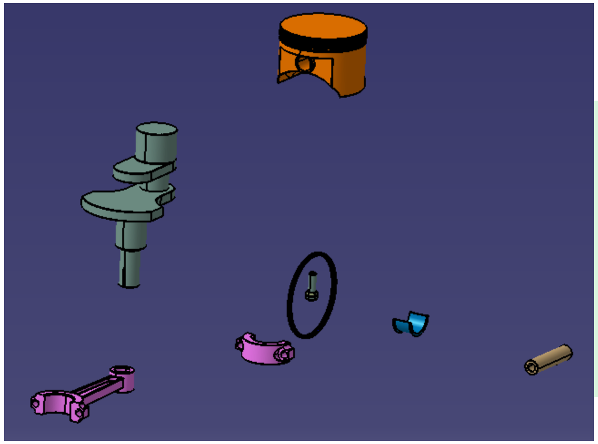
DMU KINEMATICS

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

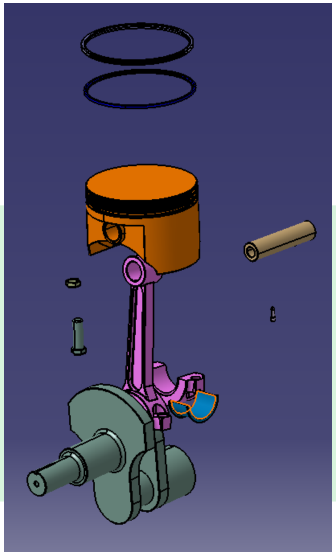
CONTENTS

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

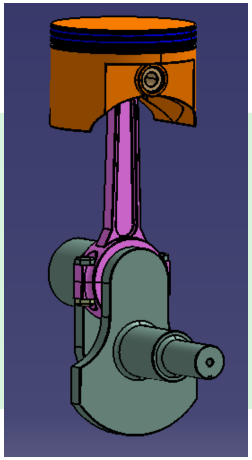
DMU KINEMATICS 진행 순서



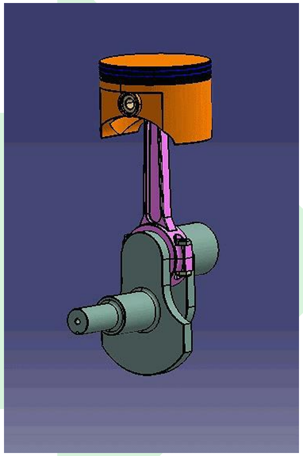
모델 불러오기



대략적 배치/수정



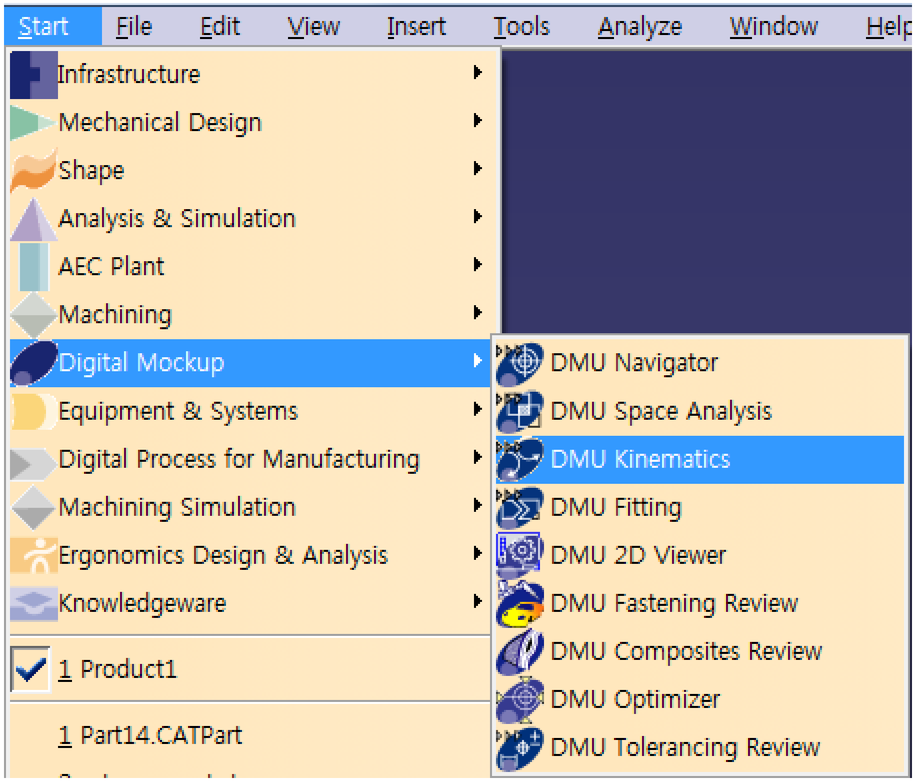
Joint 부여



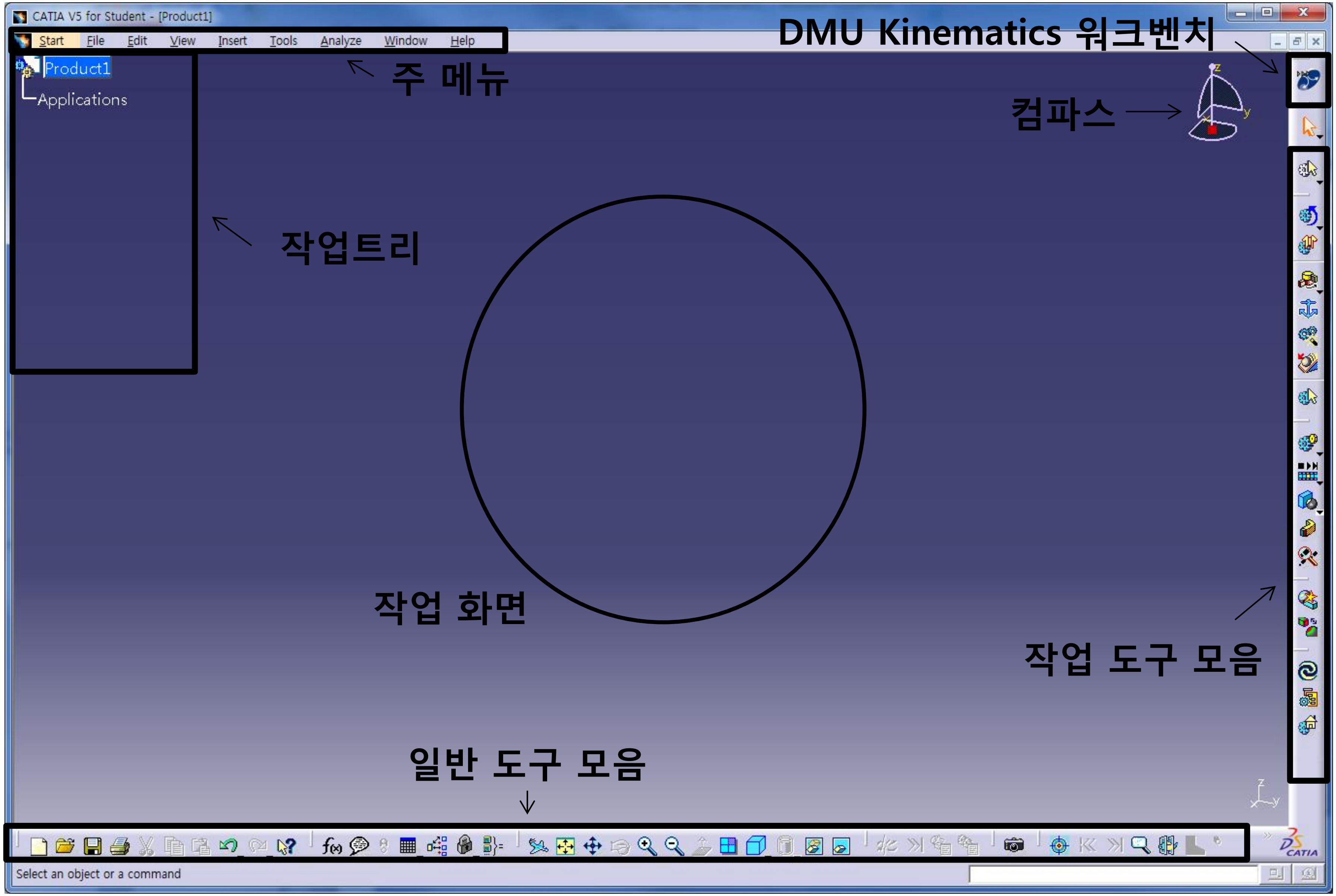
Joint 생성 후
구동 확인

DMU KINEMATICS 시작하기

Start 메뉴에서 Digital Mockup → DMU Kinematics 선택


Start
File
Edit
View
Insert
Tools
Analyze
Window
Help
Infrastructure
Mechanical Design
Shape
Analysis & Simulation
AEC Plant
Machining
Digital Mockup
Equipment & Systems
Digital Process for Manufacturing
Machining Simulation
Ergonomics Design & Analysis
Knowledgeware
1 Product1
1 Part14.CATPart
DMU Navigator
DMU Space Analysis
DMU Kinematics
DMU Fitting
DMU 2D Viewer
DMU Fastening Review
DMU Composites Review
DMU Optimizer
DMU Tolerancing Review

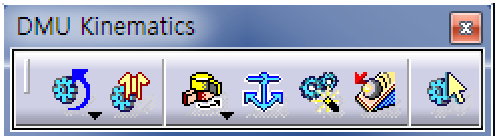
DMU KINEMATICS 작업화면



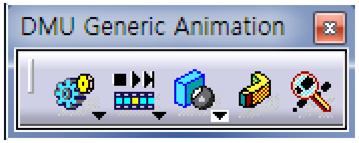
CATIA V5 for Student - [Product1]
Start
File
Edit
View
Insert
Tools
Analyze
Window
Help
Product1
Applications
주 메뉴
작업트리
DMU Kinematics 워크벤치
컴파스
작업 화면
작업 도구 모음
일반 도구 모음

Select an object or a command

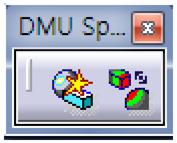
DMU KINEMATICS 툴바 종류


DMU Kinematics

만들어진 Component를 불러들여서 component간에 운동을 부여하거나 구속함.


DMU Generic Animation

만들어진 mechanism을 동작함.



Component간에 간섭, 거리를 확인함.

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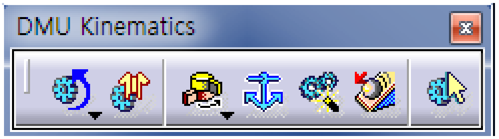
- ✓ 시작하기
- ✓ **DMU Kinematics Tools**
- ✓ DMU Generic Animation

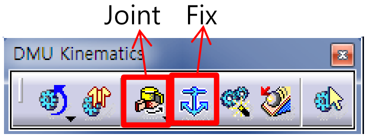
DMU KINEMATICS TOOLS

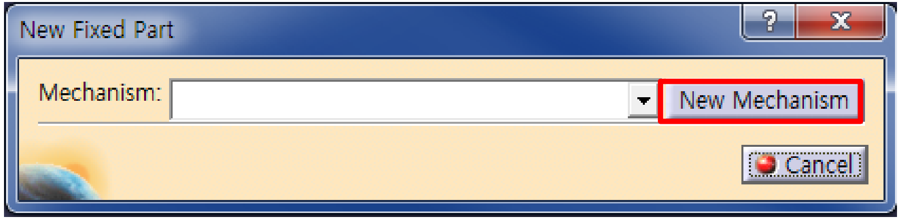
DMU Kinematics


DMU Kinematics

- Mechanisms 메뉴 생성

<Fix Part 혹은 Joint 선택>

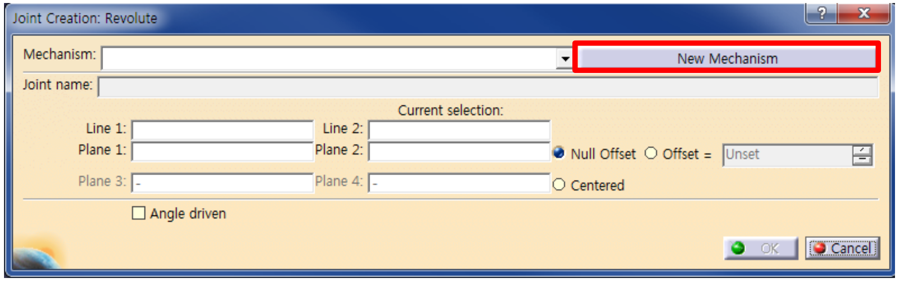

Joint
Fix
DMU Kinematics


New Fixed Part

Mechanism:

New Mechanism
Cancel

혹은


Joint Creation: Revolute

Mechanism:

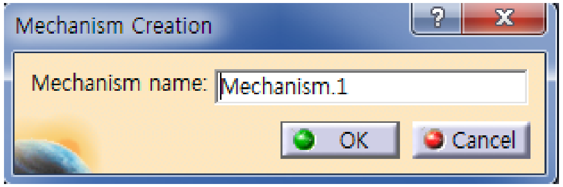
Joint name:

Current selection:

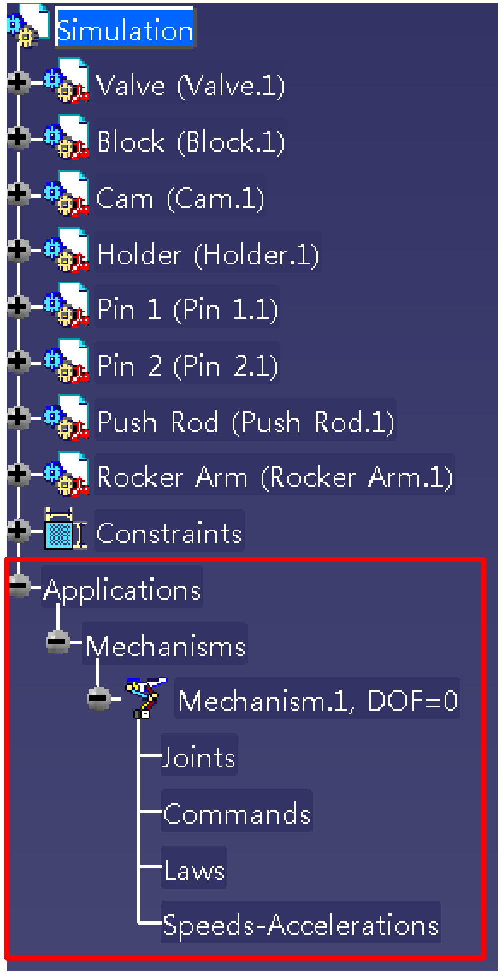
Line 1:
Line 2:
Plane 1:
Plane 2:
● Null Offset ○ Offset = Unset
Plane 3: -
Plane 4: -
○ Centered

☐ Angle driven

New Mechanism
OK
Cancel


Mechanism Creation

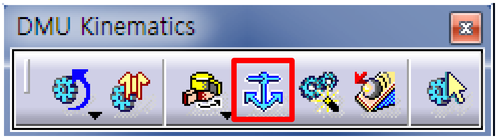
Mechanism name: Mechanism.1


```
Simulation
+ Valve (Valve.1)
+ Block (Block.1)
+ Cam (Cam.1)
+ Holder (Holder.1)
+ Pin 1 (Pin 1.1)
+ Pin 2 (Pin 2.1)
+ Push Rod (Push Rod.1)
+ Rocker Arm (Rocker Arm.1)
+ Constraints
- Applications
  - Mechanisms
    - Mechanism.1, DOF=0
        Joints
        Commands
        Laws
        Speeds-Accelerations
```

