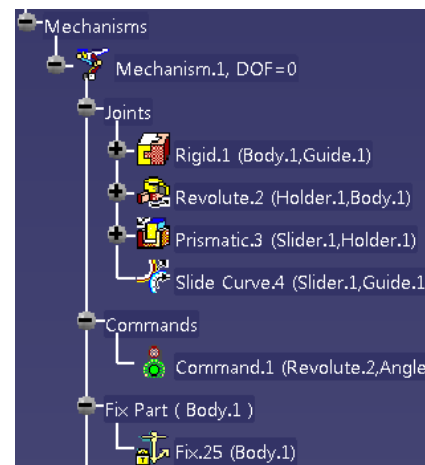
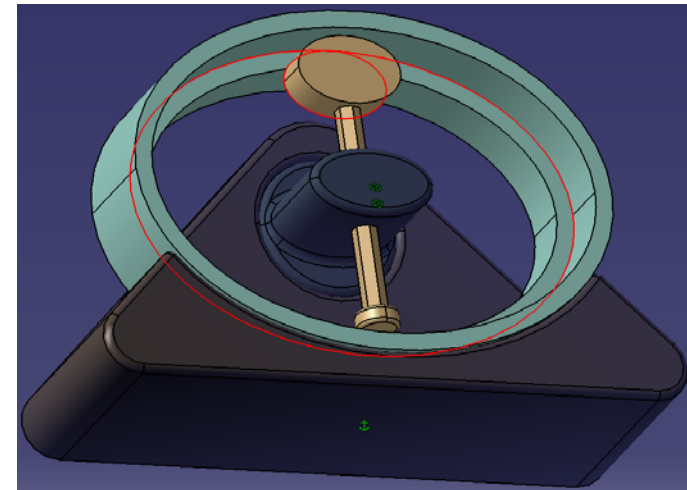
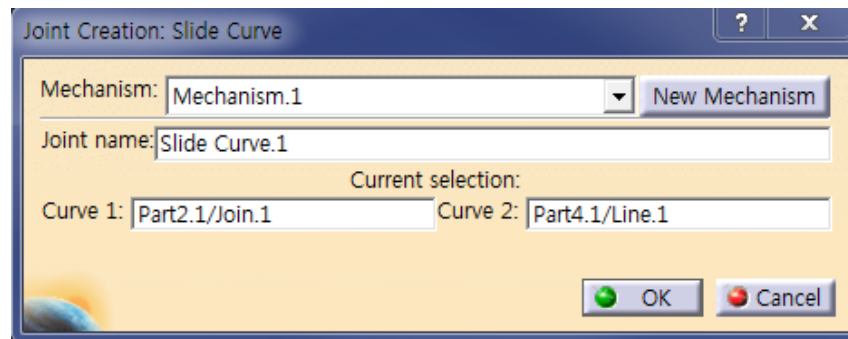
DMU Kinematics



Slide Curve Joint 

- 특정 곡선이 다른 곡선을 따라 움직이도록 joint 생성

<Curve 선택>



DMU KINEMATICS TOOLS

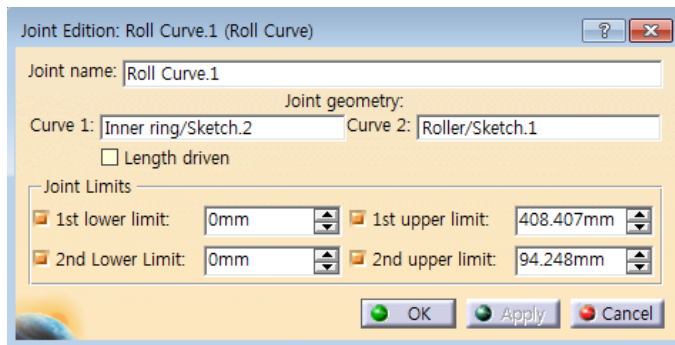
DMU Kinematics



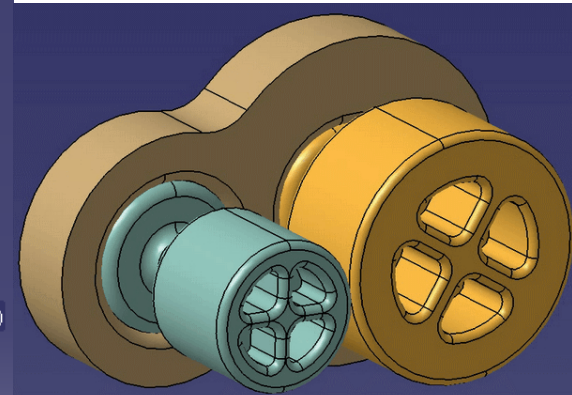
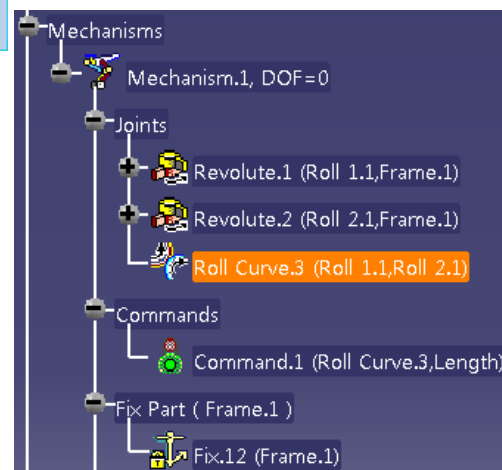
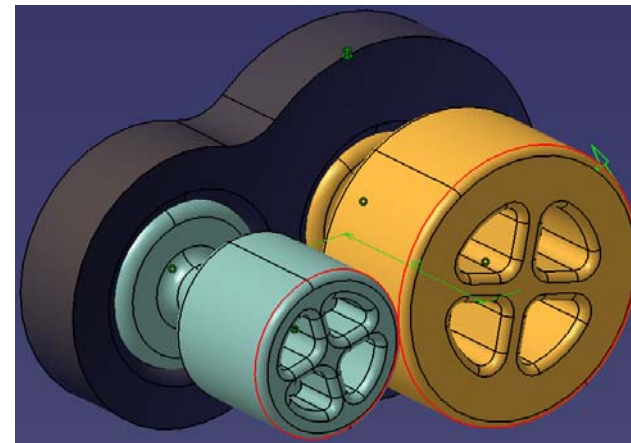
Roll Curve Joint 

- 특정 곡선끼리 맞물려 움직이도록 joint 생성

<Curve 선택>



Roll Curve Joint

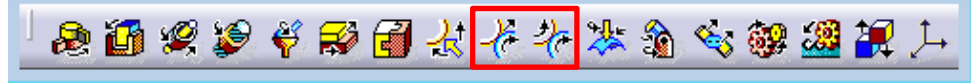


DMU KINEMATICS TOOLS

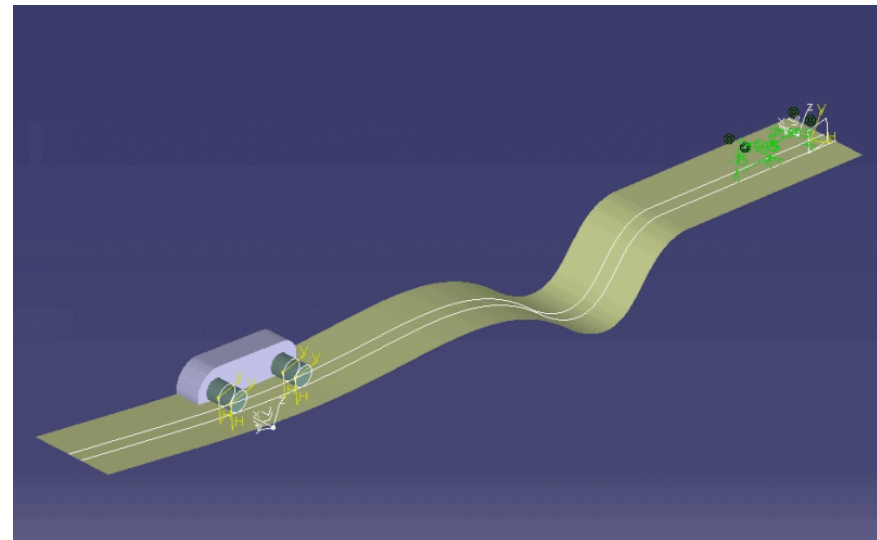
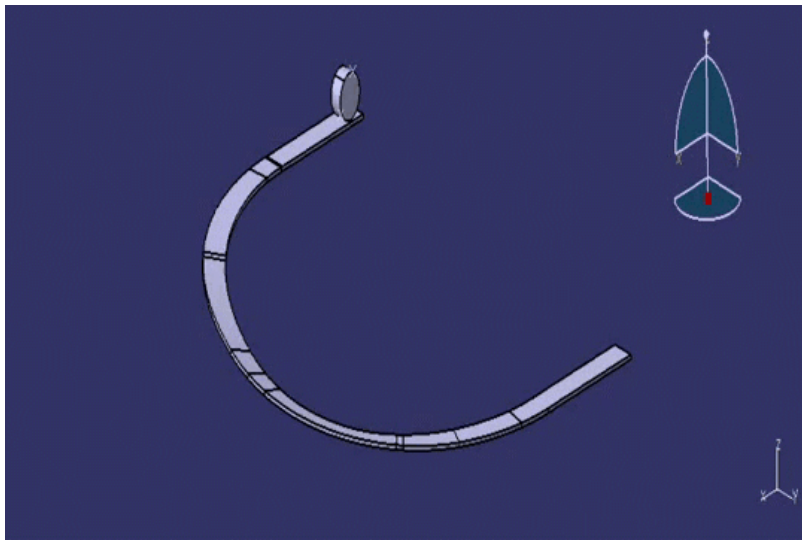
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Kinematics Joints



Slide Curve Joint + Roll Curve Joint



<http://cadsystemshelp.blogspot.kr/2012/03/how-do-you-simulate-rolling-in-catia.html>

DMU KINEMATICS TOOLS

DMU Kinematics

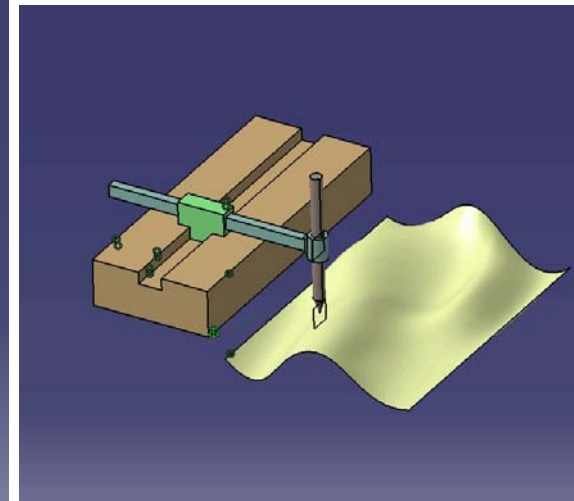
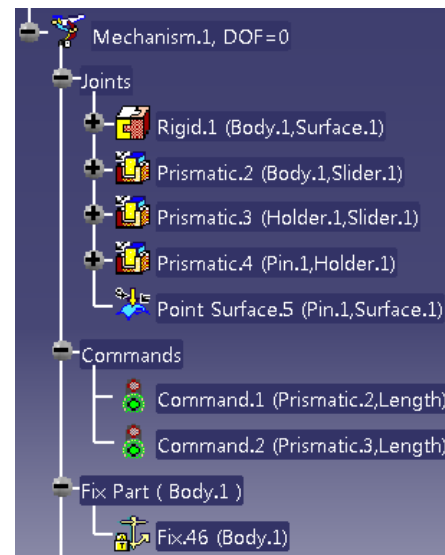
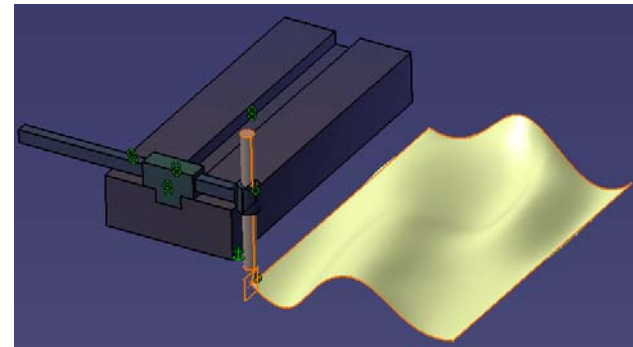
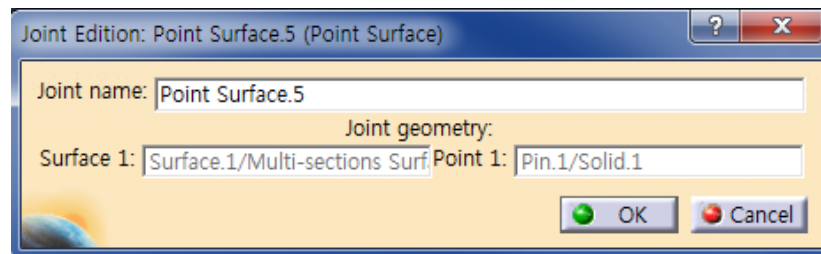