<Mechanisms 생성>

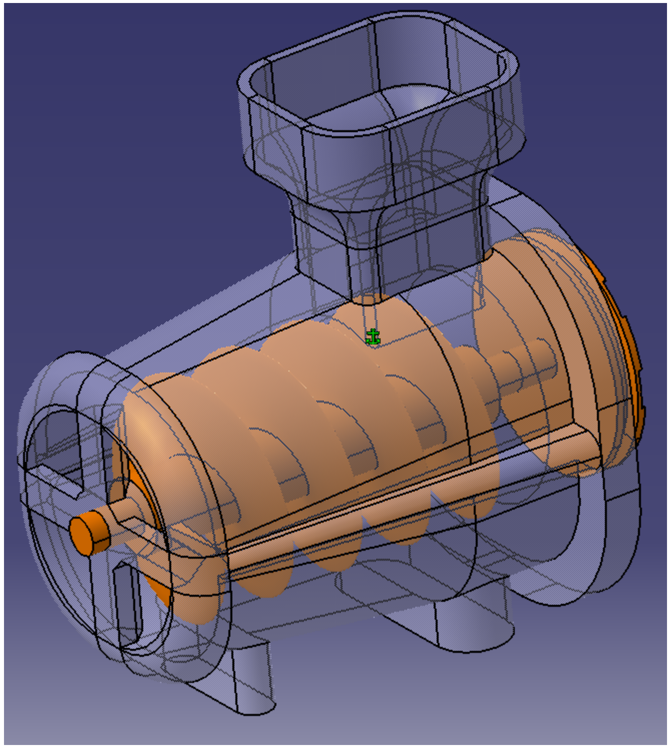
DMU KINEMATICS TOOLS

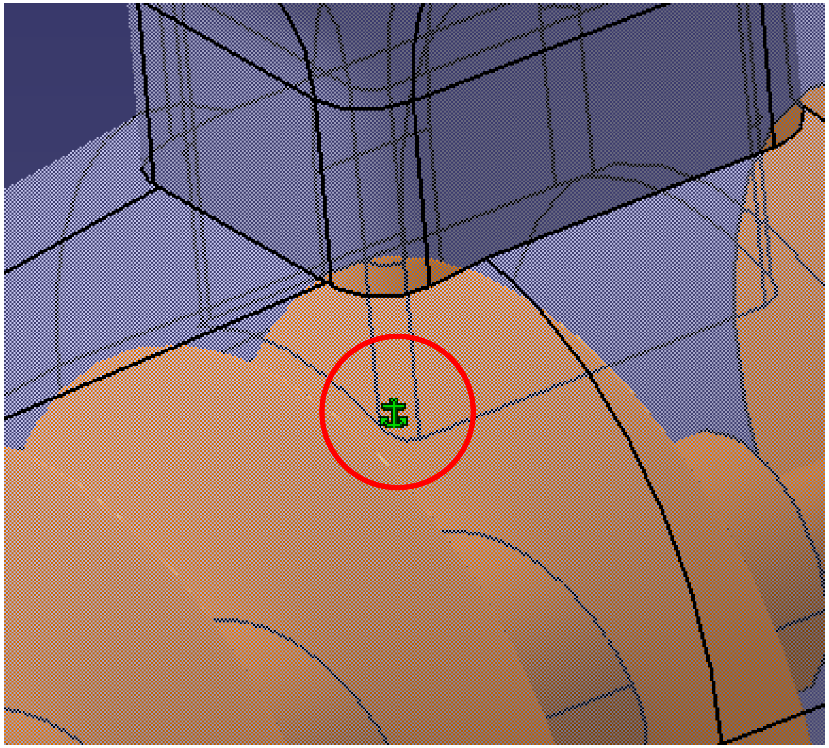
DMU Kinematics


DMU Kinematics

Fixed Part

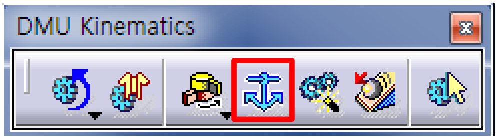
- 선택한 Component를 고정 (기준이 되는 하나의 component만 가능)





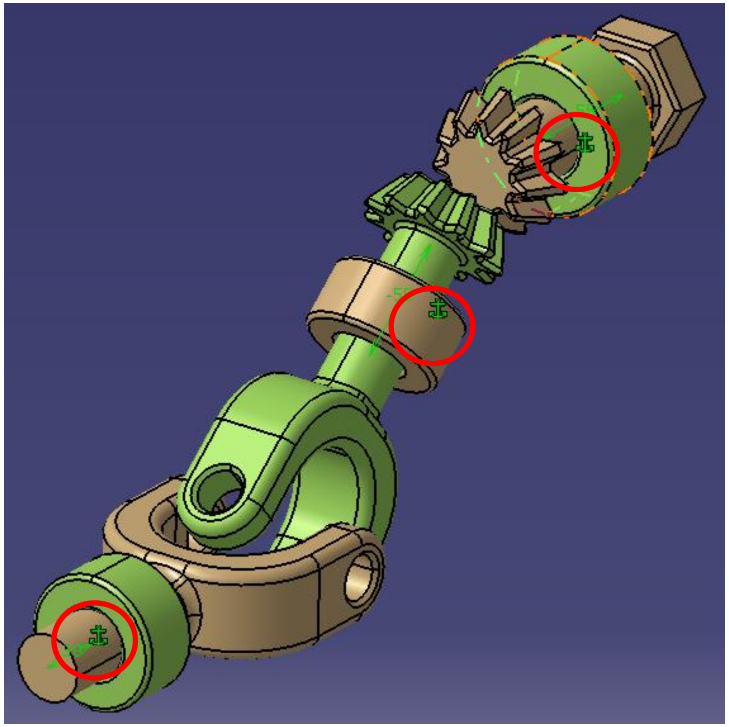
DMU KINEMATICS TOOLS

DMU Kinematics

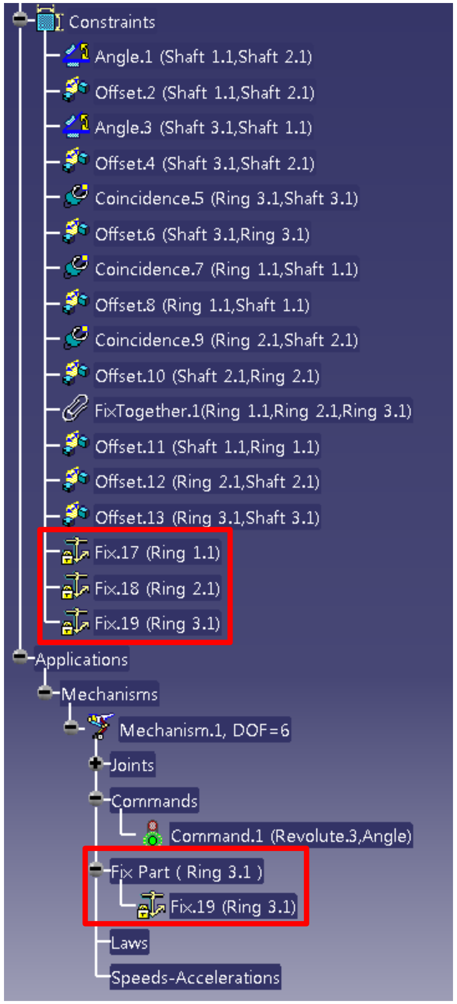


Fixed Part

- 선택한 Component를 고정 (기준이 되는 하나의 component만 가능)



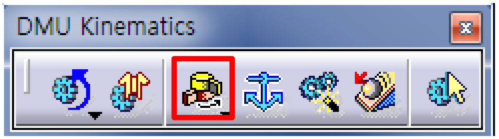
<다수의 Fix를 생성해도 mechanism에는 하나만 생성됨>

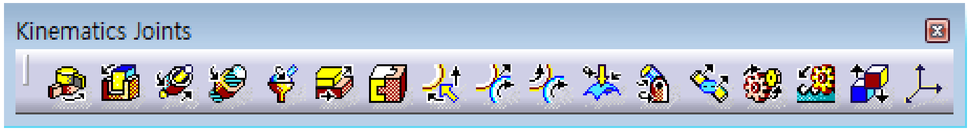


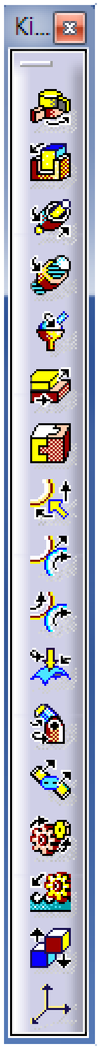
- Constraints
  - Angle.1 (Shaft 1.1,Shaft 2.1)
  - Offset.2 (Shaft 1.1,Shaft 2.1)
  - Angle.3 (Shaft 3.1,Shaft 1.1)
  - Offset.4 (Shaft 3.1,Shaft 2.1)
  - Coincidence.5 (Ring 3.1,Shaft 3.1)
  - Offset.6 (Shaft 3.1,Ring 3.1)
  - Coincidence.7 (Ring 1.1,Shaft 1.1)
  - Offset.8 (Ring 1.1,Shaft 1.1)
  - Coincidence.9 (Ring 2.1,Shaft 2.1)
  - Offset.10 (Shaft 2.1,Ring 2.1)
  - FixTogether.1(Ring 1.1,Ring 2.1,Ring 3.1)
  - Offset.11 (Shaft 1.1,Ring 1.1)
  - Offset.12 (Ring 2.1,Shaft 2.1)
  - Offset.13 (Ring 3.1,Shaft 3.1)
  - Fix.17 (Ring 1.1)
  - Fix.18 (Ring 2.1)
  - Fix.19 (Ring 3.1)
- Applications
  - Mechanisms
    - Mechanism.1, DOF=6
      - Joints
      - Commands
        - Command.1 (Revolute.3,Angle)
      - Fix Part (Ring 3.1)
        - Fix.19 (Ring 3.1)
      - Laws
      - Speeds-Accelerations

DMU KINEMATICS TOOLS

DMU Kinematics



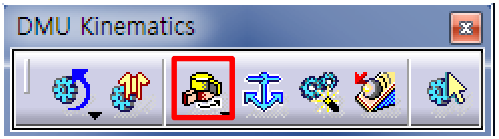


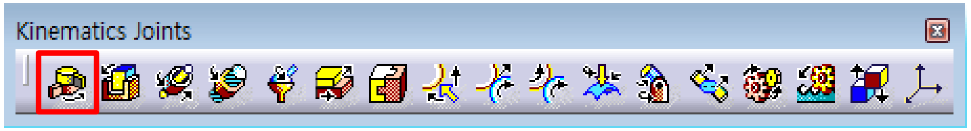


Revolute : 평면을 기준으로 회전하도록 joint 생성
Prismatic : 특정 면을 기준으로 병진 운동하도록 joint 생성
Cylindrical : 병진운동과 회전 운동하도록 joint 생성
Screw : Pitch 값을 기준으로 회전과 병진 운동하도록 joint 생성
Spherical : 특정한 point를 중심으로 운동하도록 joint 생성
Planar : 특정한 plane를 중심으로 운동하도록 joint 생성
Rigid : component간의 상대위치를 고정시켜주는 joint를 생성
Point Curve : 특정 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

DMU KINEMATICS TOOLS

DMU Kinematics

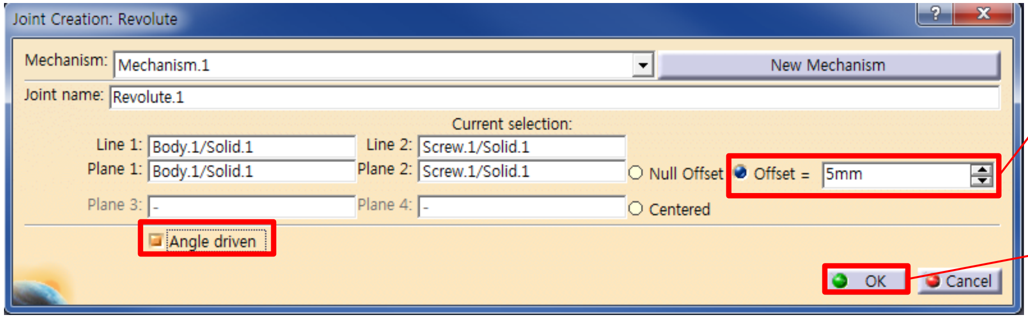




Revolute Joint

- 두 component가 평면을 기준으로 회전하도록 joint 생성

<Line, Plane 선택>



Joint Creation: Revolute

Mechanism: Mechanism.1 | New Mechanism

Joint name: Revolute.1

Current selection:

Line 1: Body.1/Solid.1 Line 2: Screw.1/Solid.1

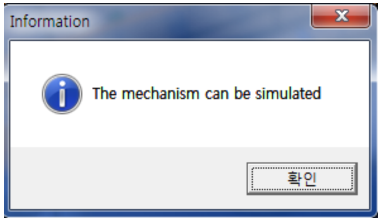
Plane 1: Body.1/Solid.1 Plane 2: Screw.1/Solid.1 ○ Null Offset ● Offset = 5mm

Plane 3: - Plane 4: - ○ Centered

☐ Angle driven

OK Cancel

Offset 선택 시, 선택한 plane 사이의
거리가 자동으로 입력됨



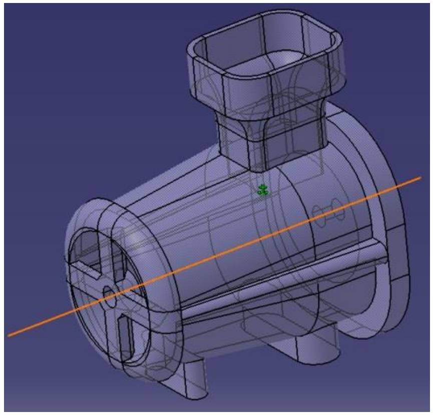
Information

The mechanism can be simulated

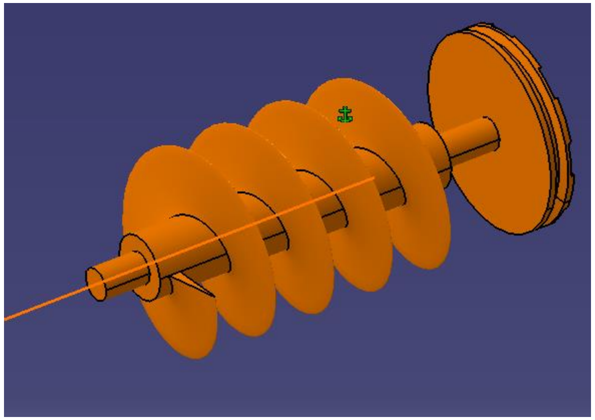
확인

Mechanism이 실행 가능한 경우

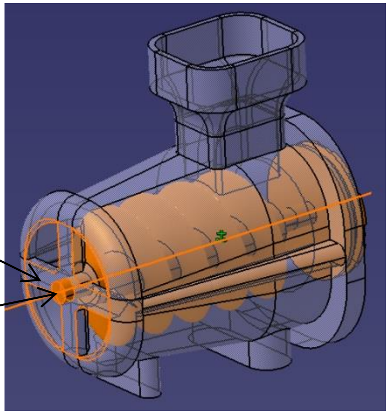
<Line 1>



<Line 2>

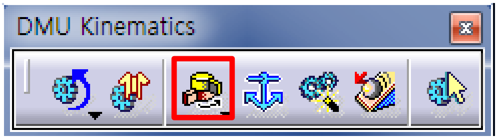


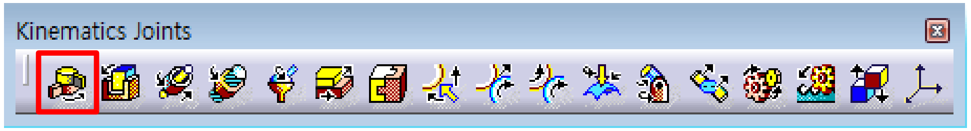
<Plane>



DMU KINEMATICS TOOLS

DMU Kinematics

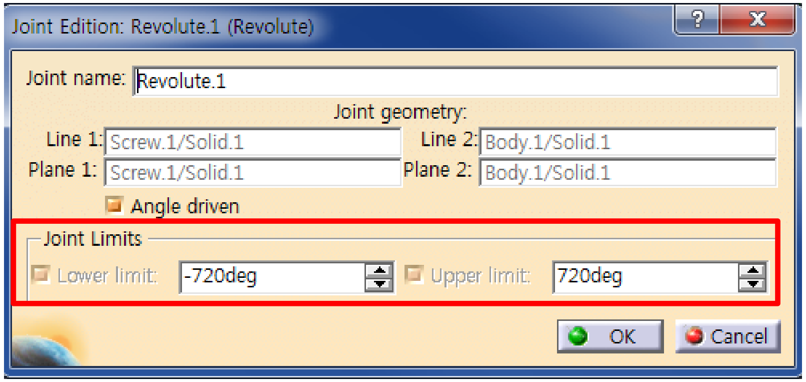

DMU Kinematics


Kinematics Joints

Revolute Joint

- 두 component가 평면을 기준으로 회전하도록 joint 생성

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


Joint Edition: Revolute.1 (Revolute)
?
X

Joint name: Revolute.1

Joint geometry:

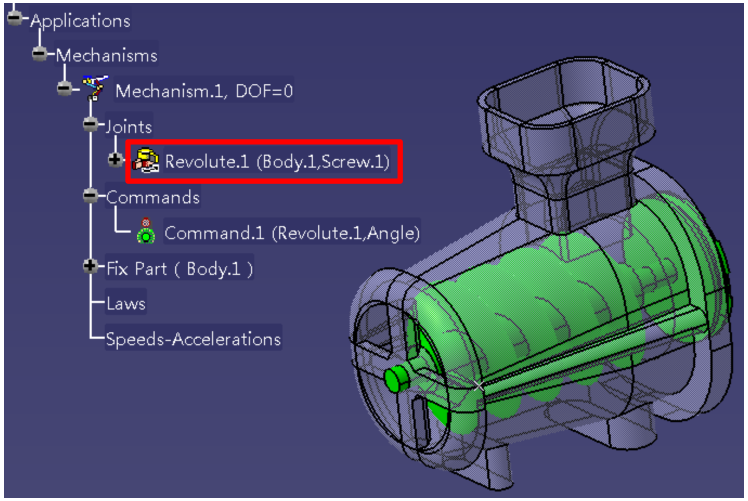
Line 1: Screw.1/Solid.1
Line 2: Body.1/Solid.1
Plane 1: Screw.1/Solid.1
Plane 2: Body.1/Solid.1

☑ Angle driven

Joint Limits

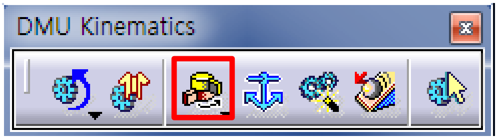
☐ Lower limit: -720deg
☐ Upper limit: 720deg

OK
Cancel


Applications
Mechanisms
Mechanism.1, DOF=0
Joints
Revolute.1 (Body.1,Screw.1)
Commands
Command.1 (Revolute.1,Angle)
Fix Part (Body.1)
Laws
Speeds-Accelerations

DMU KINEMATICS TOOLS

DMU Kinematics

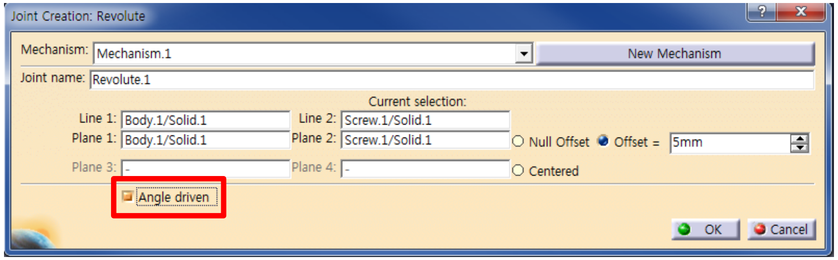


Kinematics Joints

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



Joint Creation: Revolute

Mechanism: Mechanism.1

Joint name: Revolute.1

Current selection:

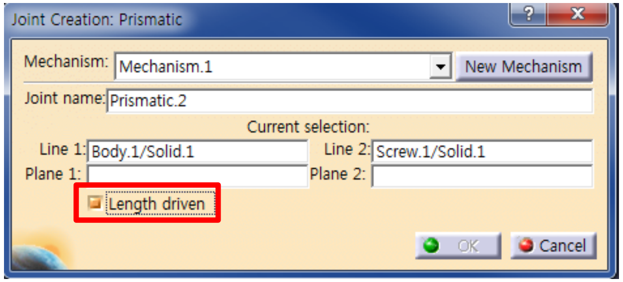
Line 1: Body.1/Solid.1 Line 2: Screw.1/Solid.1

Plane 1: Body.1/Solid.1 Plane 2: Screw.1/Solid.1 ○ Null Offset ● Offset = 5mm

Plane 3: - Plane 4: - ○ Centered

☐ Angle driven

Prismatic Joint의 Length driven



Joint Creation: Prismatic

Mechanism: Mechanism.1

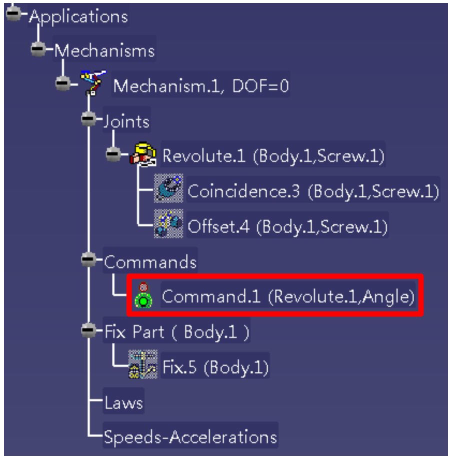
Joint name: Prismatic.2

Current selection:

Line 1: Body.1/Solid.1 Line 2: Screw.1/Solid.1

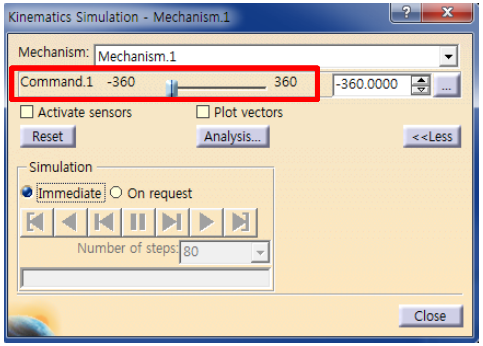
Plane 1: Plane 2:

☐ Length driven



- Applications
  - Mechanisms
    - Mechanism.1, DOF=0
      - Joints
        - Revolute.1 (Body.1,Screw.1)
          - Coincidence.3 (Body.1,Screw.1)
          - Offset.4 (Body.1,Screw.1)
      - Commands
        - Command.1 (Revolute.1,Angle)
      - Fix Part (Body.1)
        - Fix.5 (Body.1)
      - Laws
      - Speeds-Accelerations

Joint 생성 후 작업트리



Kinematics Simulation - Mechanism.1

Mechanism: Mechanism.1

Command.1 -360 360 -360.0000

☐ Activate sensors ☐ Plot vectors

Simulation

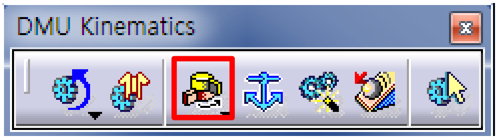
● Immediate ○ On request

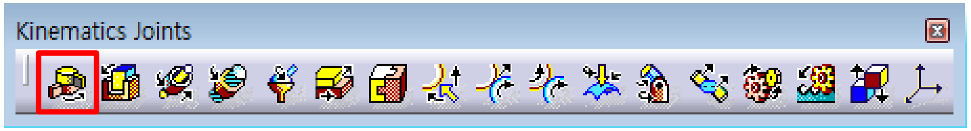
Number of steps: 80

Simulation with Commands

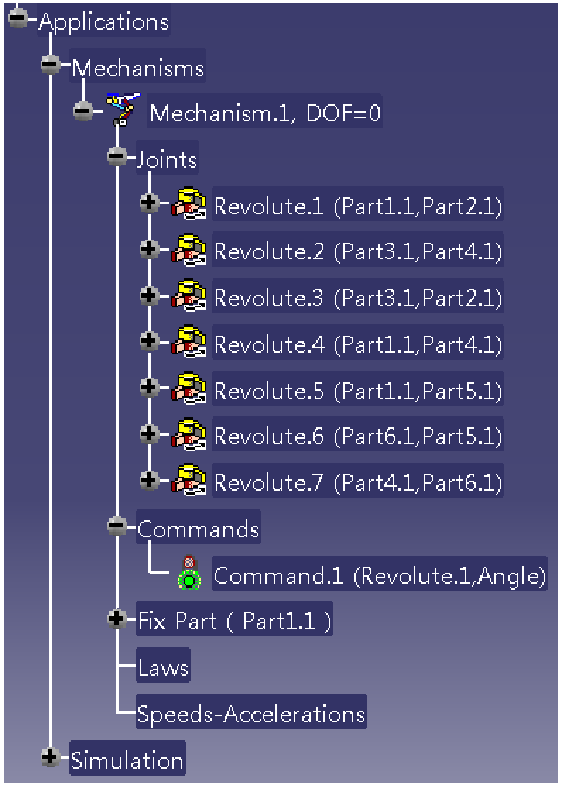
DMU KINEMATICS TOOLS

DMU Kinematics

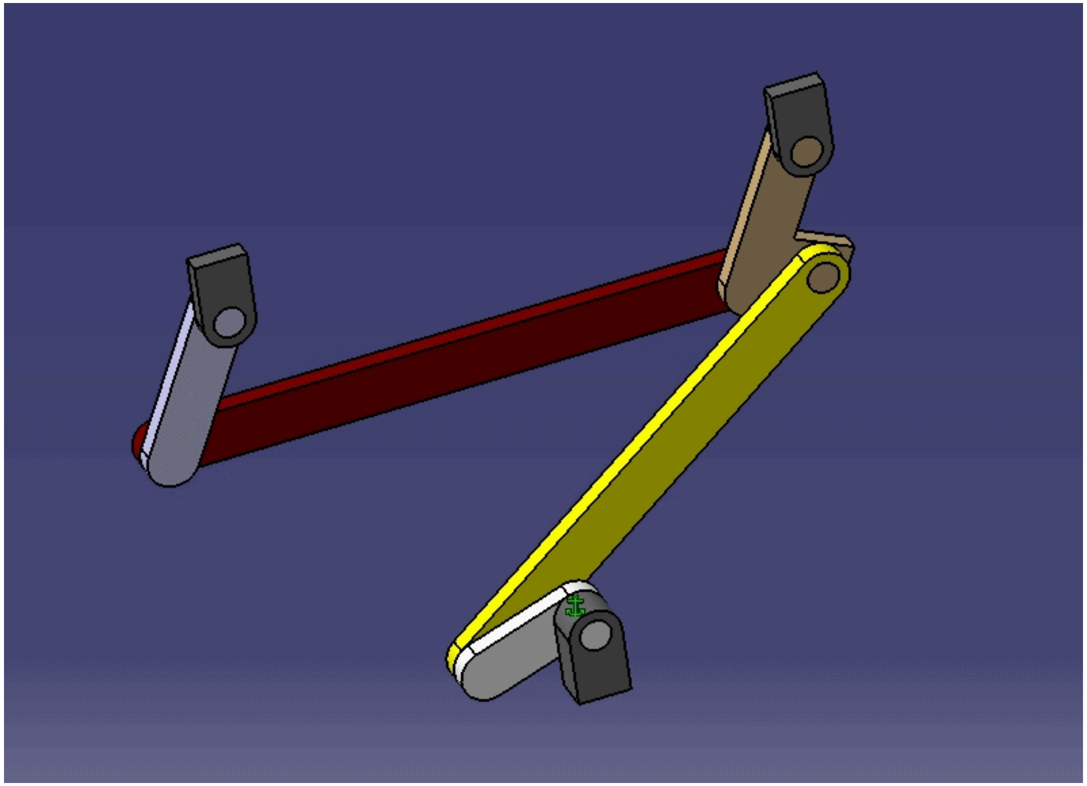




Wiper Mechanism (Revolute Joint)

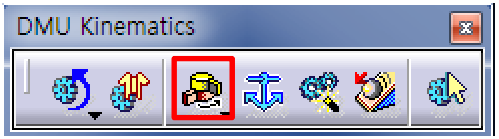


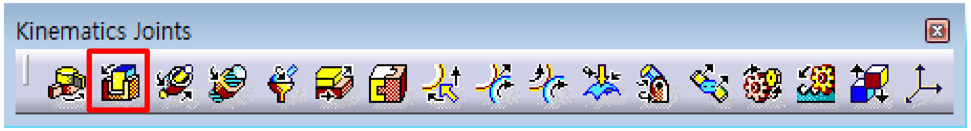
- Applications
  - Mechanisms
    - Mechanism.1, DOF=0
      - Joints
        - Revolute.1 (Part1.1,Part2.1)
        - Revolute.2 (Part3.1,Part4.1)
        - Revolute.3 (Part3.1,Part2.1)
        - Revolute.4 (Part1.1,Part4.1)
        - Revolute.5 (Part1.1,Part5.1)
        - Revolute.6 (Part6.1,Part5.1)
        - Revolute.7 (Part4.1,Part6.1)
      - Commands
        - Command.1 (Revolute.1,Angle)
      - Fix Part (Part1.1)
      - Laws
      - Speeds-Accelerations
  - Simulation