Point Surface Joint



- 특정 점이 특정 곡면을 따라 움직이도록 joint 생성

<Surface, Point 선택>



DMU KINEMATICS TOOLS

DMU Kinematics



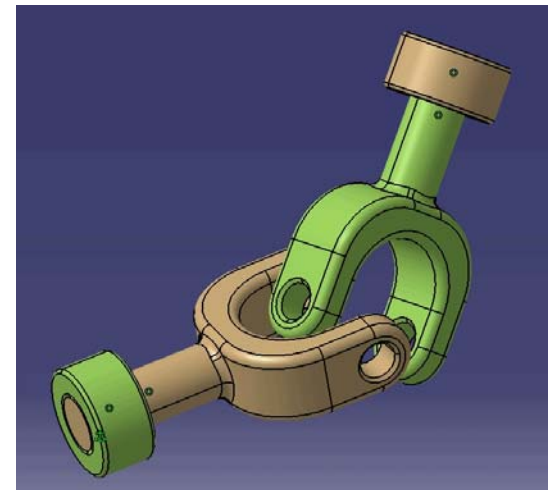
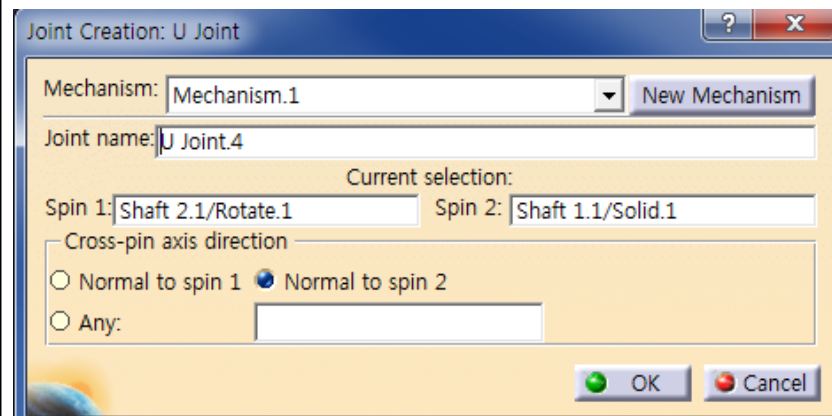
Kinematics Joints



Universal Joint 

- 두 축을 연결해주기 위한 joint 생성

<연결할 축 선택>



DMU KINEMATICS TOOLS

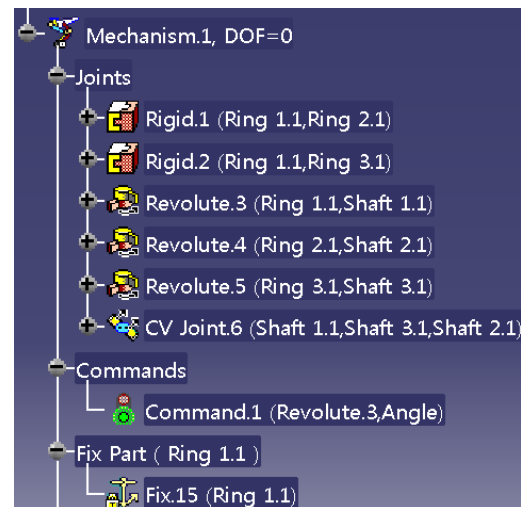
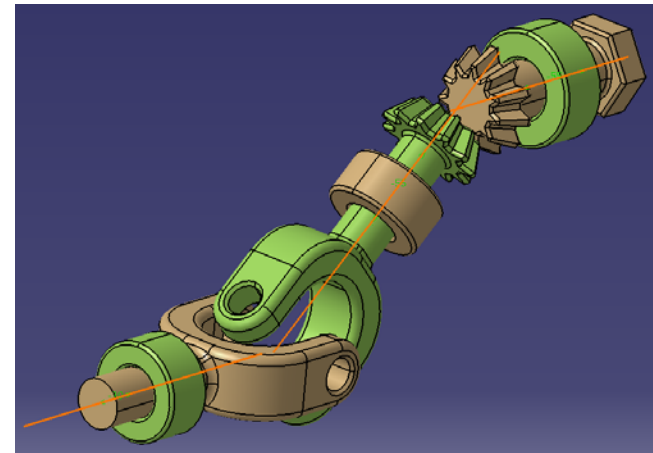
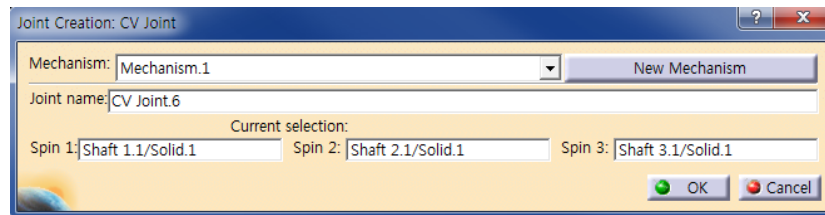
DMU Kinematics



CV Joint 

- 3개의 축을 연결해 주기 위한 joint 생성

<연결할 축 선택>



DMU KINEMATICS TOOLS

DMU Kinematics

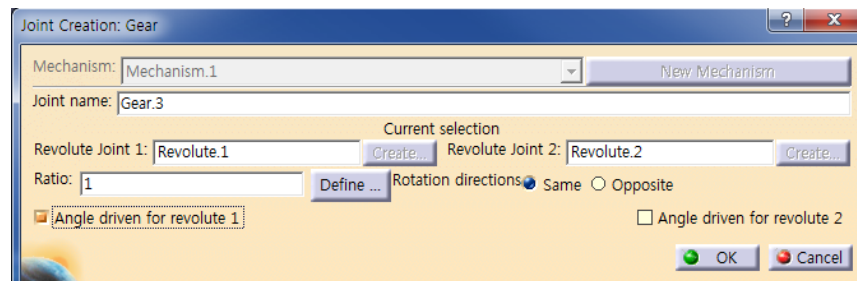


Gear Joint

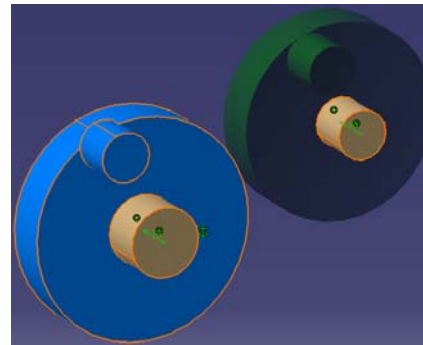


- 기어 비를 이용하여 회전운동 하도록 joint 생성

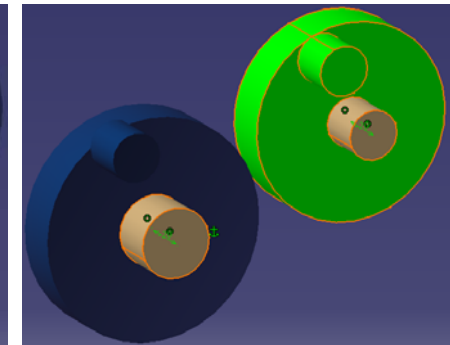
<Revolute joint 선택>



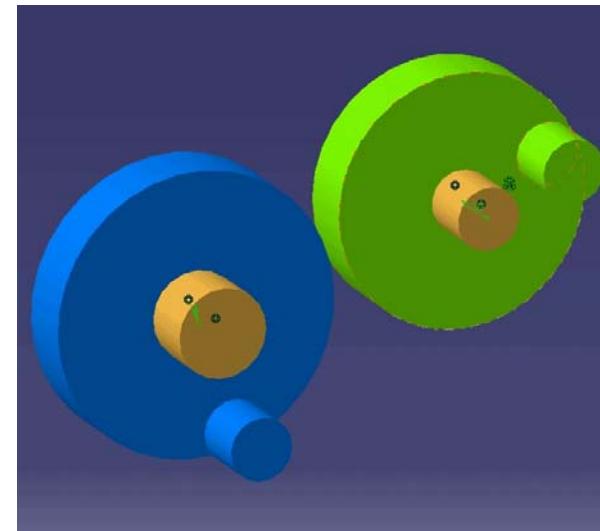
$$: Ratio = \frac{\text{Revolute Joint 2 의 회전수}}{\text{Revolute Joint 1 의 회전수}}$$