DMU KINEMATICS TOOLS

DMU Kinematics

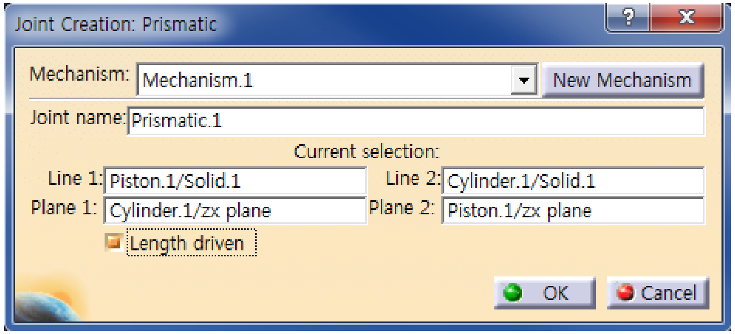




Prismatic Joint

- 두 component가 특정 면을 기준으로 병진 운동하도록 joint 생성

<Line, Plane 선택>



Joint Creation: Prismatic

Mechanism: Mechanism.1 New Mechanism

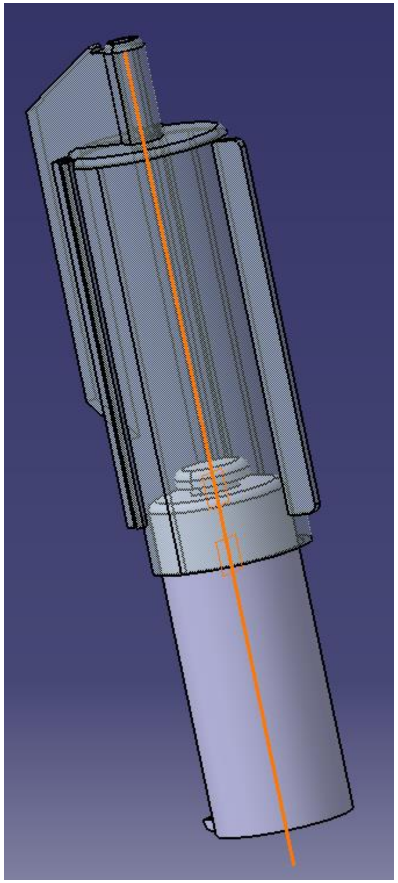
Joint name: Prismatic.1

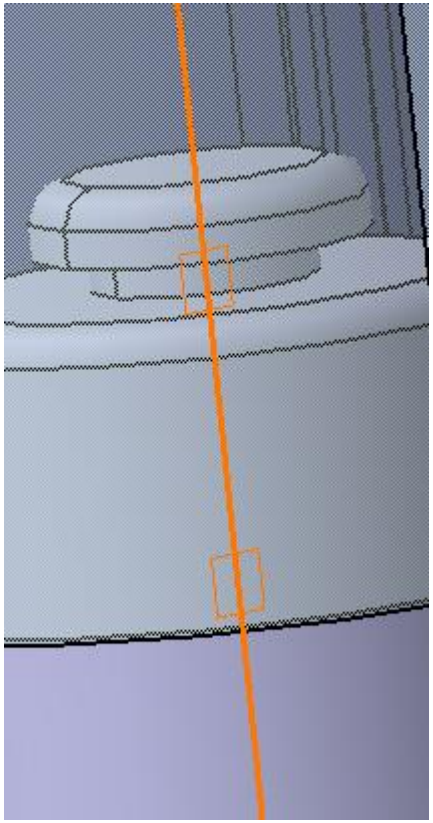
Current selection:

Line 1: Piston.1/Solid.1
Line 2: Cylinder.1/Solid.1
Plane 1: Cylinder.1/zx plane
Plane 2: Piston.1/zx plane

☐ Length driven

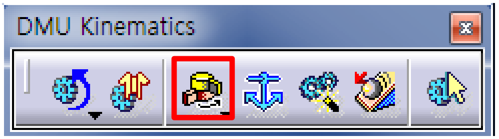
OK Cancel

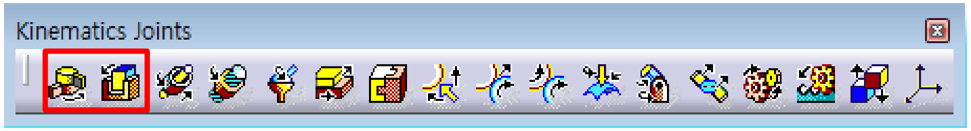




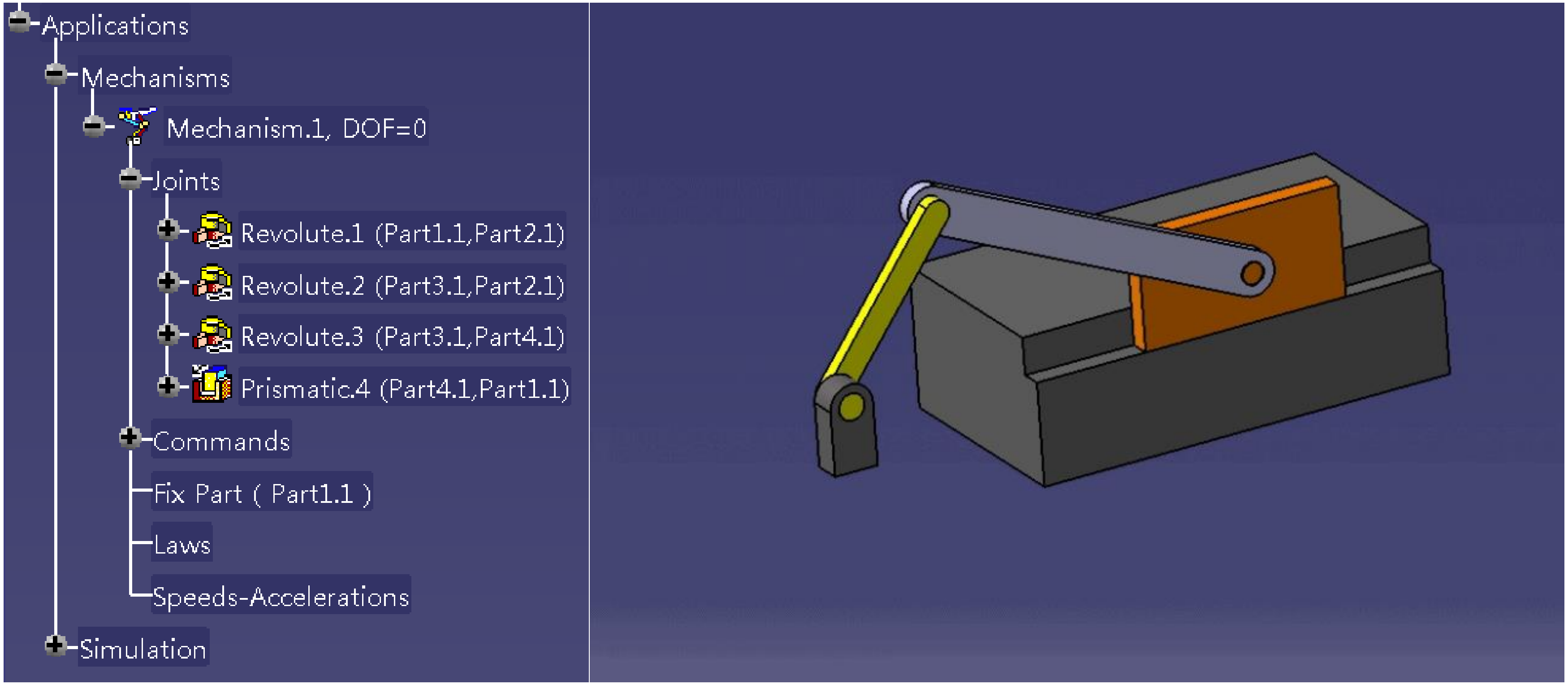
DMU KINEMATICS TOOLS

DMU Kinematics





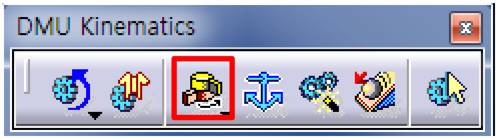
Crank-Slider Mechanism (Revolute Joint + Prismatic Joint)

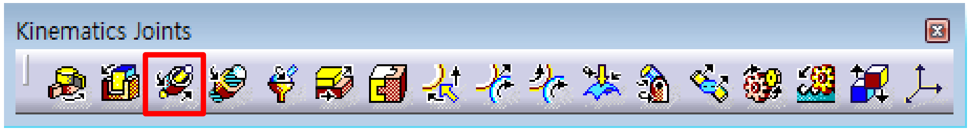


- Applications
  - Mechanisms
    - Mechanism.1, DOF=0
      - Joints
        - Revolute.1 (Part1.1,Part2.1)
        - Revolute.2 (Part3.1,Part2.1)
        - Revolute.3 (Part3.1,Part4.1)
        - Prismatic.4 (Part4.1,Part1.1)
      - Commands
      - Fix Part (Part1.1)
      - Laws
      - Speeds-Accelerations
  - Simulation

DMU KINEMATICS TOOLS

DMU Kinematics

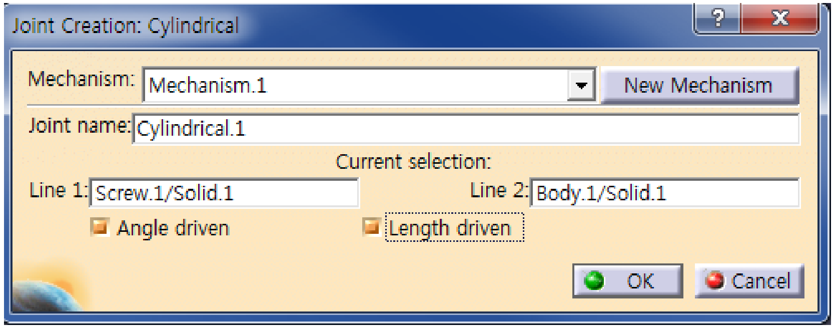

DMU Kinematics


Kinematics Joints

Cylindrical Joint

- 두 component가 병진운동과 회전 운동하도록 joint 생성

<Line 선택>


?
X
New Mechanism
OK
Cancel

Joint Creation: Cylindrical

Mechanism: Mechanism.1

Joint name: Cylindrical.1

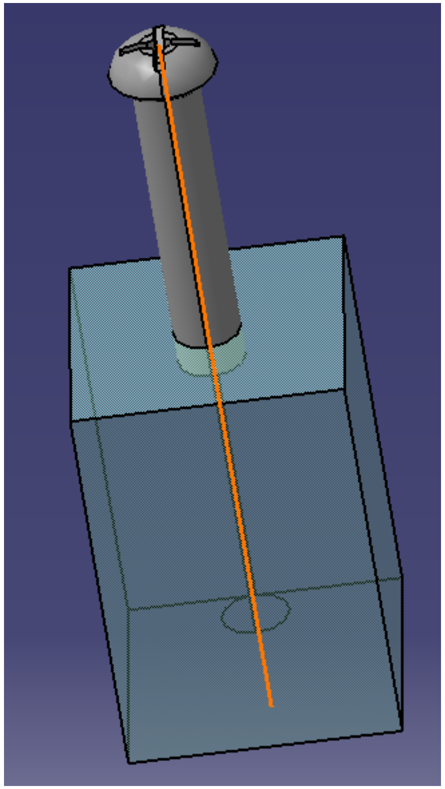
Current selection:

Line 1: Screw.1/Solid.1

Line 2: Body.1/Solid.1

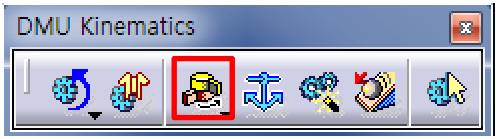
☐ Angle driven

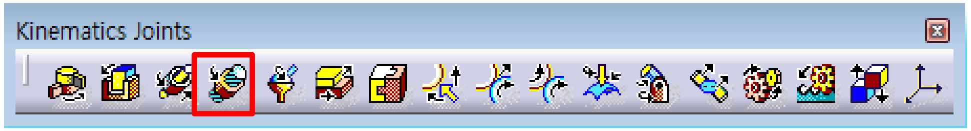
☐ Length driven



DMU KINEMATICS TOOLS

DMU Kinematics

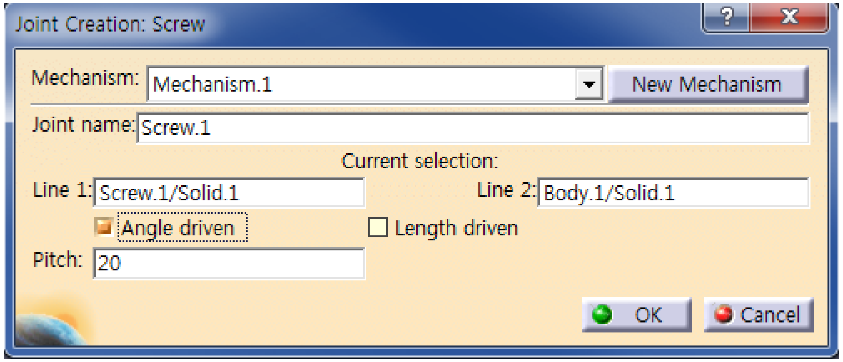

DMU Kinematics


Kinematics Joints

Screw Joint

- 두 component가 pitch 값을 기준으로 회전과 병진 운동하도록 joint 생성

<Line 선택, Pitch값 입력>


Joint Creation: Screw
?
X
New Mechanism
OK
Cancel

Mechanism: Mechanism.1

Joint name: Screw.1

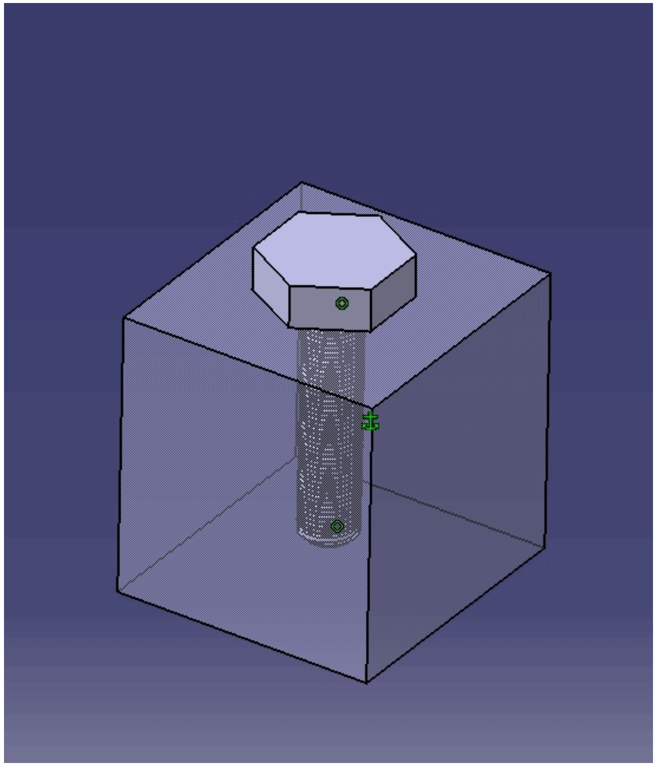
Current selection:

Line 1: Screw.1/Solid.1

Line 2: Body.1/Solid.1

☑ Angle driven ☐ Length driven

Pitch: 20

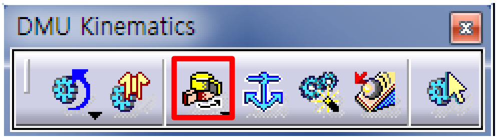


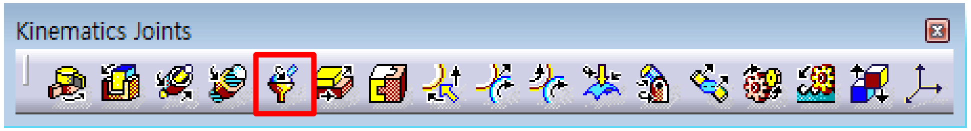
Angle driven & Pitch : 지정해준 각도만큼 회전하며, 360도 회전 할 때 지정한 pitch 값 만큼 이동함.