<Revolute Joint 1>



<Revolute Joint 2>



DMU KINEMATICS TOOLS

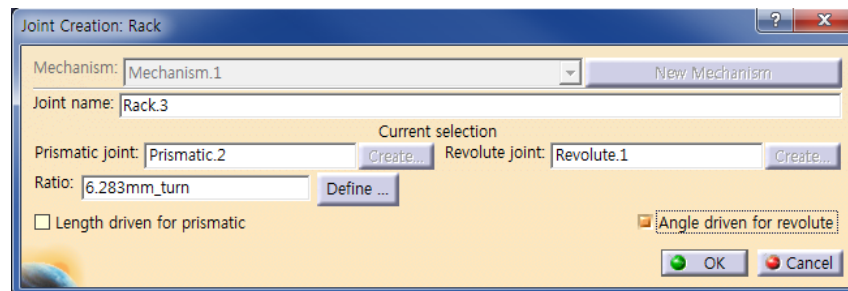
DMU Kinematics



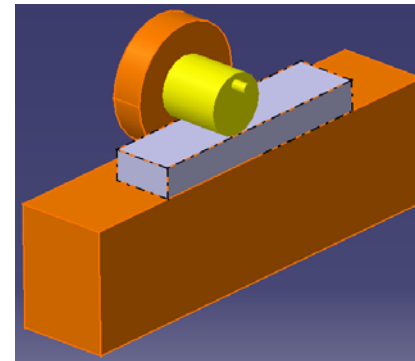
Rack Joint 

- 기어 비를 이용하여 회전/병진 운동하도록 joint 생성

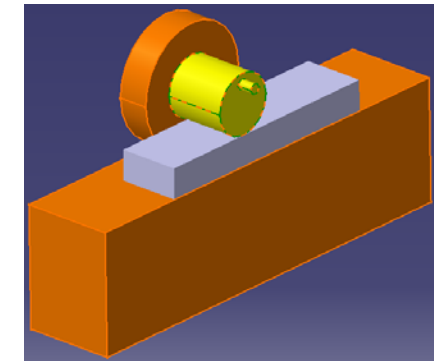
<Prismatic, Revolute 선택>



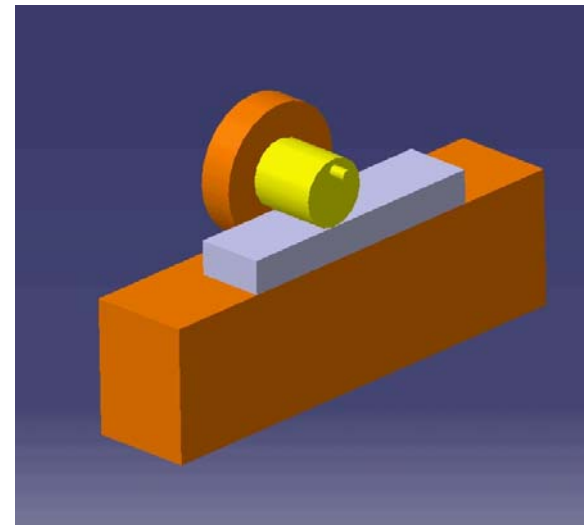
: $Ratio = \text{이동 길이} / \text{회전}$



<Prismatic>



<Revolute>



DMU KINEMATICS TOOLS

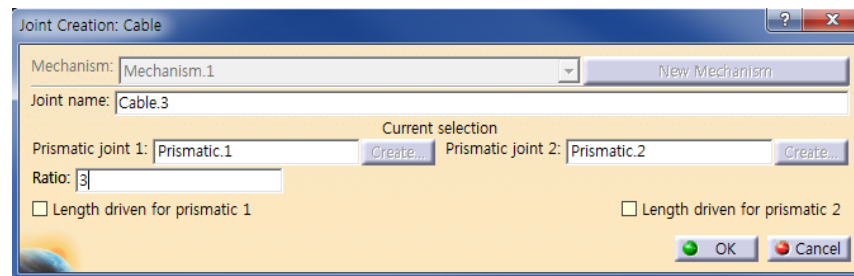
DMU Kinematics



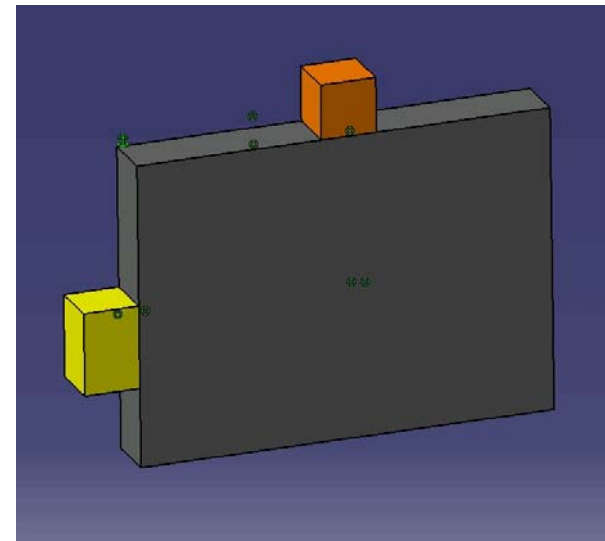
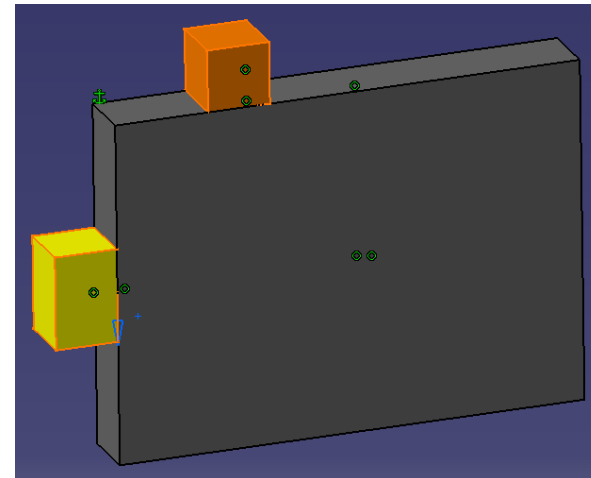
Cable Joint 

- Cable이 연결 된 것처럼 움직이도록 joint 생성

<Prismatic joint 선택>



$$: Ratio = \frac{\text{Prismatic Joint 2의 이동길이}}{\text{Prismatic Joint 1의 이동길이}}$$

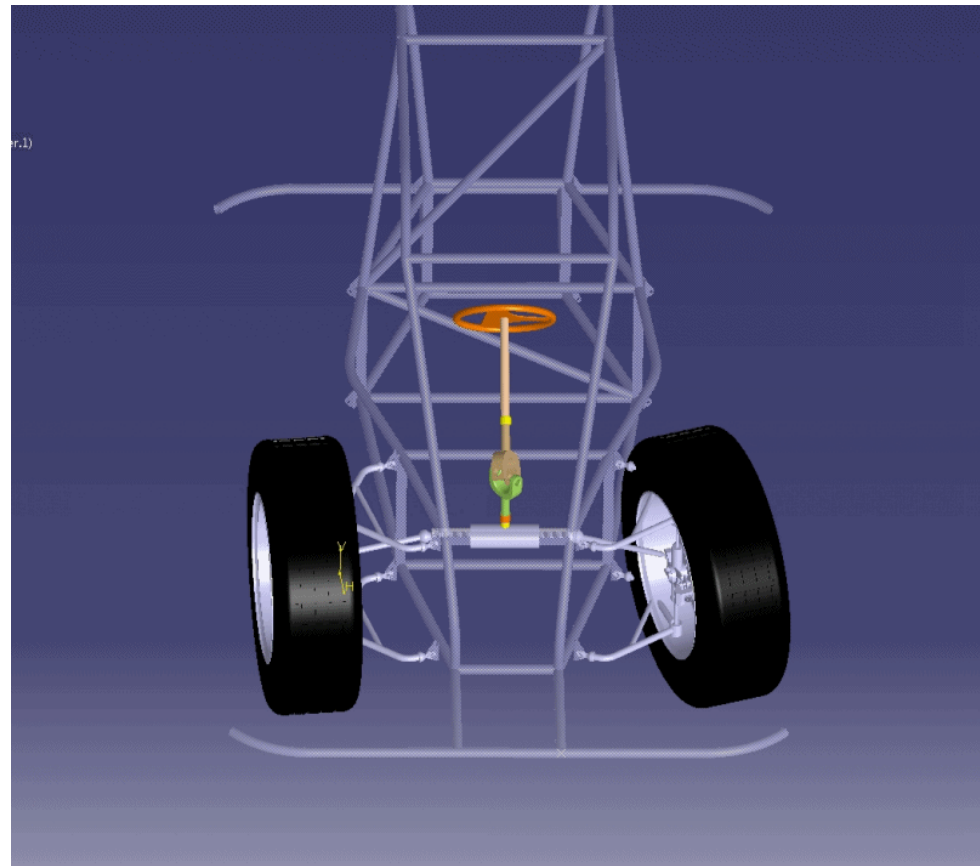
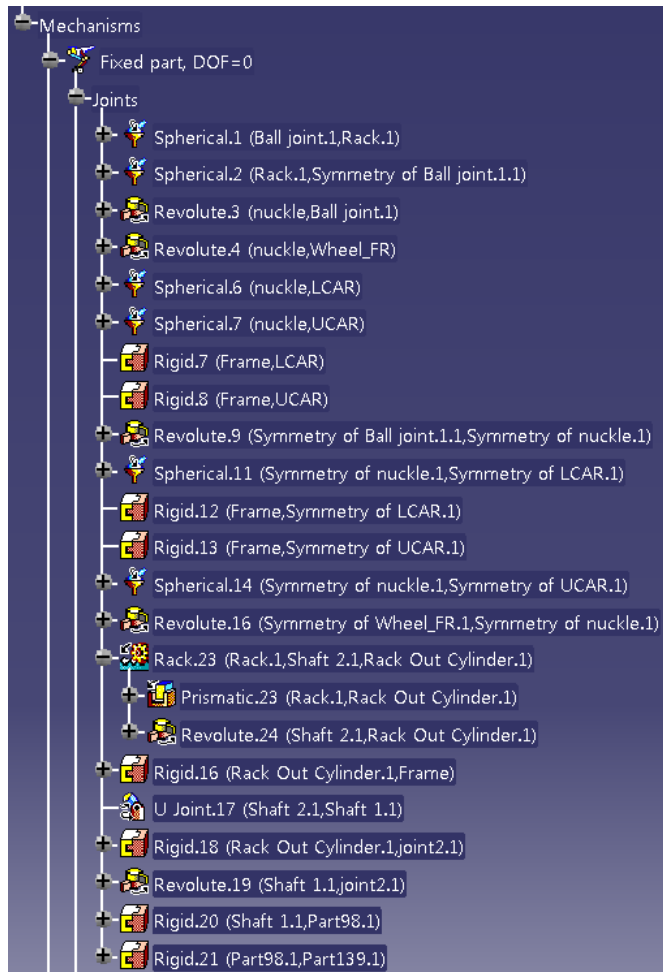


DMU KINEMATICS TOOLS

DMU Kinematics



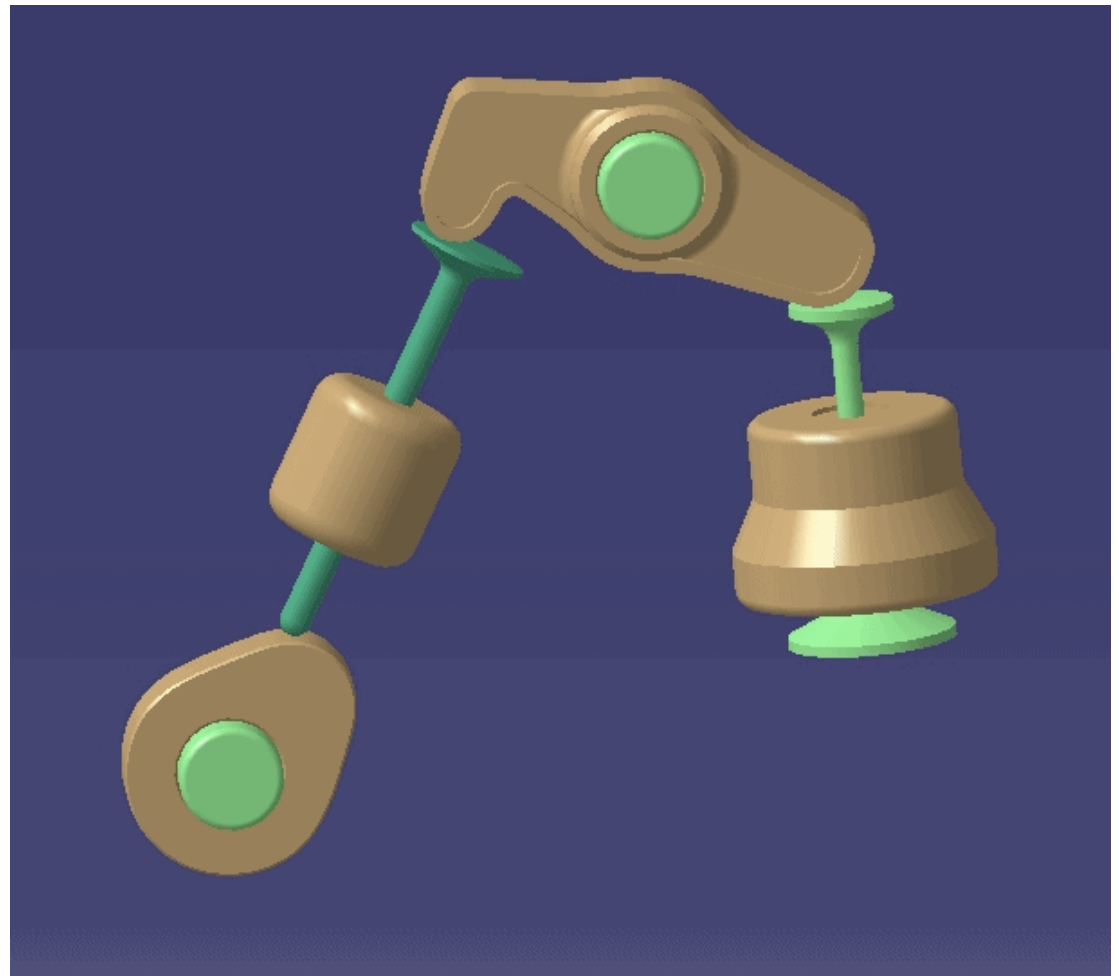
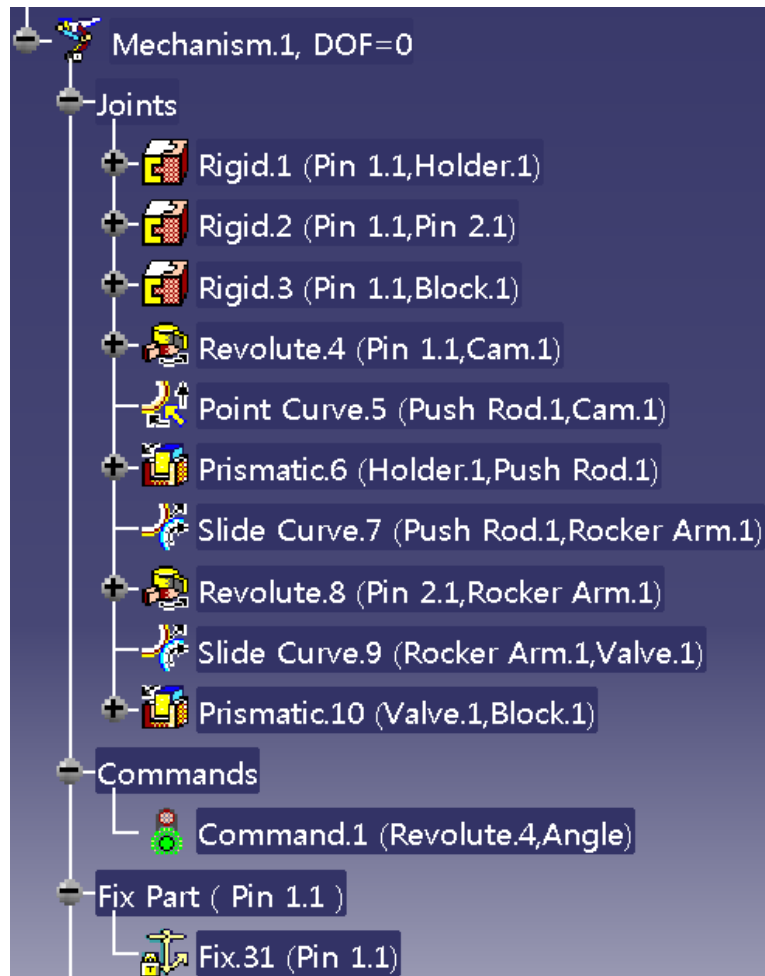
Steering System Mechanism