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

DMU KINEMATICS TOOLS

DMU Kinematics

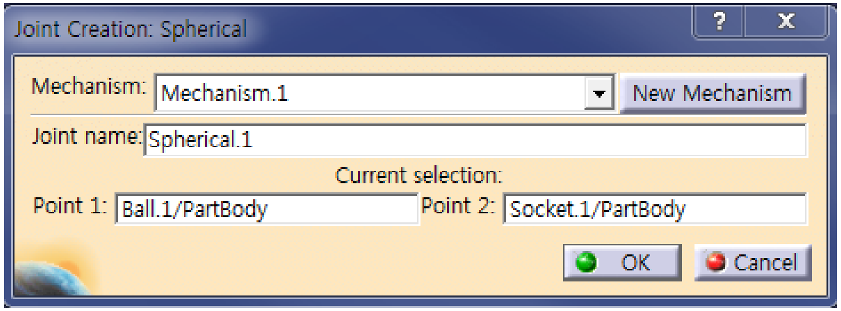

DMU Kinematics


Kinematics Joints

Spherical Joint

- 두 component가 특정한 point를 중심으로 운동하도록 joint 생성

<Point 선택>

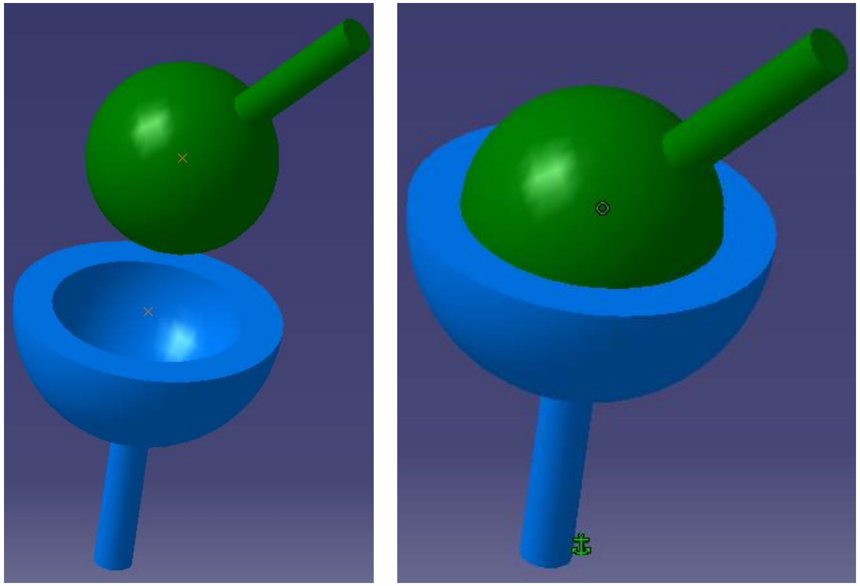

Joint Creation: Spherical
New Mechanism
Current selection:
OK
Cancel

Mechanism: Mechanism.1

Joint name: Spherical.1

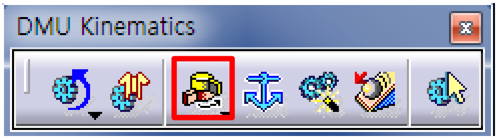
Point 1: Ball.1/PartBody

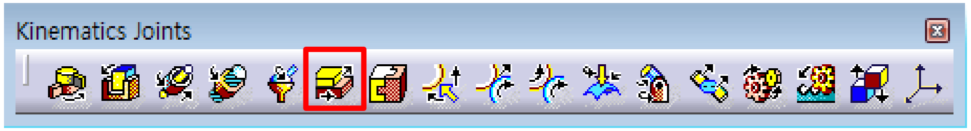
Point 2: Socket.1/PartBody



DMU KINEMATICS TOOLS

DMU Kinematics

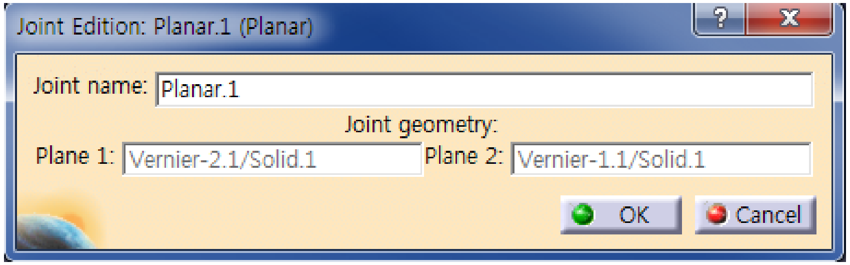

DMU Kinematics


Kinematics Joints

Planar Joint

- 두 component가 특정한 plane를 중심으로 운동하도록 joint 생성

<Plane 선택>

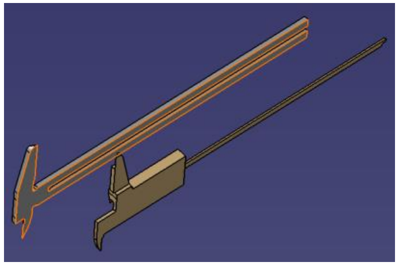

Joint Edition: Planar.1 (Planar)
OK
Cancel

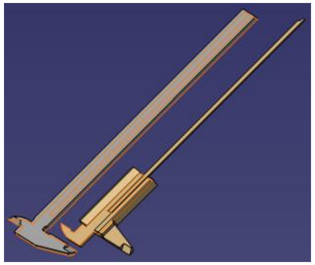
Joint name: Planar.1

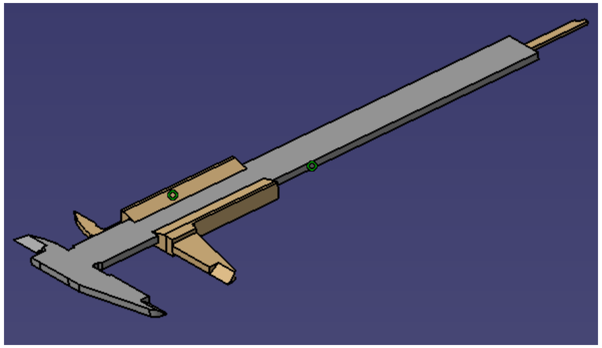
Joint geometry:

Plane 1: Vernier-2.1/Solid.1

Plane 2: Vernier-1.1/Solid.1

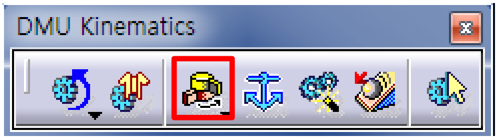


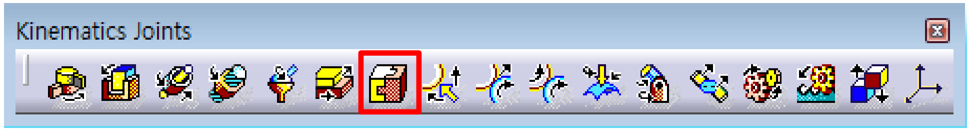




DMU KINEMATICS TOOLS

DMU Kinematics

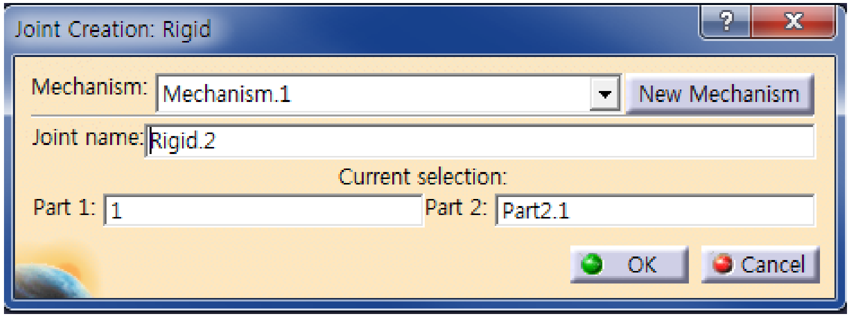

DMU Kinematics


Kinematics Joints

Rigid Joint

- 두 component의 상대위치를 고정시켜주는 joint를 생성

<Component 선택>



Joint Creation: Rigid

Mechanism: Mechanism.1

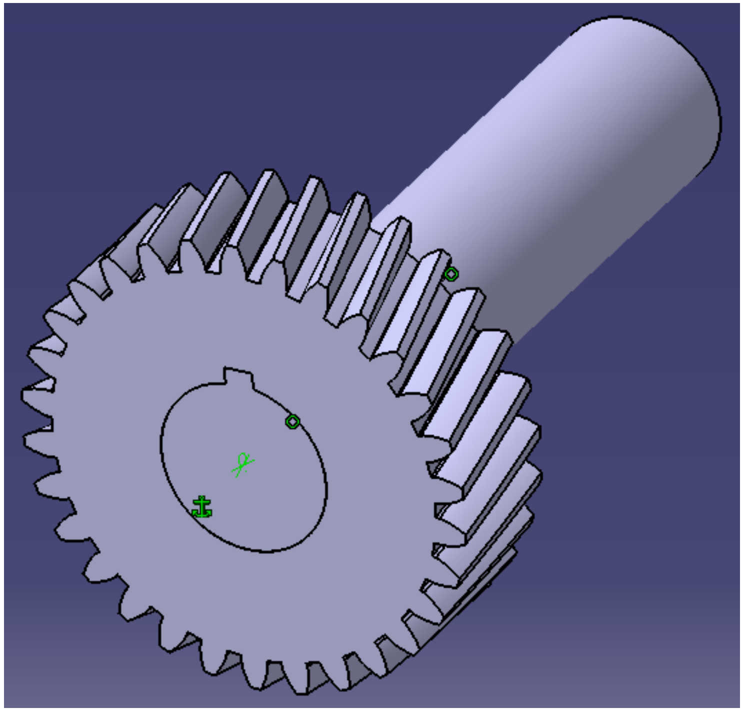
Joint name: Rigid.2

Current selection:

Part 1: 1

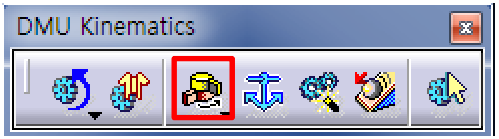
Part 2: Part2.1

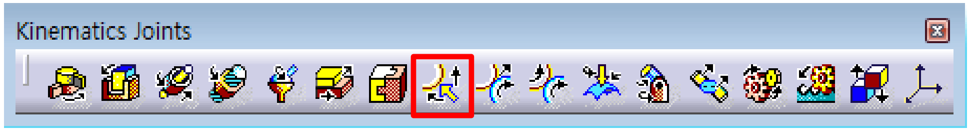
New Mechanism
OK
Cancel



DMU KINEMATICS TOOLS

DMU Kinematics

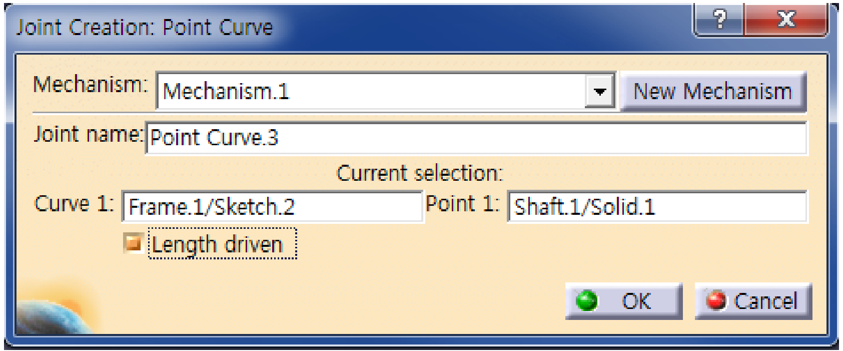




Point Curve Joint

- 특정 점이 특정 곡선을 따라 움직이도록 joint 생성

<Curve, Point 선택>



Joint Creation: Point Curve

Mechanism: Mechanism.1 New Mechanism

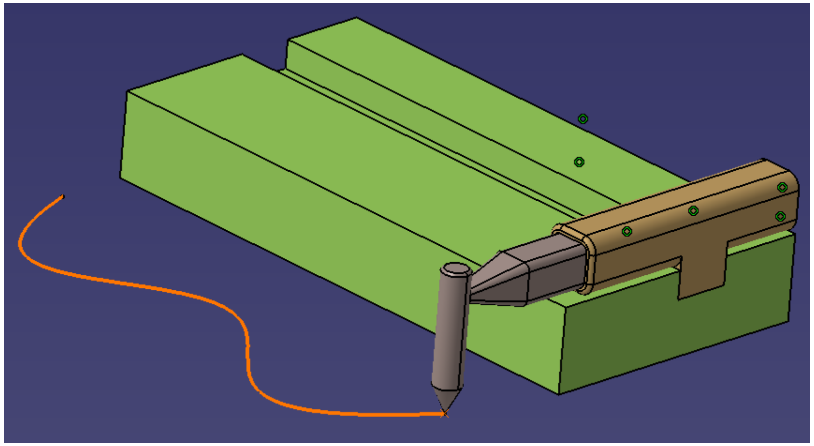
Joint name: Point Curve.3

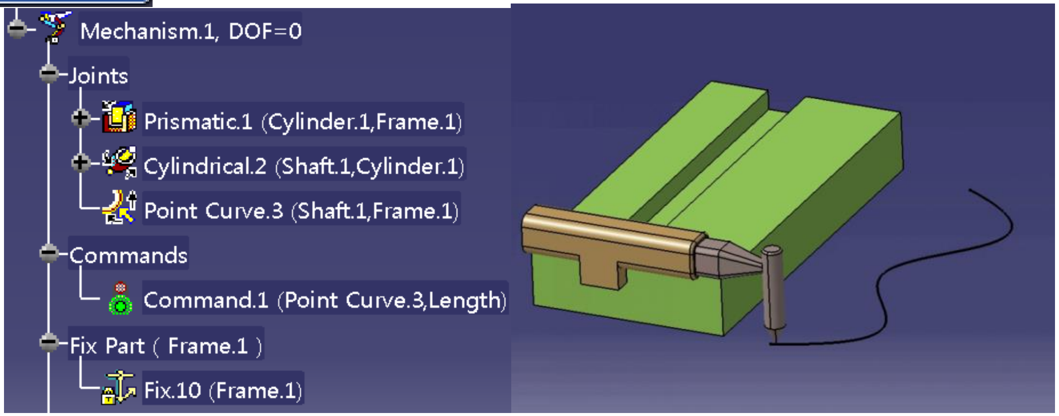
Current selection:

Curve 1: Frame.1/Sketch.2 Point 1: Shaft.1/Solid.1

☐ Length driven

OK Cancel

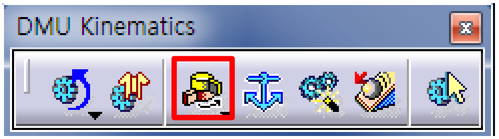


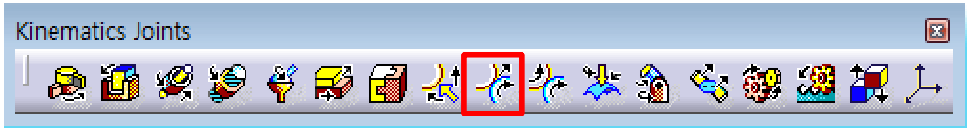


- Mechanism.1, DOF=0
  - Joints
    - Prismatic.1 (Cylinder.1,Frame.1)
    - Cylindrical.2 (Shaft.1,Cylinder.1)
    - Point Curve.3 (Shaft.1,Frame.1)
  - Commands
    - Command.1 (Point Curve.3,Length)
  - Fix Part (Frame.1)
    - Fix.10 (Frame.1)

DMU KINEMATICS TOOLS

DMU Kinematics

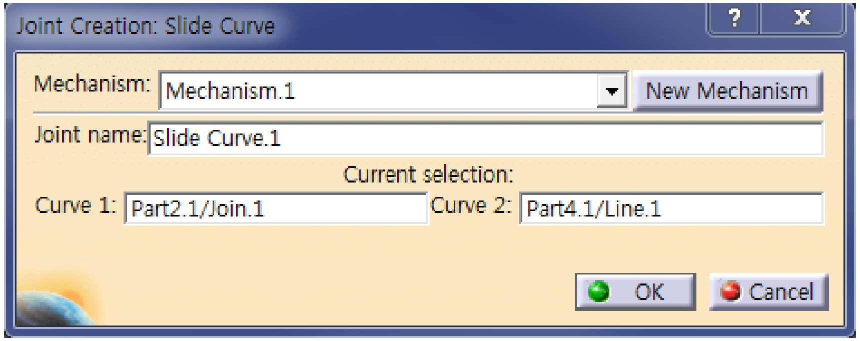

DMU Kinematics


Kinematics Joints

Slide Curve Joint

- 특정 곡선이 다른 곡선을 따라 움직이도록 joint 생성

<Curve 선택>



Joint Creation: Slide Curve

Mechanism: Mechanism.1

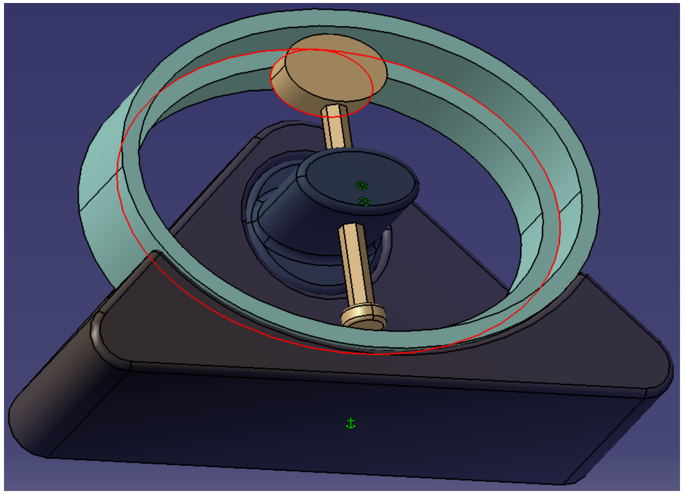
Joint name: Slide Curve.1

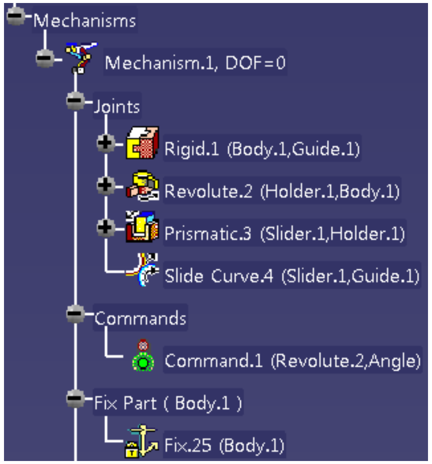
Current selection:

Curve 1: Part2.1/Join.1

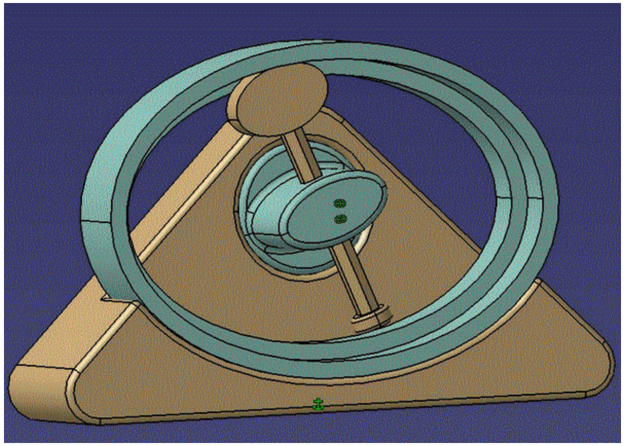
Curve 2: Part4.1/Line.1

New Mechanism
OK
Cancel



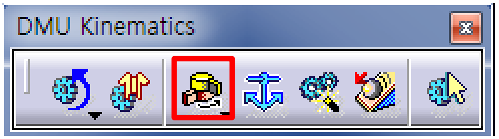


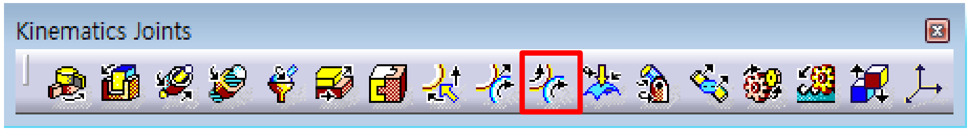
- Mechanisms
  - Mechanism.1, DOF=0
    - Joints
      - Rigid.1 (Body.1,Guide.1)
      - Revolute.2 (Holder.1,Body.1)
      - Prismatic.3 (Slider.1,Holder.1)
      - Slide Curve.4 (Slider.1,Guide.1)
    - Commands
      - Command.1 (Revolute.2,Angle)
    - Fix Part (Body.1)
      - Fix.25 (Body.1)



DMU KINEMATICS TOOLS

DMU Kinematics

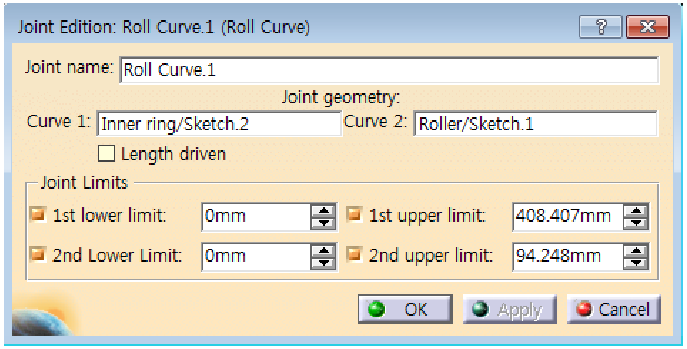




Roll Curve Joint

- 특정 곡선끼리 맞물려 움직이도록 joint 생성

<Curve 선택>



Joint Edition: Roll Curve.1 (Roll Curve)

Joint name: Roll Curve.1

Joint geometry:

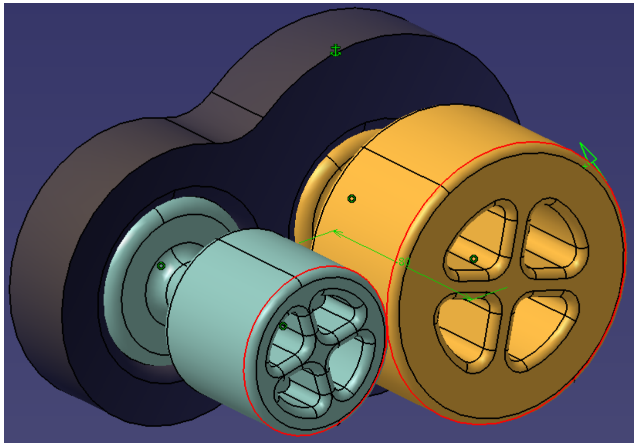
Curve 1: Inner ring/Sketch.2 Curve 2: Roller/Sketch.1

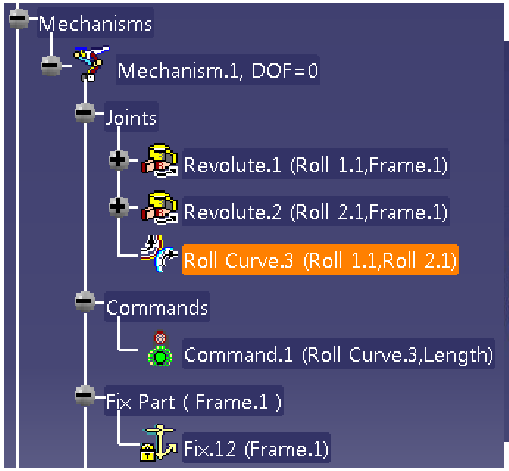
☐ Length driven

Joint Limits

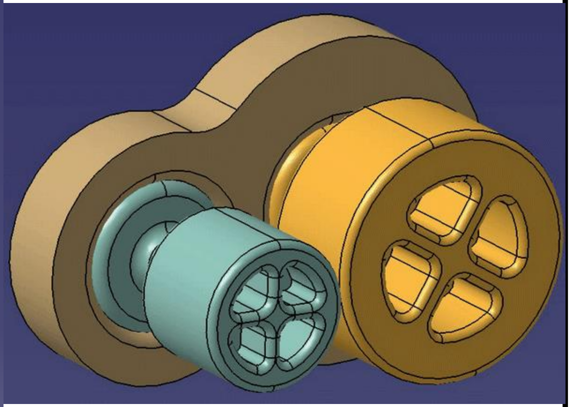
☑ 1st lower limit:	0mm	☑ 1st upper limit:	408.407mm
☑ 2nd Lower Limit:	0mm	☑ 2nd upper limit:	94.248mm

Roll Curve Joint



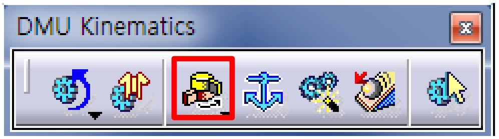


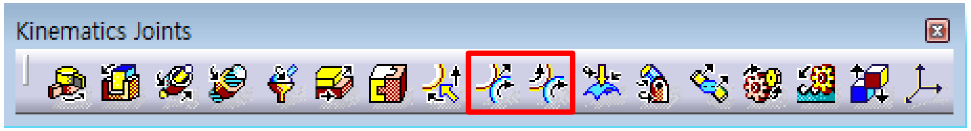
- Mechanisms
  - Mechanism.1, DOF=0
    - Joints
      - Revolute.1 (Roll 1.1,Frame.1)
      - Revolute.2 (Roll 2.1,Frame.1)
      - Roll Curve.3 (Roll 1.1,Roll 2.1)
    - Commands
      - Command.1 (Roll Curve.3,Length)
    - Fix Part (Frame.1)
      - Fix.12 (Frame.1)



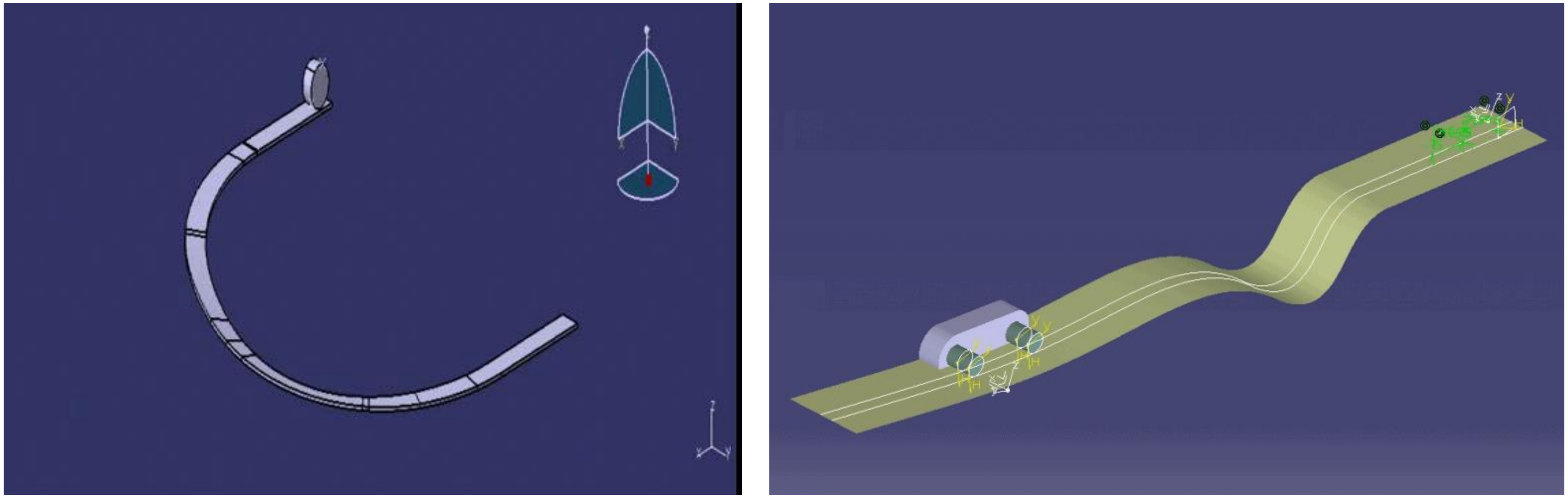
DMU KINEMATICS TOOLS

DMU Kinematics


DMU Kinematics


Kinematics Joints

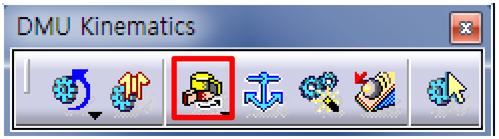
Slide Curve Joint + Roll Curve Joint

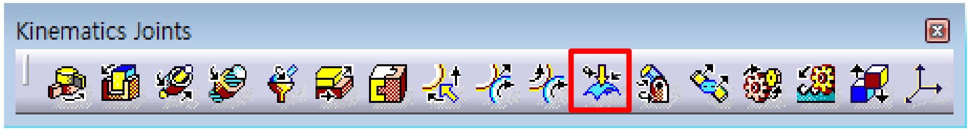


http://cadsystemshelp.blogspot.kr/2012/03/how-do-you-simulate-rolling-in-catia.html

DMU KINEMATICS TOOLS

DMU Kinematics

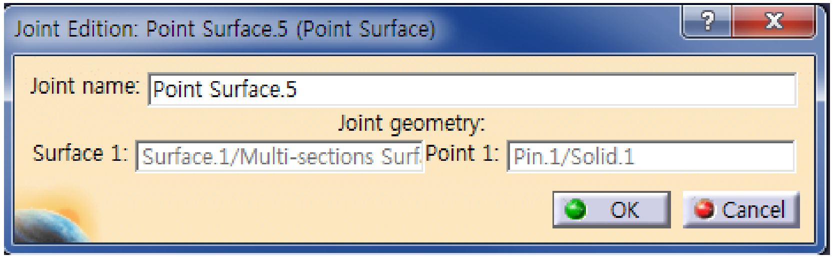




Point Surface Joint

- 특정 점이 특정 곡면을 따라 움직이도록 joint 생성

<Surface, Point 선택>

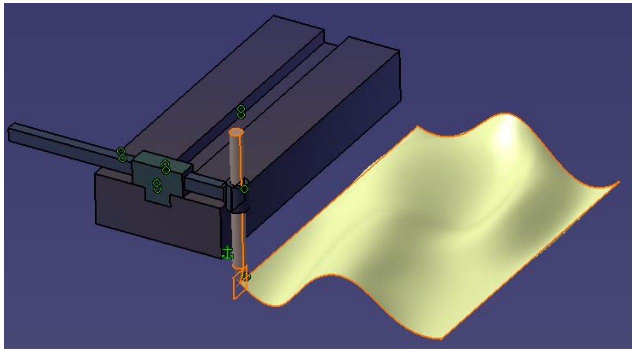

Joint Edition: Point Surface.5 (Point Surface)

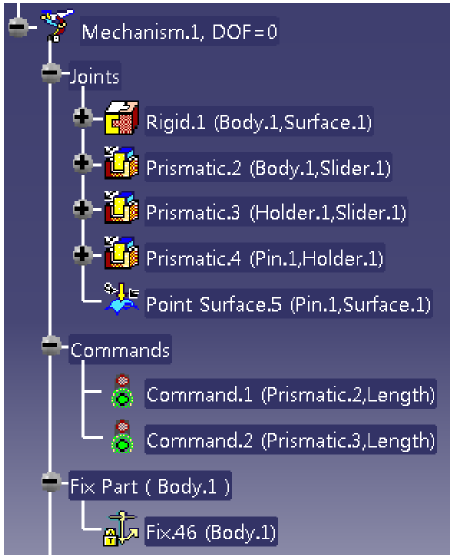
Joint name: Point Surface.5

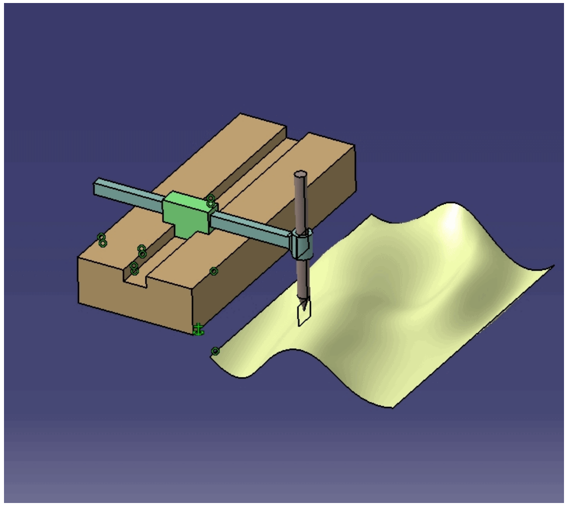
Joint geometry:

Surface 1: Surface.1/Multi-sections Surf

Point 1: Pin.1/Solid.1

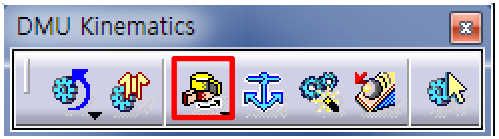


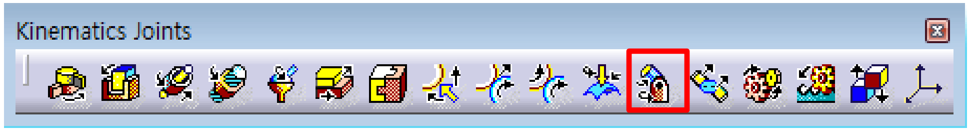

Mechanism.1, DOF=0
- Joints
  - Rigid.1 (Body.1,Surface.1)
  - Prismatic.2 (Body.1,Slider.1)
  - Prismatic.3 (Holder.1,Slider.1)
  - Prismatic.4 (Pin.1,Holder.1)
  - Point Surface.5 (Pin.1,Surface.1)
- Commands
  - Command.1 (Prismatic.2,Length)
  - Command.2 (Prismatic.3,Length)
- Fix Part (Body.1)
  - Fix.46 (Body.1)



DMU KINEMATICS TOOLS

DMU Kinematics

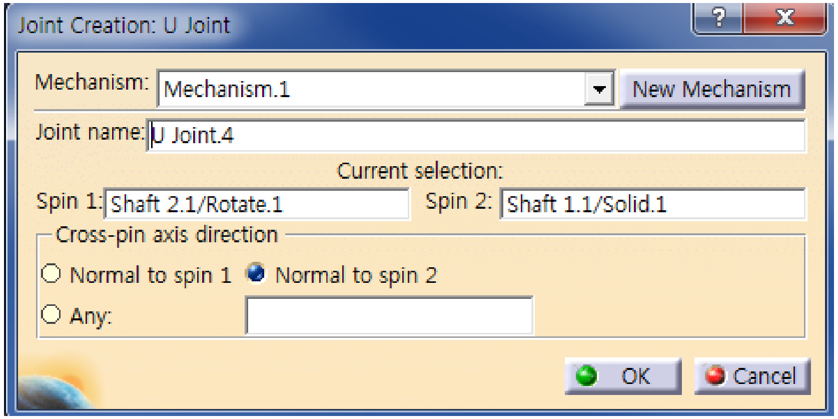




Universal Joint

- 두 축을 연결해주기 위한 joint 생성

<연결할 축 선택>



Joint Creation: U Joint

Mechanism: Mechanism.1 | New Mechanism

Joint name: U Joint.4

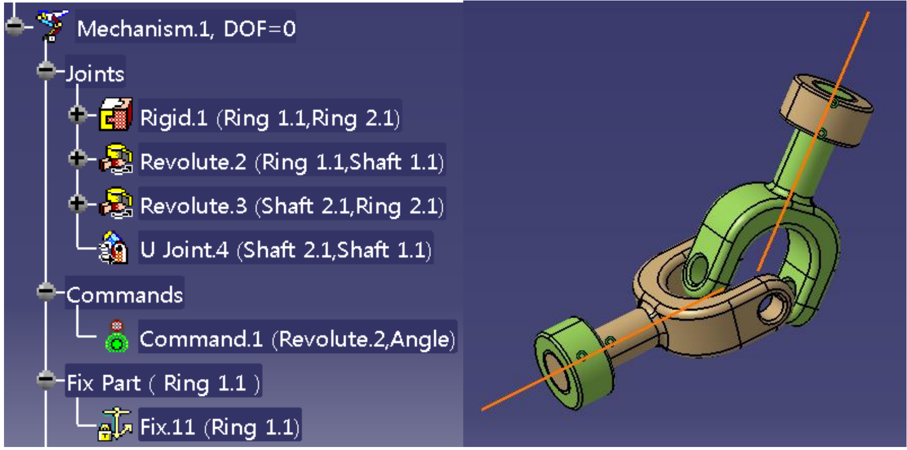
Current selection:

Spin 1: Shaft 2.1/Rotate.1 Spin 2: Shaft 1.1/Solid.1

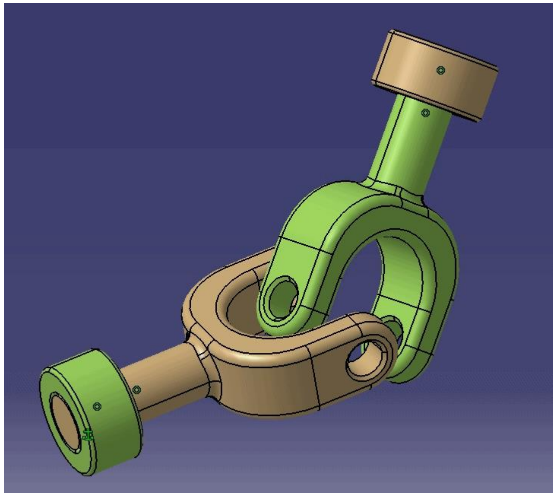
Cross-pin axis direction

○ Normal to spin 1 ● Normal to spin 2

○ Any:

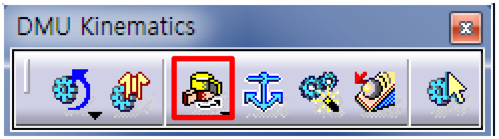


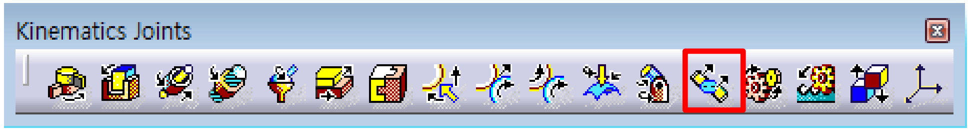
```
Mechanism.1, DOF=0
  Joints
    Rigid.1 (Ring 1.1,Ring 2.1)
    Revolute.2 (Ring 1.1,Shaft 1.1)
    Revolute.3 (Shaft 2.1,Ring 2.1)
    U Joint.4 (Shaft 2.1,Shaft 1.1)
  Commands
    Command.1 (Revolute.2,Angle)
  Fix Part ( Ring 1.1 )
    Fix.11 (Ring 1.1)
```



DMU KINEMATICS TOOLS

DMU Kinematics

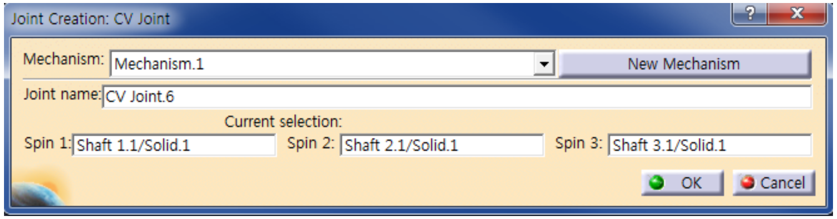

DMU Kinematics


Kinematics Joints

CV Joint

- 3개의 축을 연결해 주기 위한 joint 생성

<연결할 축 선택>


Joint Creation: CV Joint
New Mechanism
OK
Cancel

Mechanism: Mechanism.1

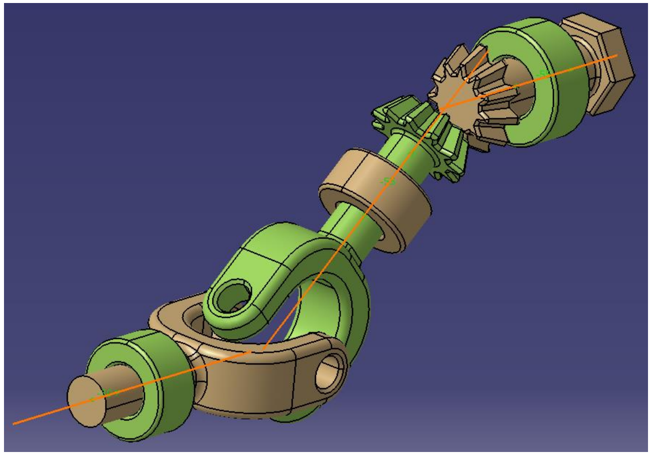
Joint name: CV Joint.6

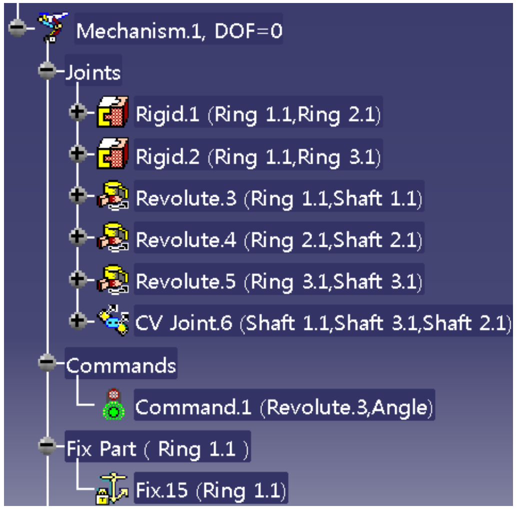
Current selection:

Spin 1: Shaft 1.1/Solid.1

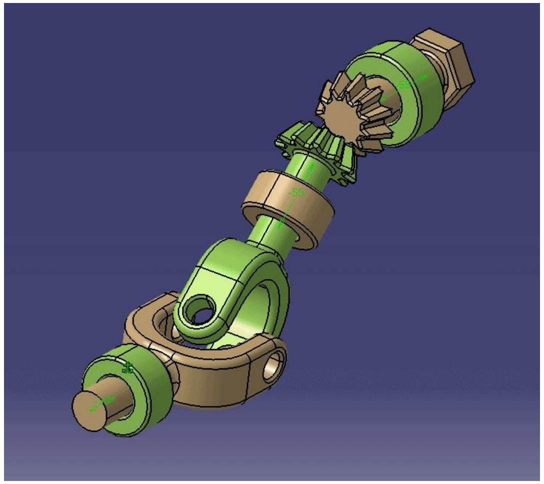
Spin 2: Shaft 2.1/Solid.1

Spin 3: Shaft 3.1/Solid.1



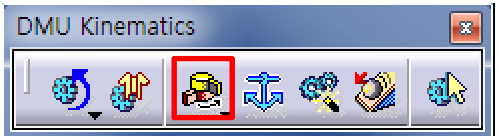


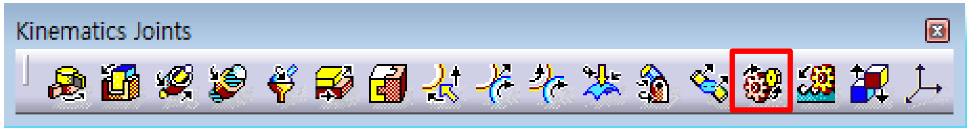
- Mechanism.1, DOF=0
  - Joints
    - Rigid.1 (Ring 1.1,Ring 2.1)
    - Rigid.2 (Ring 1.1,Ring 3.1)
    - Revolute.3 (Ring 1.1,Shaft 1.1)
    - Revolute.4 (Ring 2.1,Shaft 2.1)
    - Revolute.5 (Ring 3.1,Shaft 3.1)
    - CV Joint.6 (Shaft 1.1,Shaft 3.1,Shaft 2.1)
  - Commands
    - Command.1 (Revolute.3,Angle)
  - Fix Part (Ring 1.1)
    - Fix.15 (Ring 1.1)



DMU KINEMATICS TOOLS

DMU Kinematics

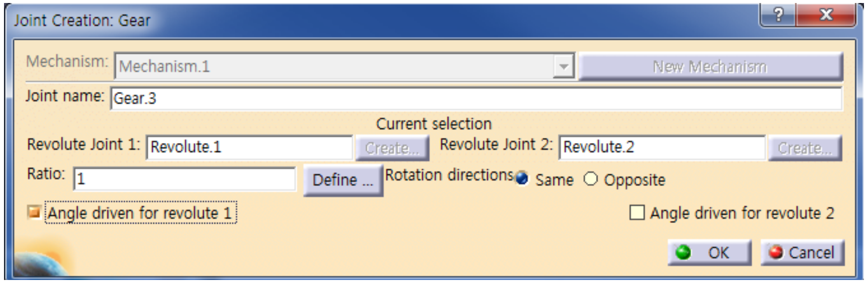




Gear Joint

- 기어 비를 이용하여 회전운동 하도록 joint 생성

<Revolute joint 선택>



Joint Creation: Gear

Mechanism: Mechanism.1 New Mechanism

Joint name: Gear.3

Current selection

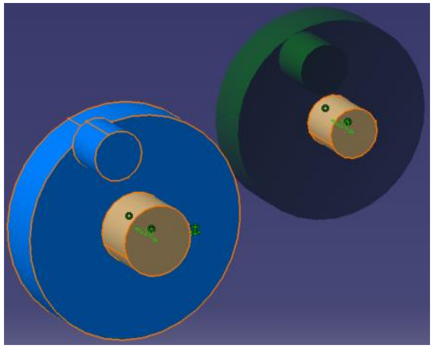
Revolute Joint 1: Revolute.1 Create... Revolute Joint 2: Revolute.2 Create...