2012 CAD Project – '조석' 팀 수정 자료

실습 예제

홈페이지의 Practice 파일을 이용하여 아래의 그림과 같이 DMU Kinematics 작업을 진행하기



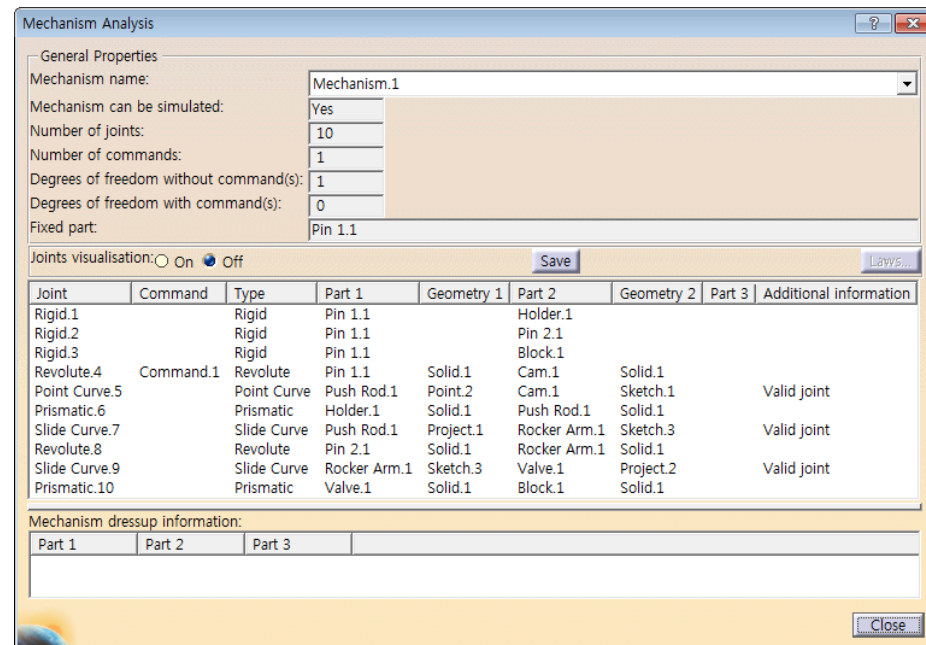
DMU KINEMATICS TOOLS

DMU Kinematics



Mechanism Analysis 

-생성된 joint들의 연결 상태를 확인함



DMU KINEMATICS TOOLS

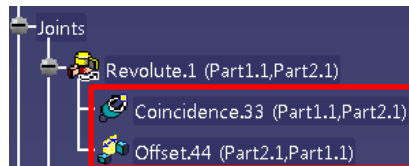
DMU Kinematics



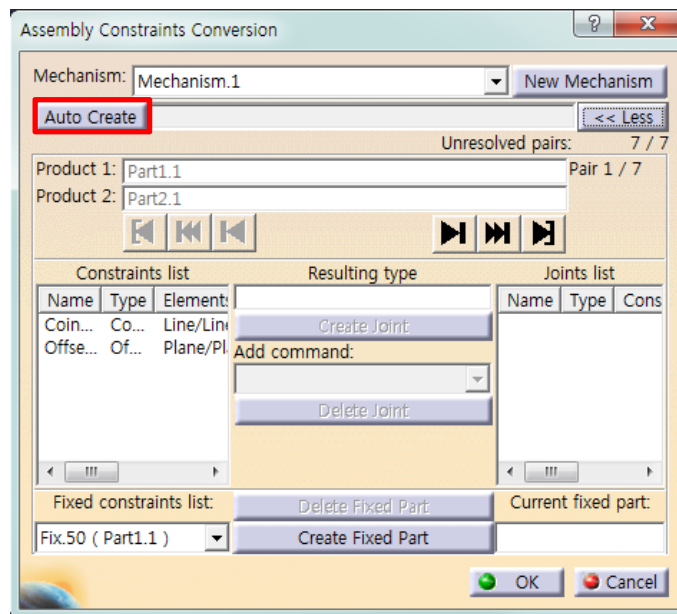
Assembly Constraints Conversion



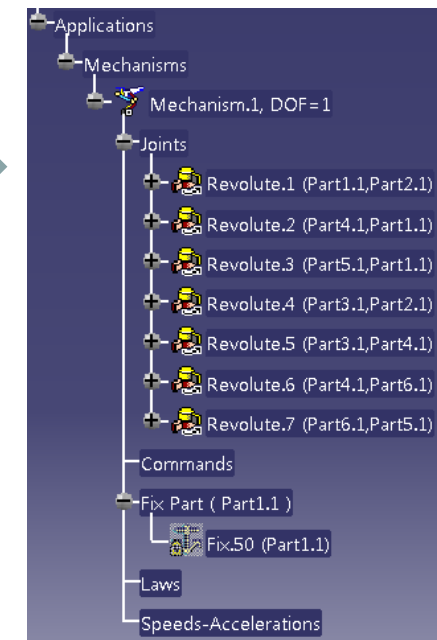
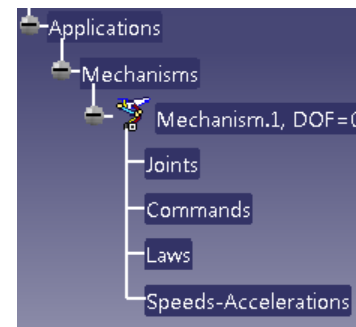
- Assembly Design에서 생성한 constraint를 Joint로 변경



여러 개의 constraint로 구성된 joint



Joint 자동 생성



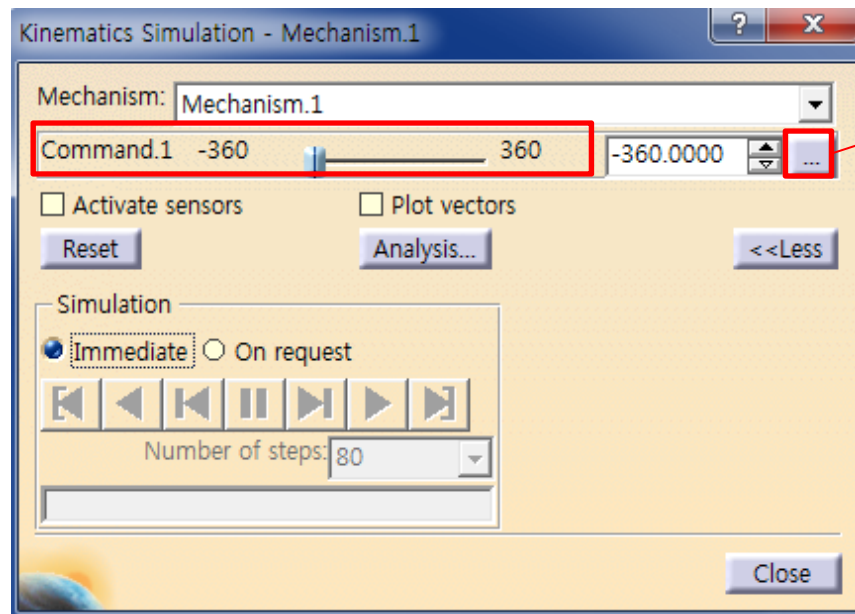
DMU KINEMATICS TOOLS

DMU Kinematics



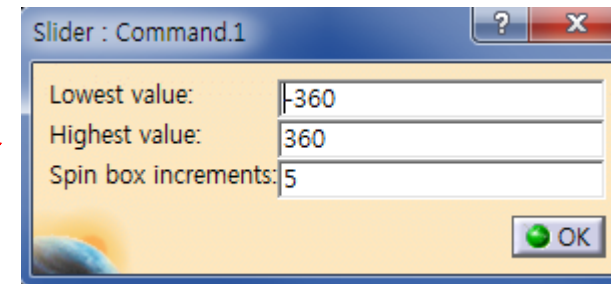
Simulation with Commands 

- 생성된 mechanism이 command를 기준으로 동작

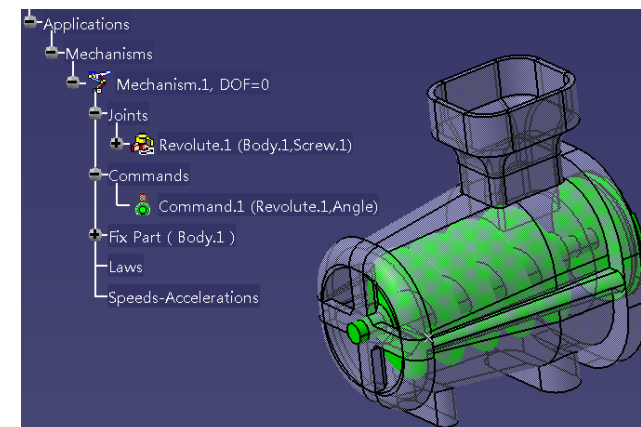


Joint에서의 Angle/Length driven 수만큼 Command가 생성됨

Command의 Limits 조절 가능



Revolute Joint 모델



DMU KINEMATICS TOOLS

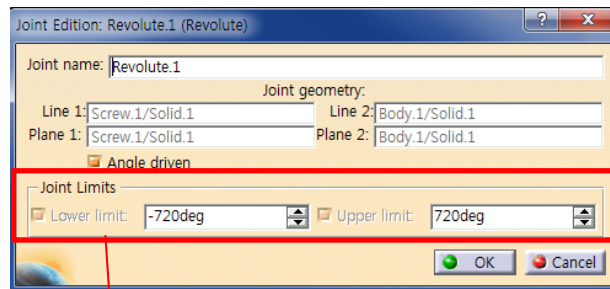
DMU Kinematics



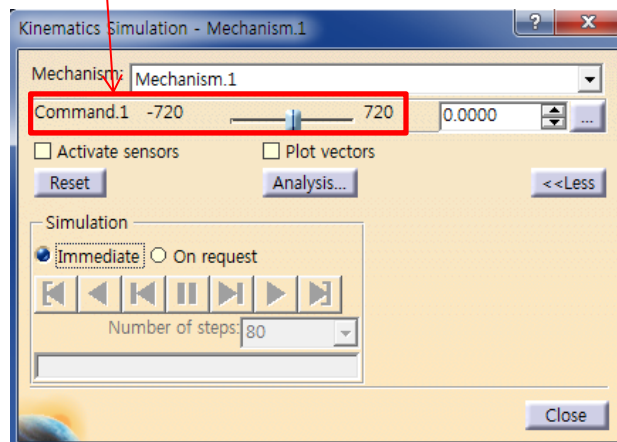
Simulation with Commands 

- 생성된 mechanism이 command를 기준으로 동작

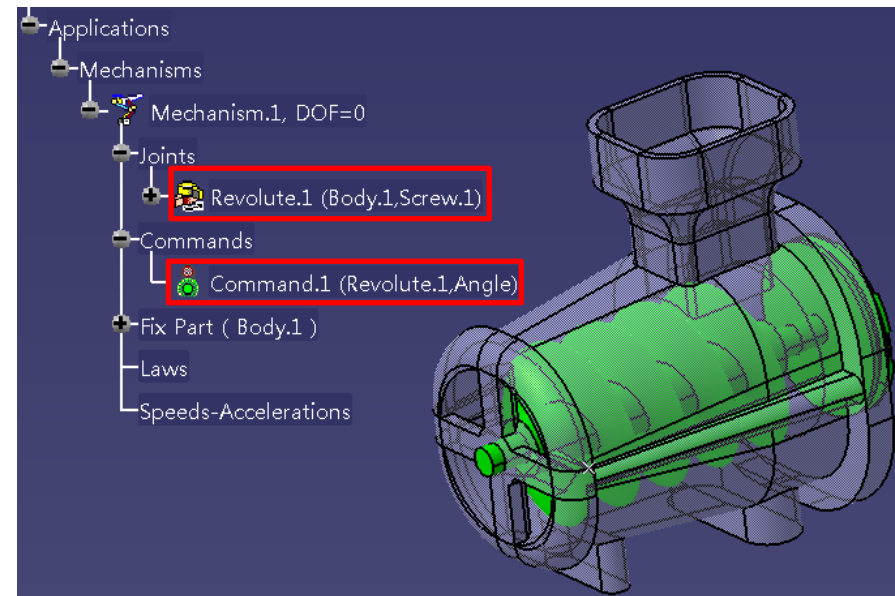
생성한 Joint를 더블 클릭하여 Limits 조절 가능



Simulation Command의 Limits이 됨



Revolute Joint 모델



DMU KINEMATICS TOOLS

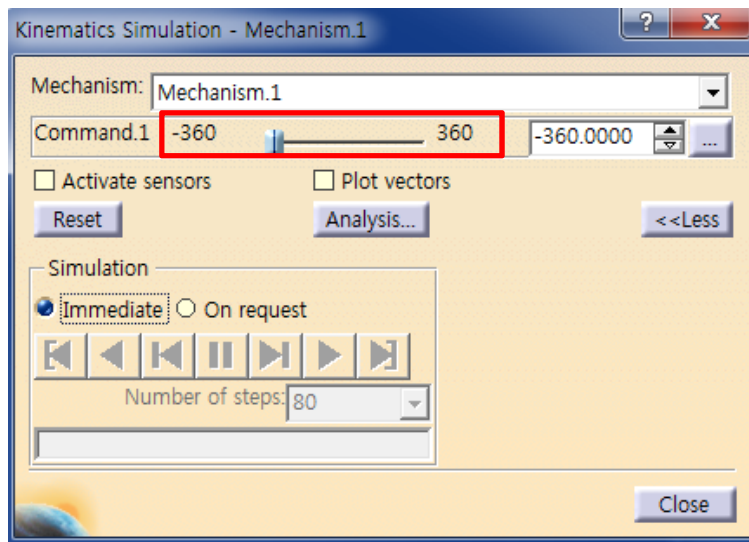
DMU Kinematics



Simulation with Commands 

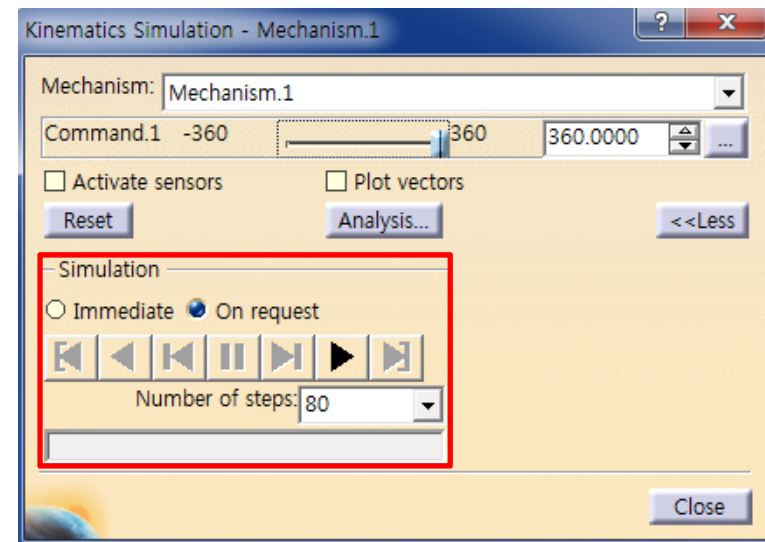
- 생성된 mechanism이 command를 기준으로 동작

스크롤이 이동하는 만큼 mechanism이 구동



Simulation: Immediate

움직인 command 값을 steps수로 나누어 연속적으로 구동



Simulation: On request

DMU KINEMATICS TOOLS

DMU Kinematics

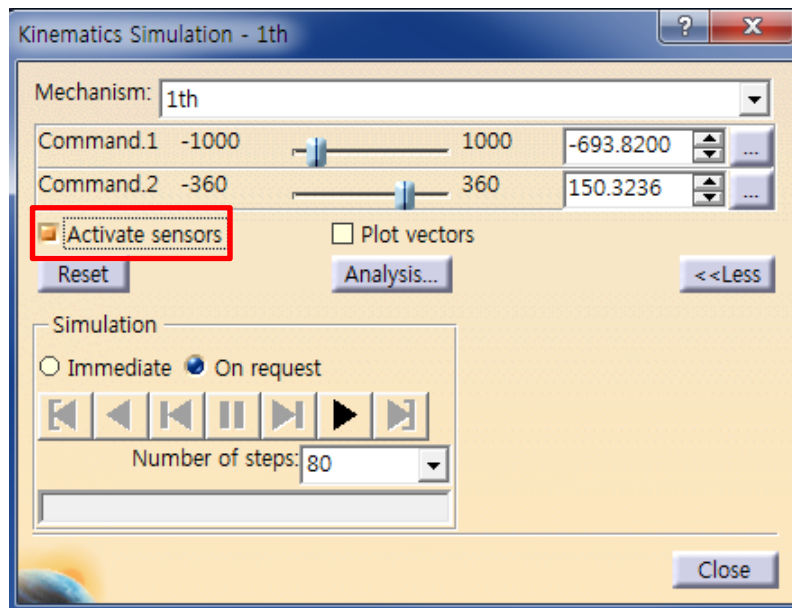


Simulation with Commands

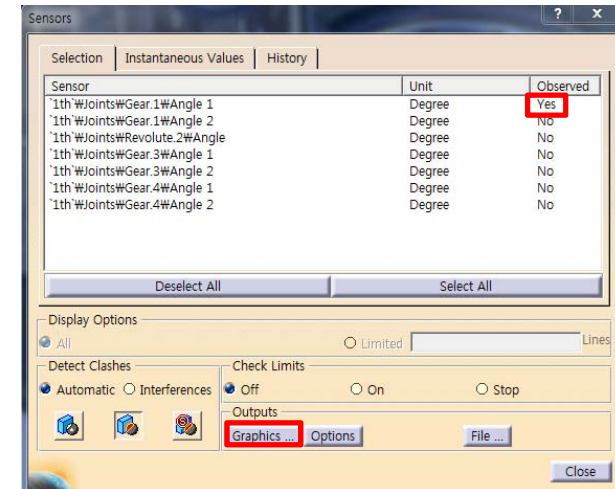


- 생성된 mechanism이 command를 기준으로 동작

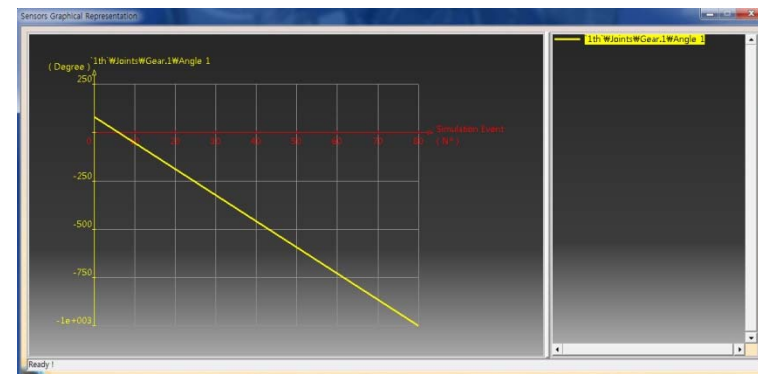
Command를 통해 움직인 Joint의 변화량을 그래프로 확인 가능



측정하고자 하는 Joint를 No→Yes로 변경 (클릭)



시뮬레이션 재생 후 위 그림의 Graphics를 클릭하면 결과 값이 그래프로 나타남



DMU KINEMATICS TOOLS

DMU Kinematics



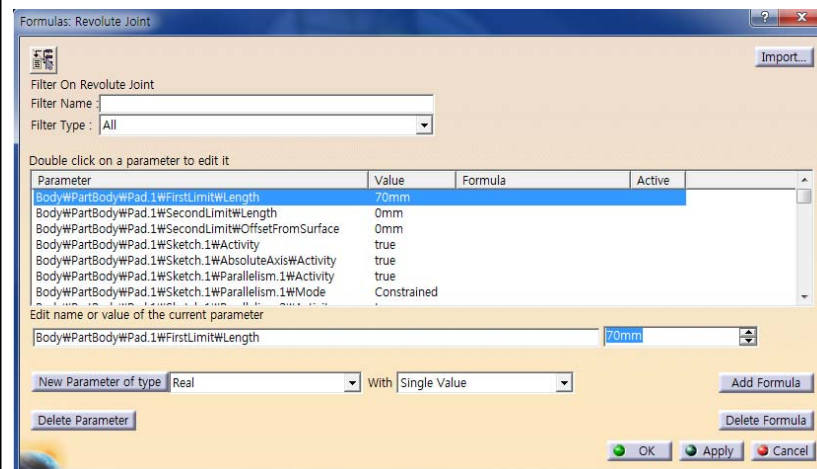
Simulation with Laws 

- 생성한 Formula를 기준으로 시뮬레이션 적용 (시간에 대한 변수 사용)

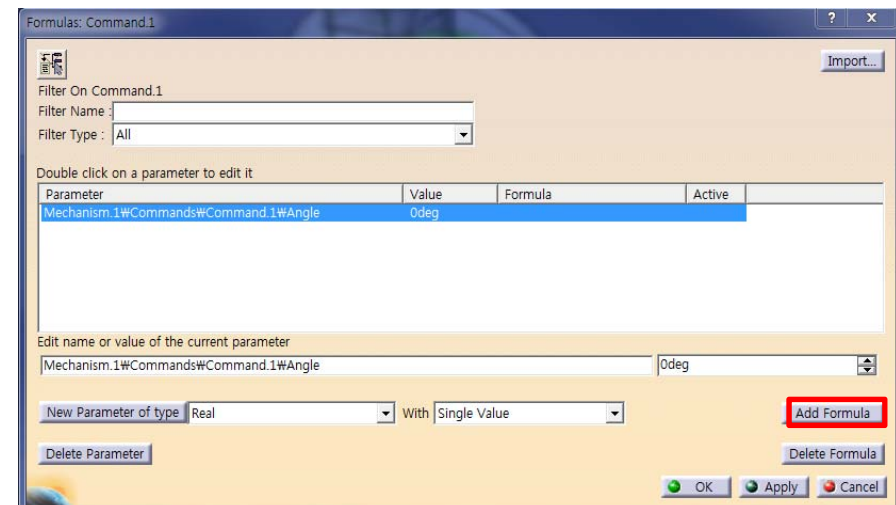
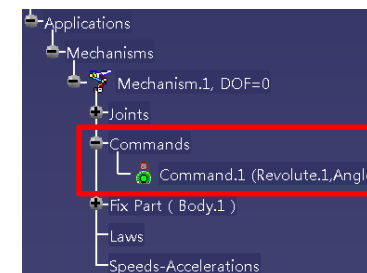
① 화면 하단의 툴바에서 Formula 선택



Formula 초기 화면



② 적용할 command를 더블클릭 후 Add Formula 클릭



DMU KINEMATICS TOOLS

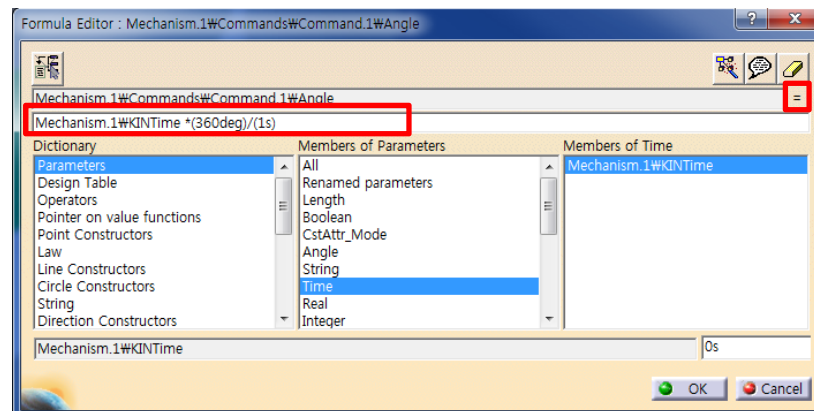
DMU Kinematics



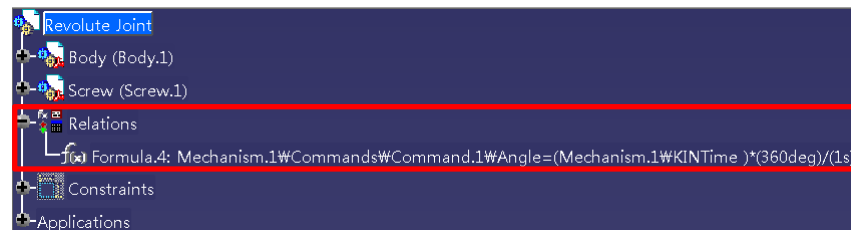
Simulation with Laws 

- 생성한 Formula를 기준으로 시뮬레이션 적용 (시간에 대한 변수 사용)

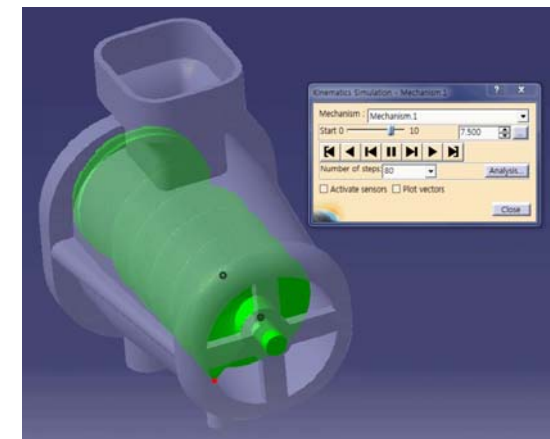
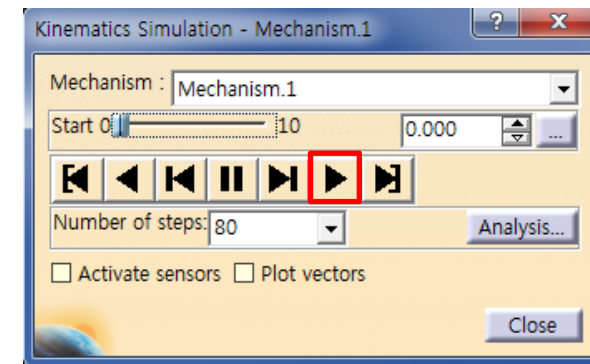
- ③ Parameters → Time → WKINTime 더블 클릭 후
수식 입력 후 Ok 클릭 < Mechanism.1#WKINTime *(360deg)/(1s) >



- ④ Formula 생성 확인



- ⑤  실행 후 적용됐는지 확인



DMU KINEMATICS TOOLS

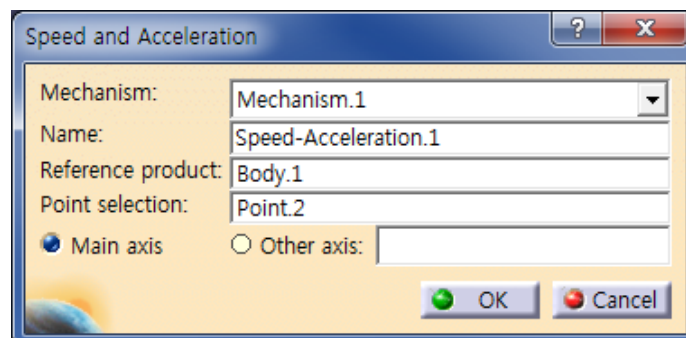
DMU Kinematics



Speed and Acceleration

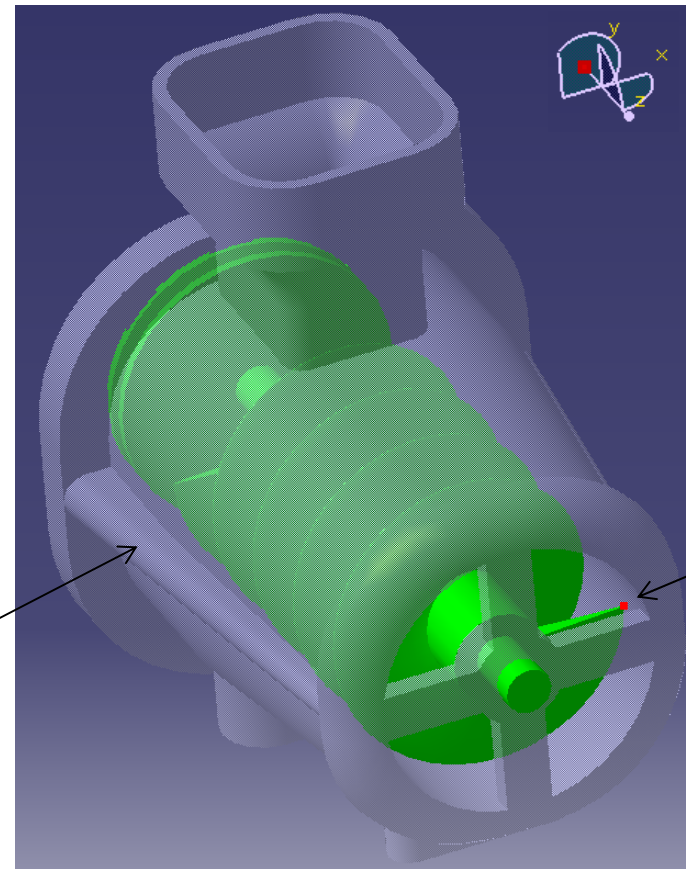
- 특정 위치의 속도, 가속도 등을 확인함

- ①  실행 후 Reference product와 측정 Point 선택



Reference product

Point



DMU KINEMATICS TOOLS

DMU Kinematics



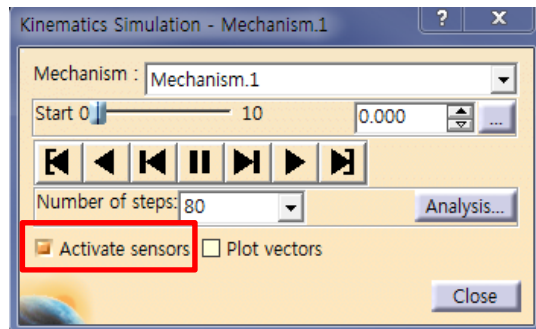
Speed and Acceleration

- 특정 위치의 속도, 가속도 등을 확인함

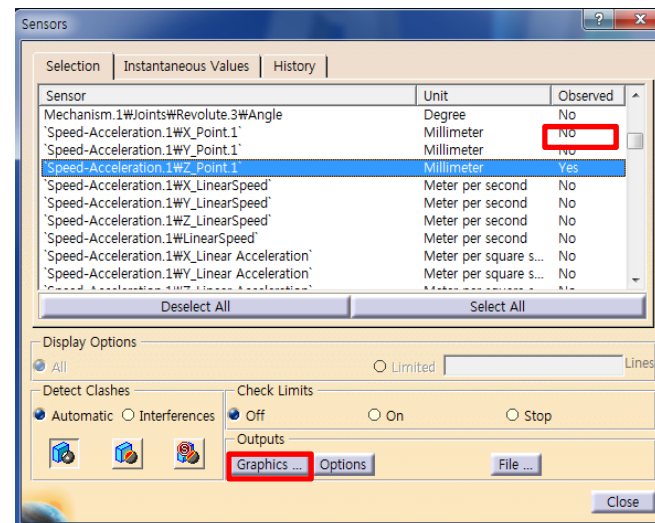
② Simulation with Laws 선택



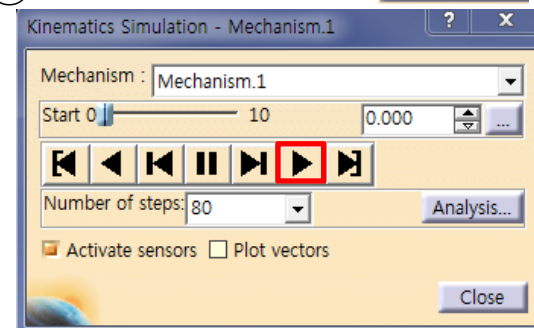
③ Activate sensors 선택



- ④ 측정하고자 하는 속도, 가속도 등을 활성화
(Observed의 No 클릭→Yes로 변환)
- EX) X_LinearSpeed, Z_Angular Acceleration, Z_Angular Speed



- ⑤ 시뮬레이션 실행 후 (4)의 Graphics ... 클릭



DMU KINEMATICS TOOLS

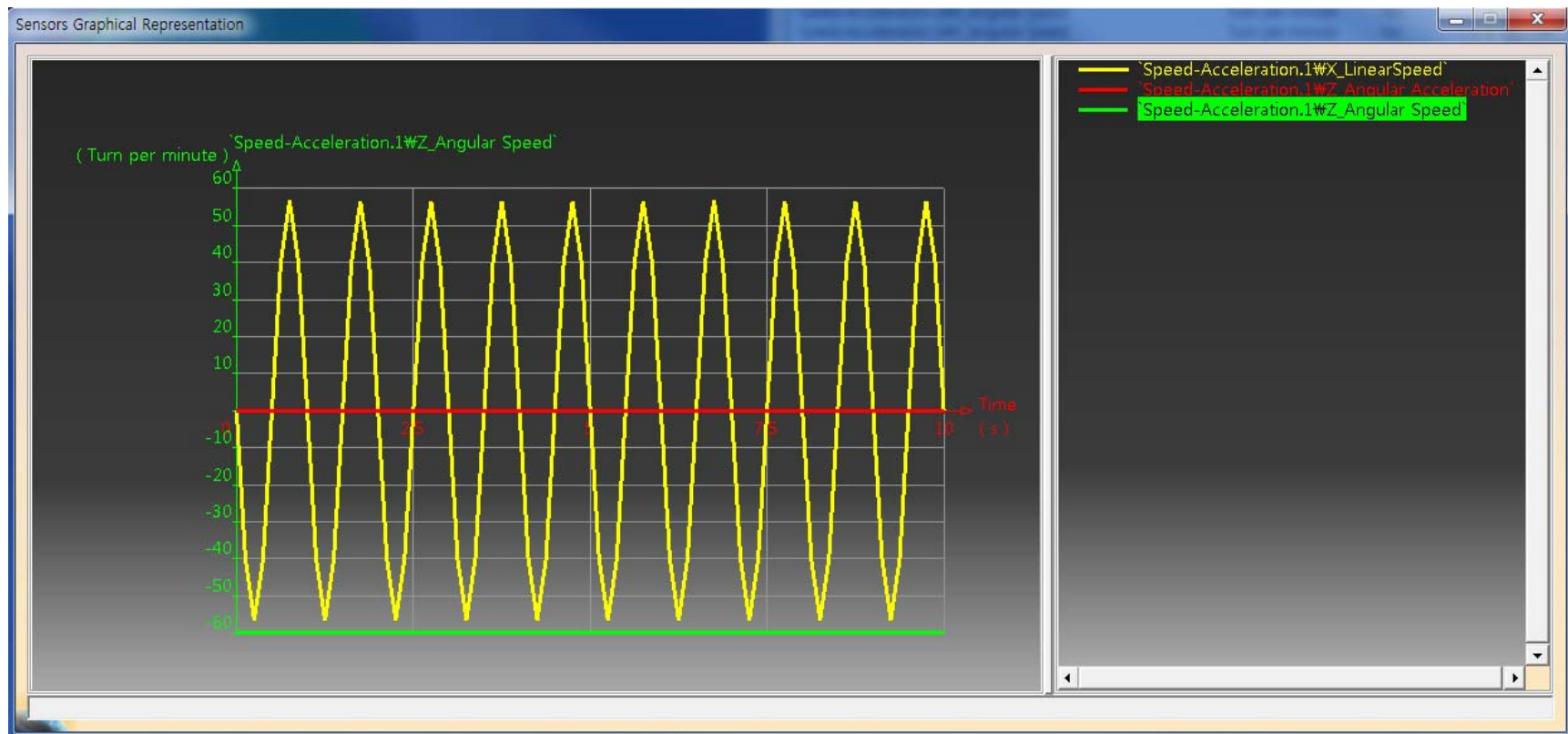
DMU Kinematics



Speed and Acceleration 

- 특정 위치의 속도, 가속도 등을 확인함

⑥ 속도/가속도 결과



CONTENTS

- ✓ 시작하기
- ✓ DMU Kinematics Tools
- ✓ **DMU Generic Animation**

DMU KINEMATICS TOOLS

DMU Generic Animation

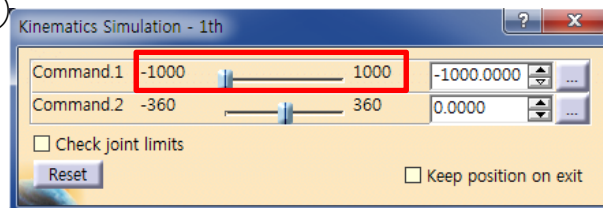


Simulation

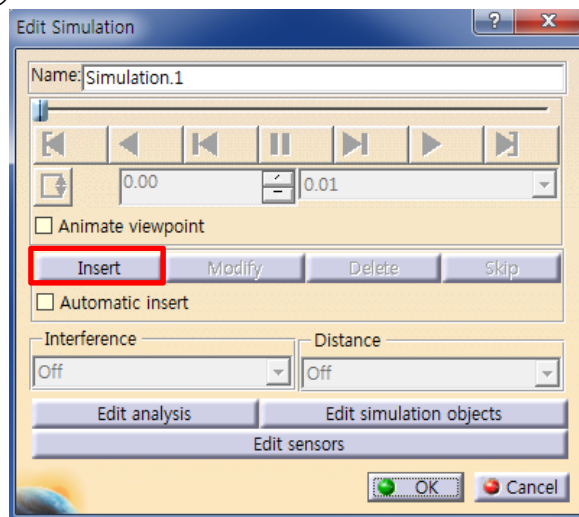


- 변화된 command 값 만큼 mechanism을 동작시킴

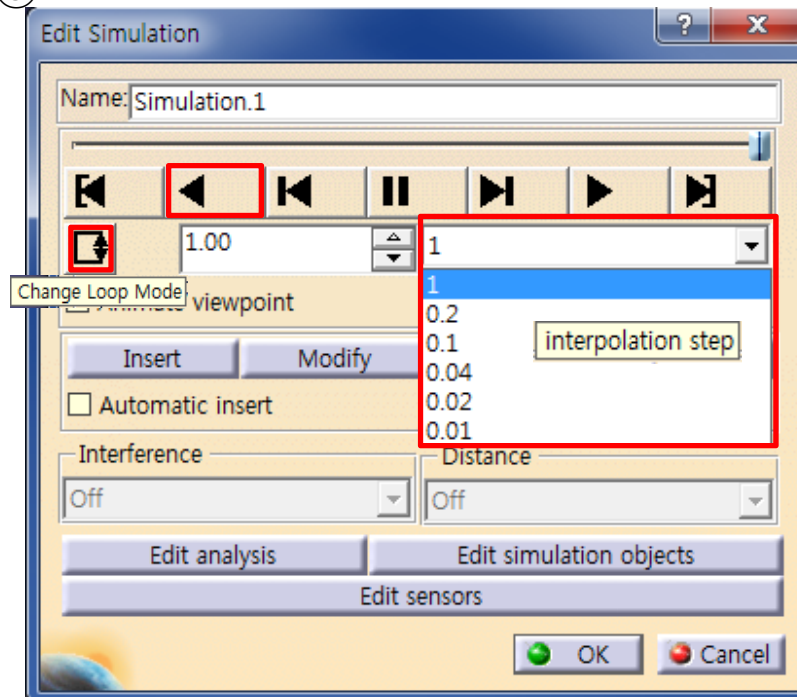
① 원하는 동작을 설정



② Insert



③ Loop Mode 및 Step 선택 후 재생



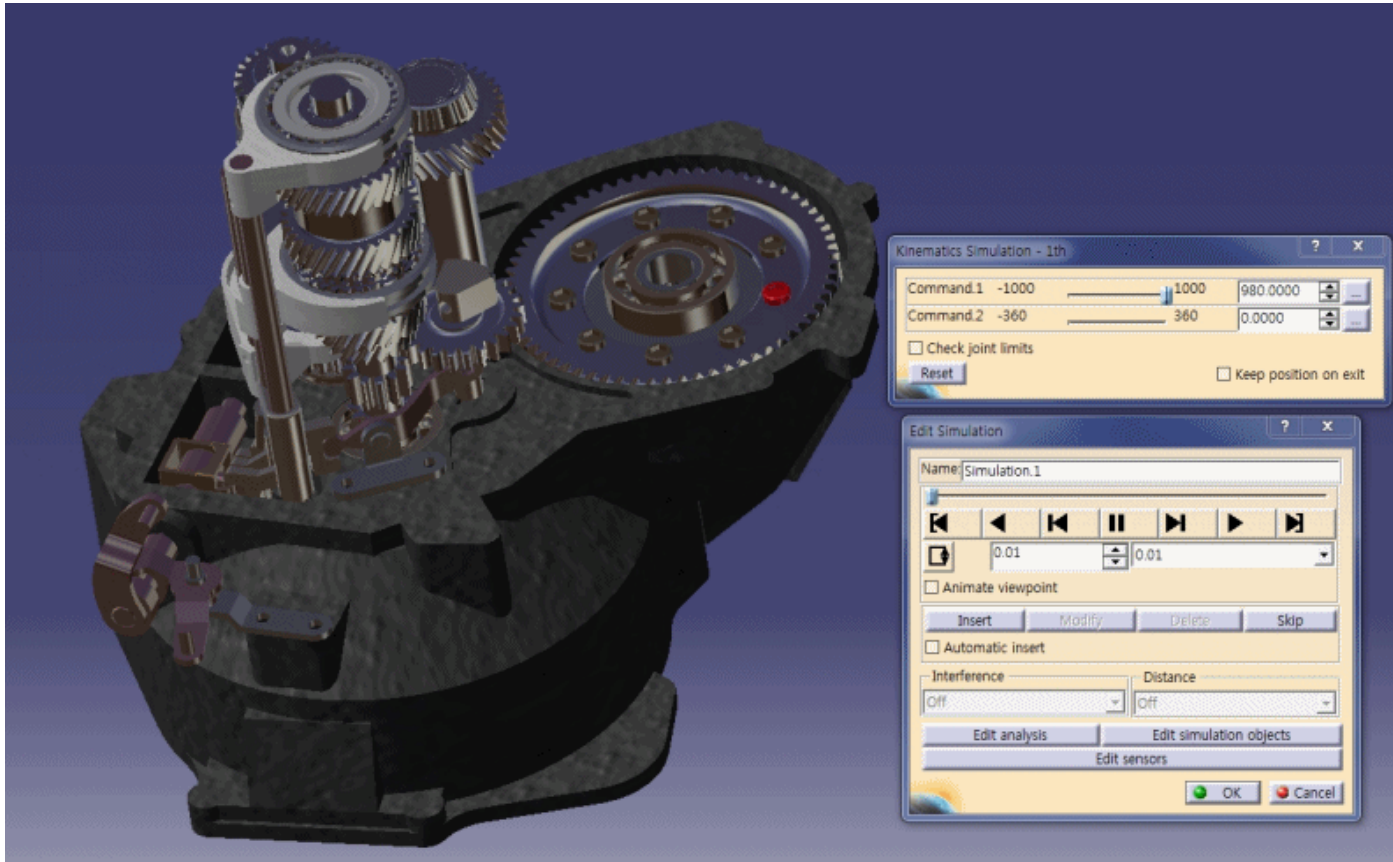
DMU KINEMATICS TOOLS

DMU Generic Animation



Simulation 

- 변화된 command 값 만큼 mechanism을 동작시킴



DMU KINEMATICS TOOLS

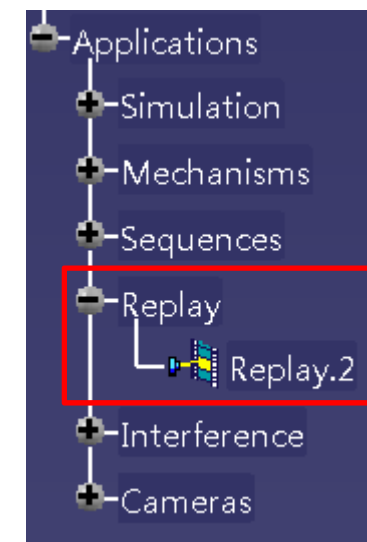
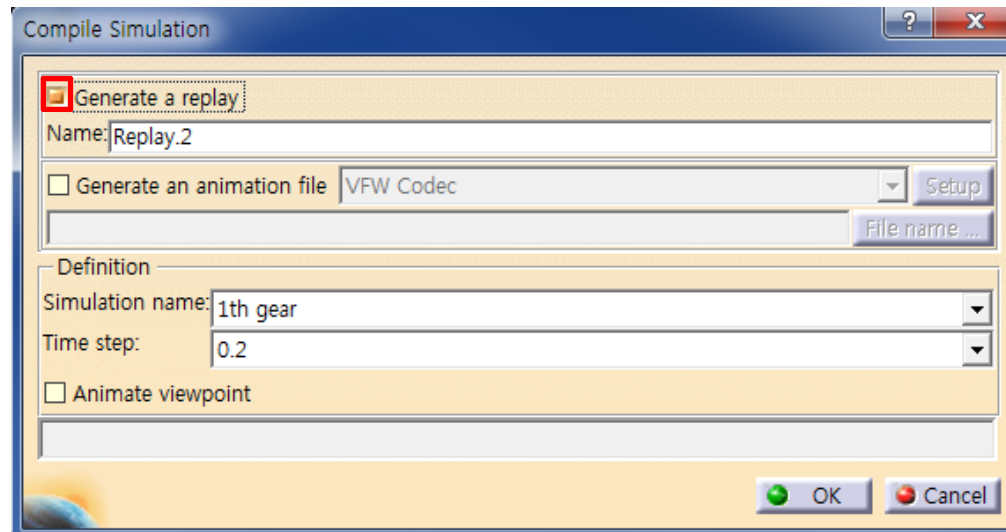
DMU Generic Animation



Compile Simulation 

- 만들어진 시뮬레이션을 Replay 또는 동영상 파일로 저장함

Replay 생성



DMU KINEMATICS TOOLS

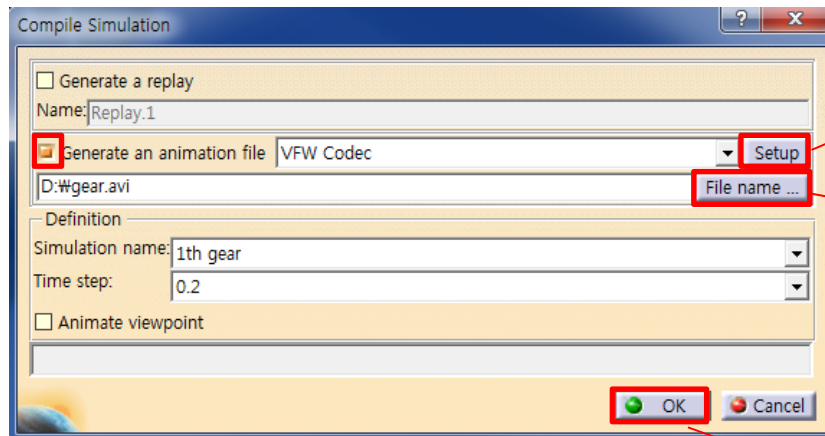
DMU Generic Animation



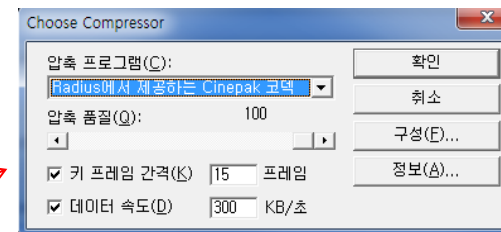
Compile Simulation

- 만들어진 시뮬레이션을 Replay 또는 동영상 파일로 저장함

동영상 파일 생성



압축 코덱 /프레임 설정



파일 경로 설정

동영상 파일 생성



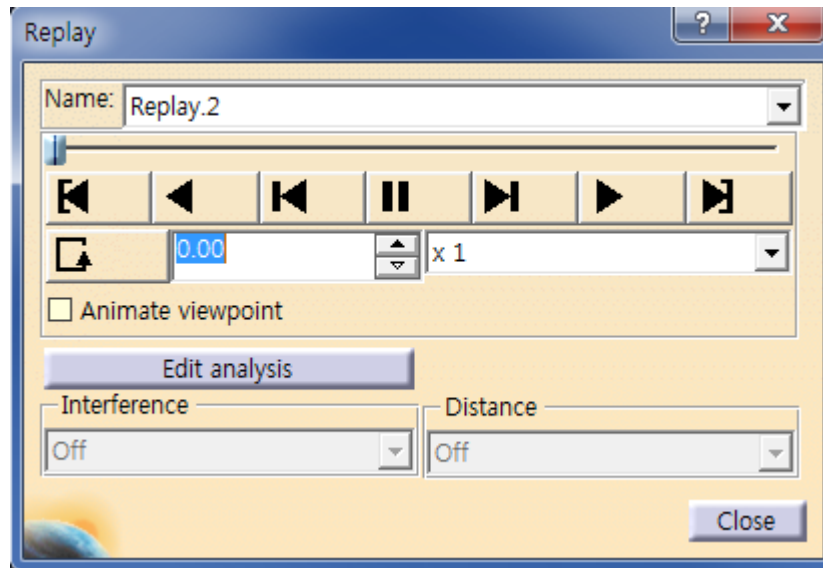
DMU KINEMATICS TOOLS

DMU Generic Animation



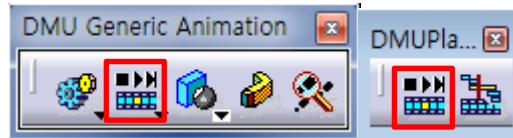
Replay 

- 만들어진 시뮬레이션의 Replay를 실행함



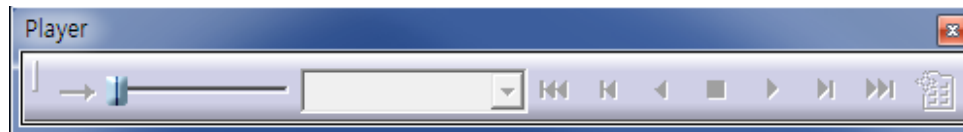
DMU KINEMATICS TOOLS

DMU Generic Animation



Simulation Player 

- 만들어진 simulation, replay, sequences를 실행시킴



Simulation 또는 Replay 선택



corresponds to the single loop mode

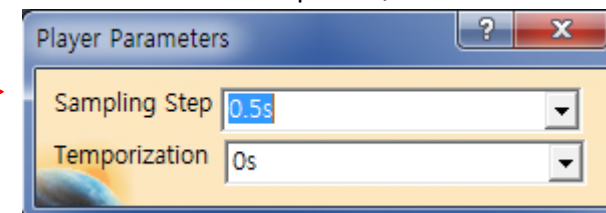


corresponds to the one way loop mode



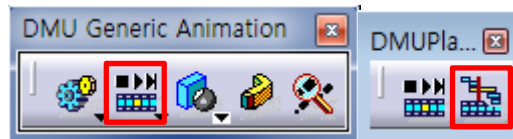
corresponds to the return simulation mode.

Step 입력



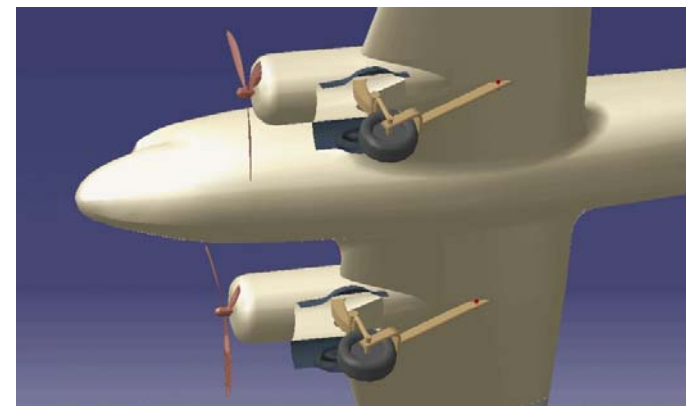
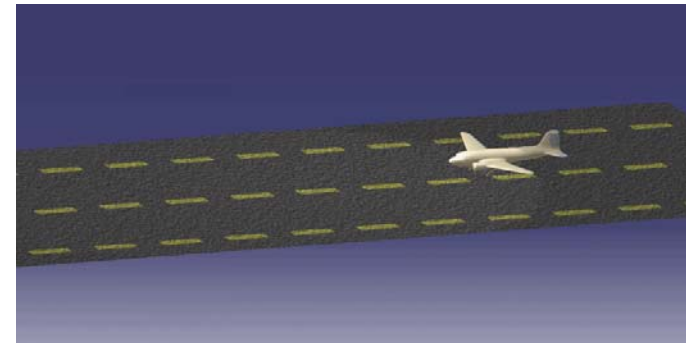
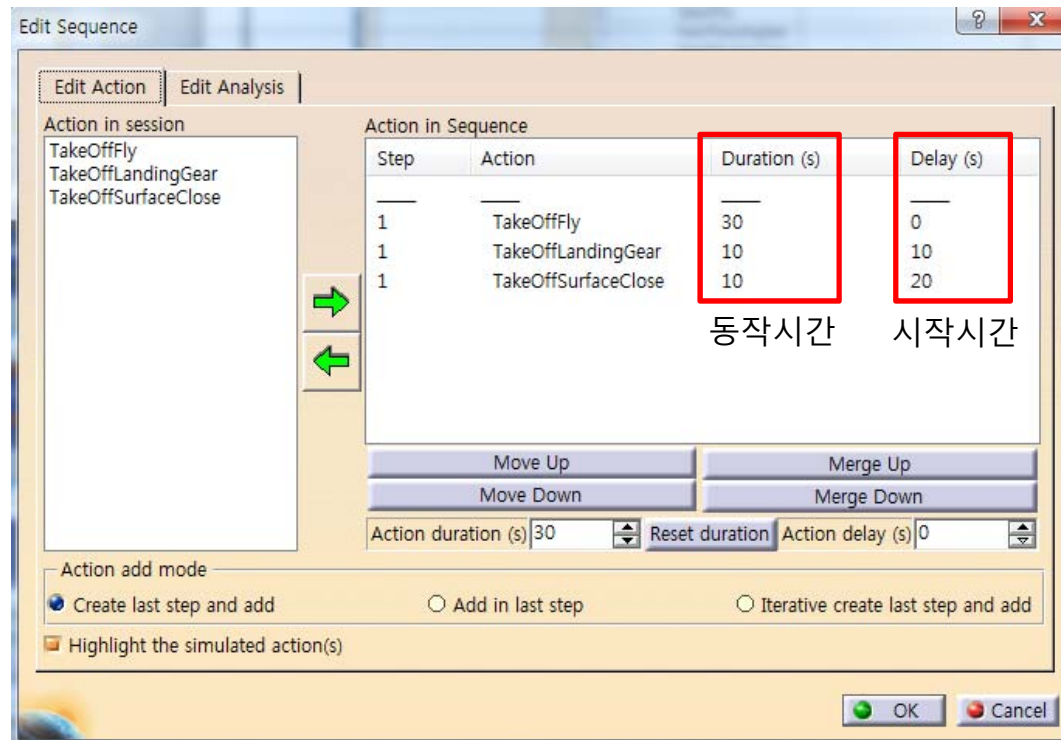
DMU KINEMATICS TOOLS

DMU Generic Animation



Edit Sequence 

- 만들어진 시뮬레이션들의 시간을 조절하여 하나의 시뮬레이션으로 구성함



DMU KINEMATICS TOOLS

DMU Generic Animation



Clash Mode

- 시뮬레이션을 실행할 때 간섭여부를 확인함

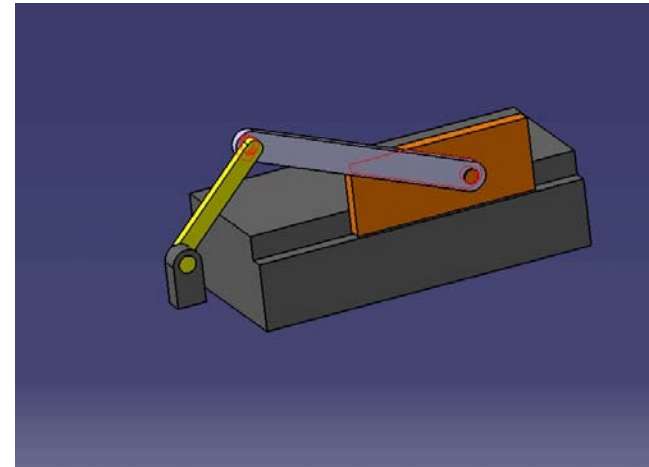


Deactivates automatic clash detection for simulation

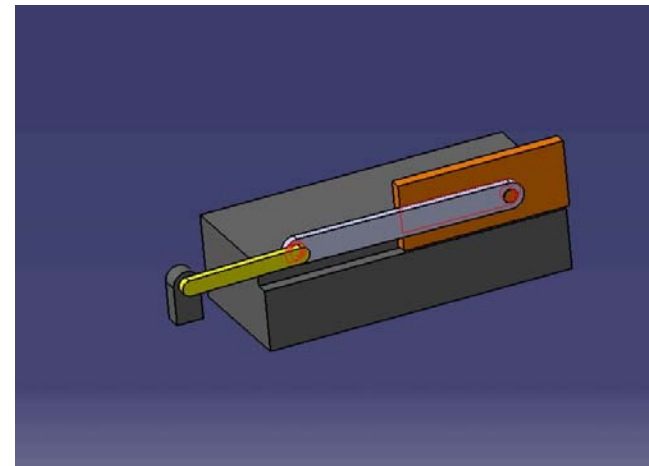
Activates automatic clash detection for simulation

Activates automatic clash detection stop mode for simulation

기존의 Slider-Crank 모델

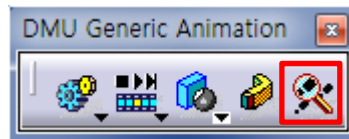


간섭이 일어나는 모델



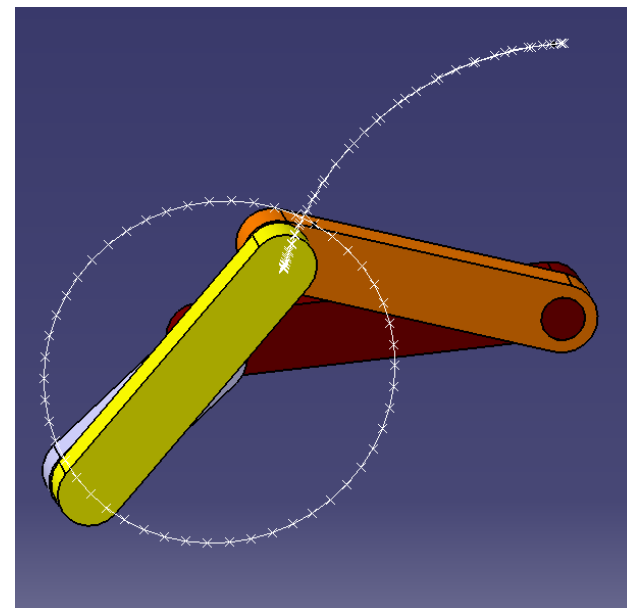
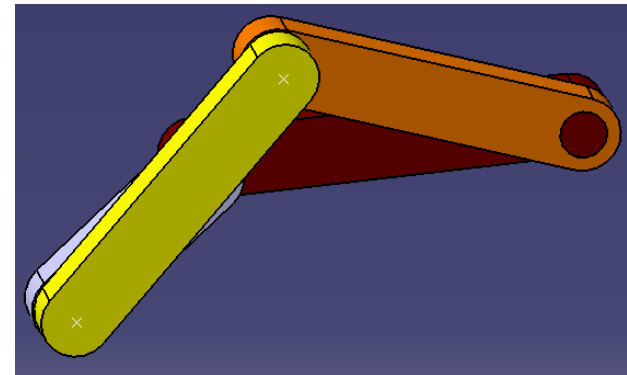
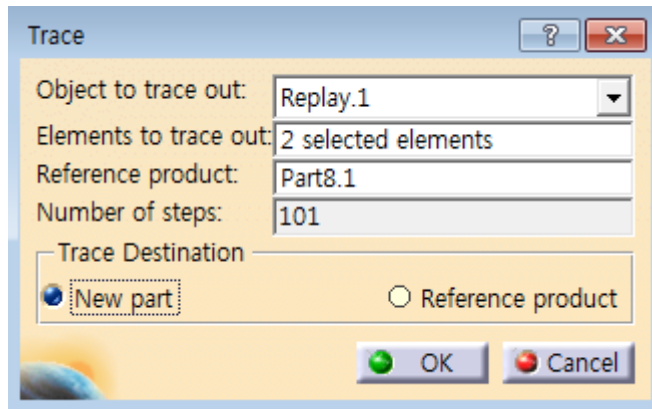
DMU KINEMATICS TOOLS

DMU Generic Animation



Trace

- 선택한 elements의 이동을 replay를 기준으로 표시함.



실습 과제

Assembly Design의 Piston 모델을 이용하여 아래와 같이 DMU Kinematics 작업 진행하기
(Simulation 동영상 + Product + Part 파일들 압축하여 업로드)