Ratio: 1 Define ... Rotation directions ● Same ○ Opposite

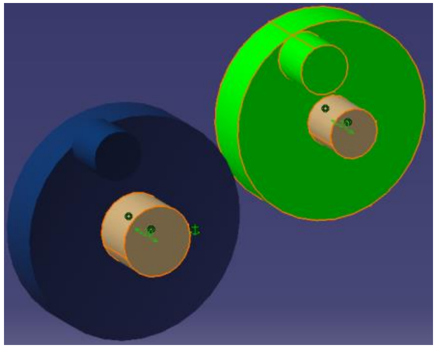
☑ Angle driven for revolute 1 ☐ Angle driven for revolute 2

OK Cancel

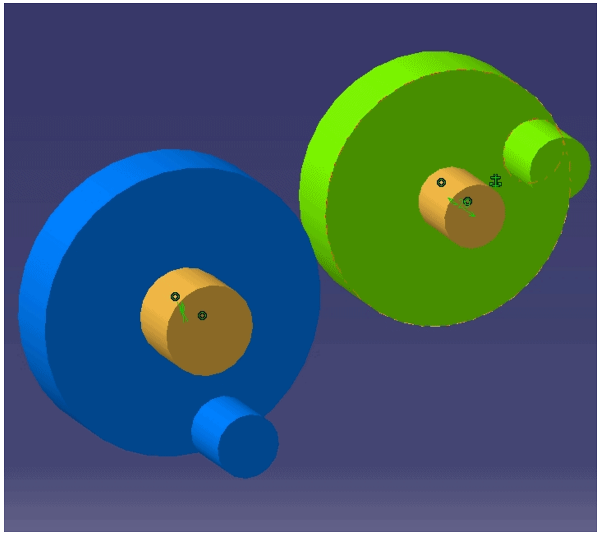
$$: \ Ratio = \frac{Revolute\ Joint\ 2\ \text{의 회전수}}{Revolute\ Joint\ 1\ \text{의 회전수}}$$



<Revolute Joint 1>

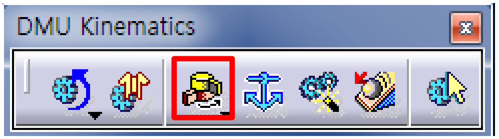


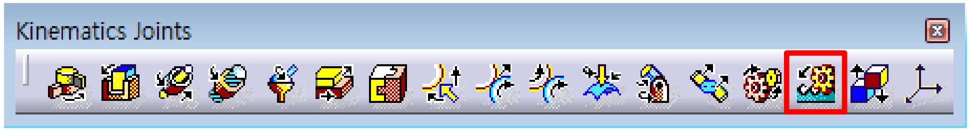
<Revolute Joint 2>



DMU KINEMATICS TOOLS

DMU Kinematics

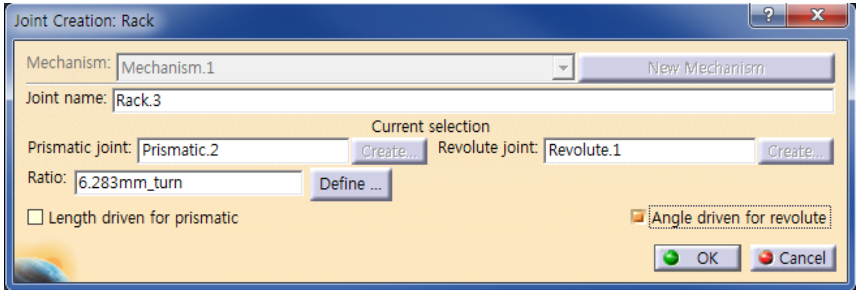

DMU Kinematics


Kinematics Joints

Rack Joint

- 기어 비를 이용하여 회전/병진 운동하도록 joint 생성

<Prismatic, Revolute 선택>


?
New Mechanism
Create...
Create...
Define ...
OK
Cancel

Joint Creation: Rack

Mechanism: Mechanism.1

Joint name: Rack.3

Current selection

Prismatic joint: Prismatic.2

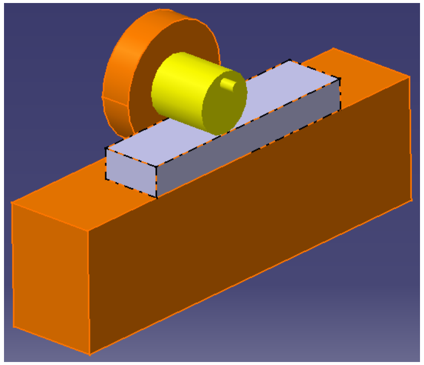
Revolute joint: Revolute.1

Ratio: 6.283mm_turn

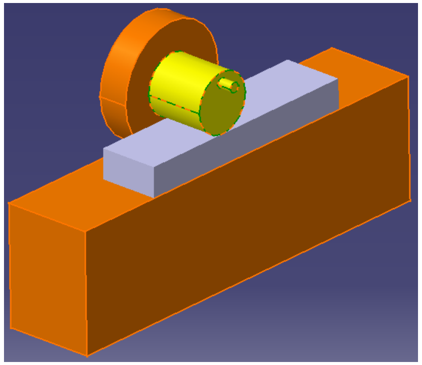
☐ Length driven for prismatic

☐ Angle driven for revolute

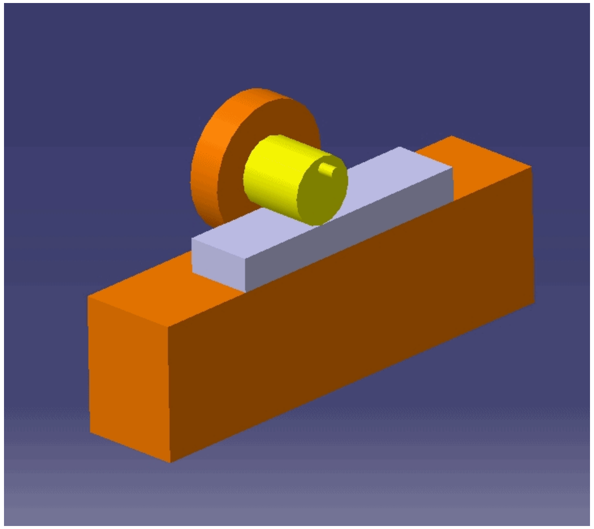
: $Ratio =$ 이동 길이/회전



<Prismatic>



<Revolute>



DMU KINEMATICS TOOLS

DMU Kinematics

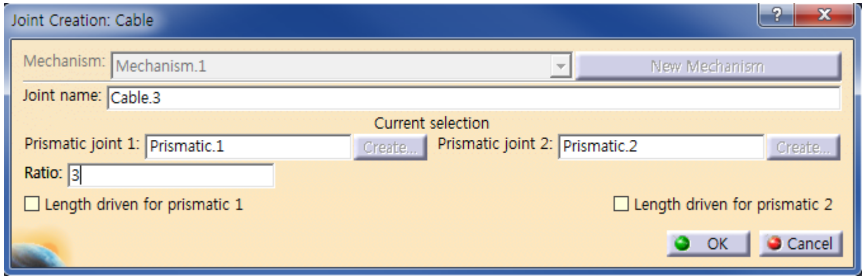
DMU Kinematics

Kinematics Joints

Cable Joint

- Cable이 연결 된 것처럼 움직이도록 joint 생성

<Prismatic joint 선택>



Joint Creation: Cable

Mechanism: Mechanism.1 New Mechanism

Joint name: Cable.3

Current selection

Prismatic joint 1: Prismatic.1 Create...

Prismatic joint 2: Prismatic.2 Create...

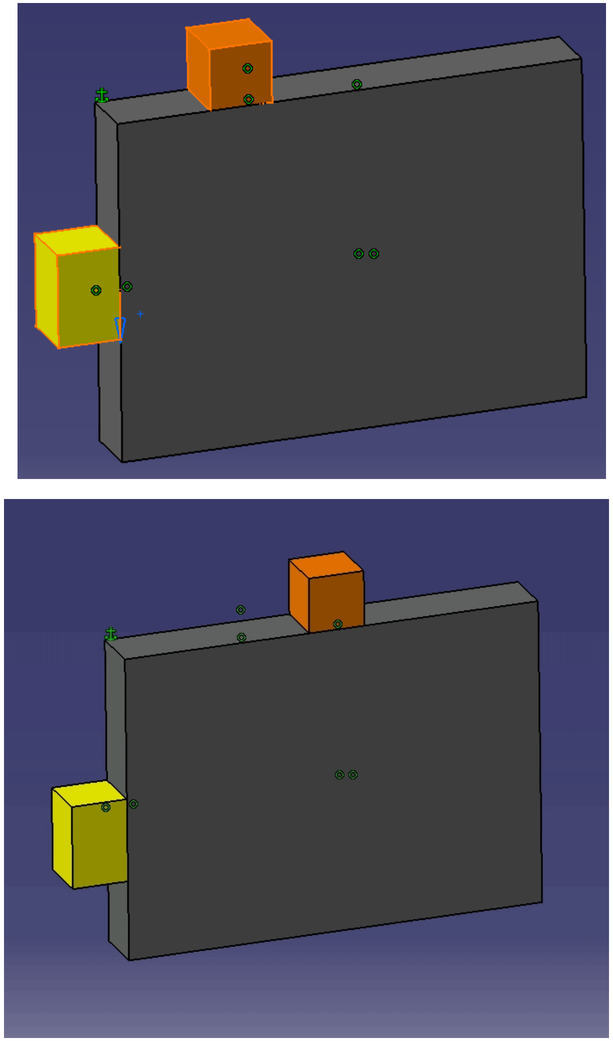
Ratio: 3

☐ Length driven for prismatic 1

☐ Length driven for prismatic 2

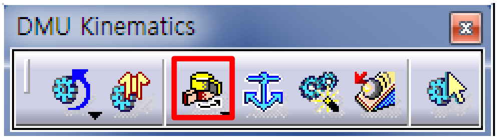
OK Cancel

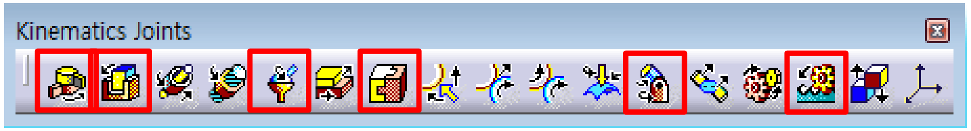
$$: Ratio = \frac{Prismatic\ Joint\ 2\text{의 이동길이}}{Prismatic\ Joint\ 1\text{의 이동길이}}$$



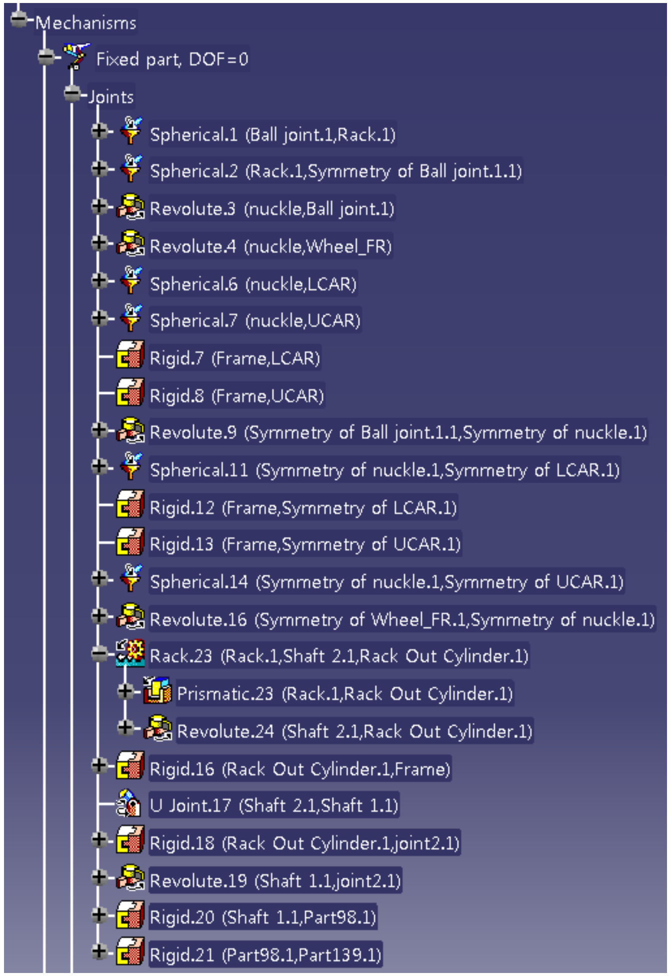
DMU KINEMATICS TOOLS

DMU Kinematics

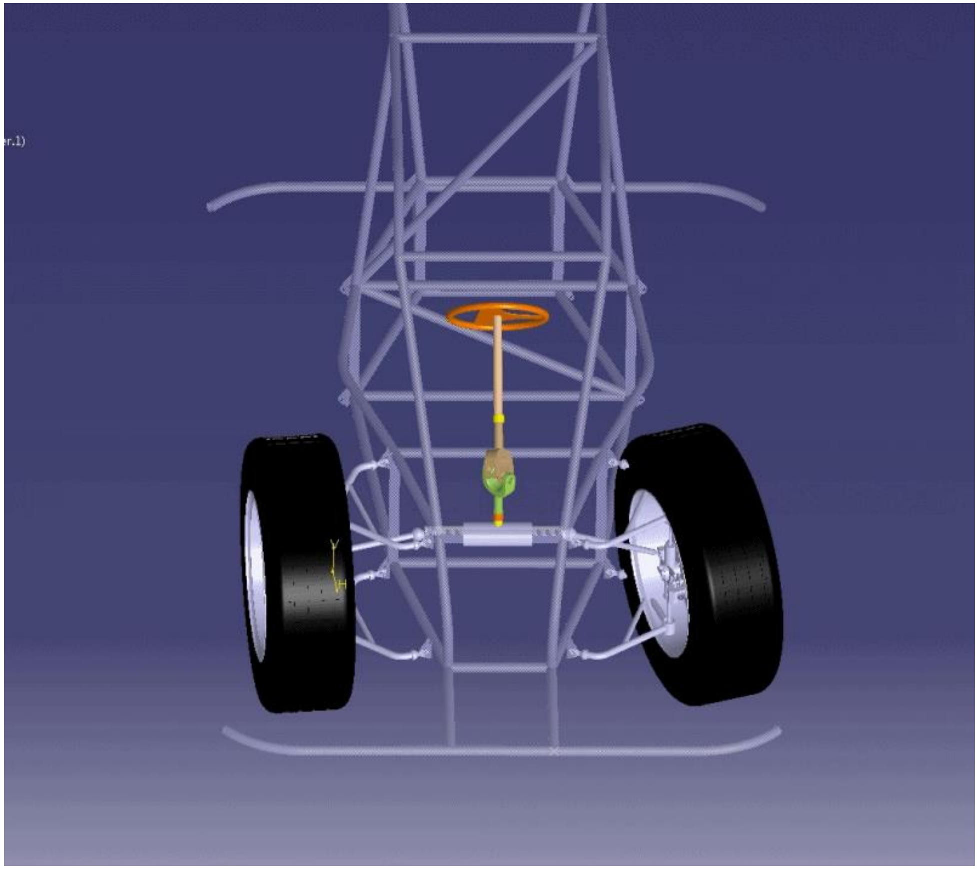




Steering System Mechanism



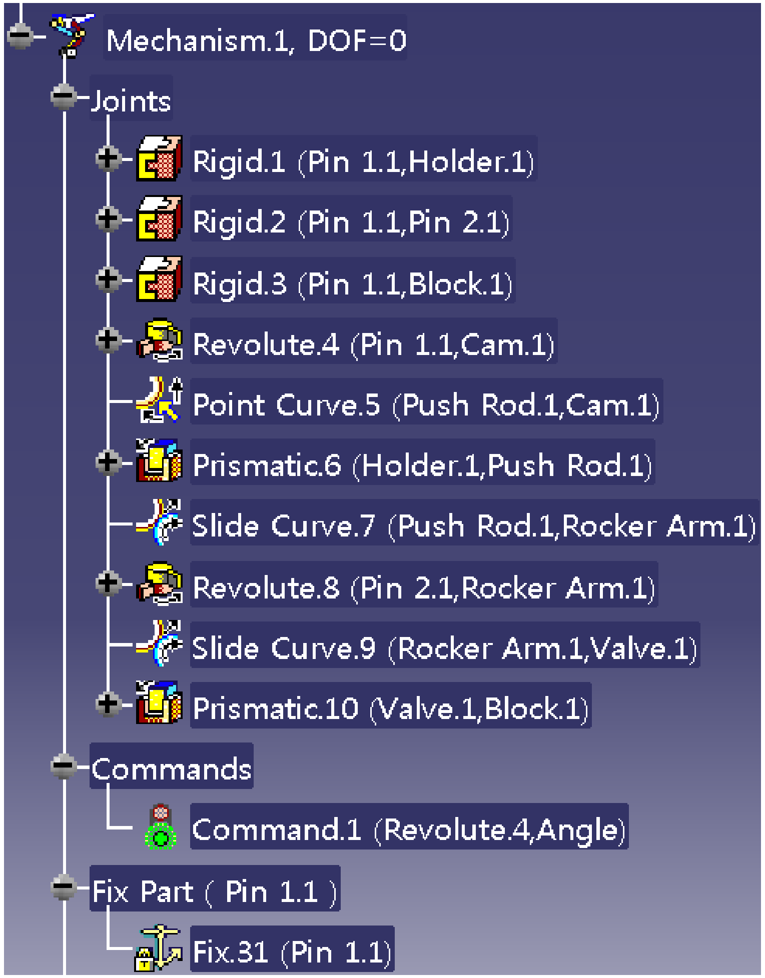
- Mechanisms
  - Fixed part, DOF=0
    - Joints
      - Spherical.1 (Ball joint.1,Rack.1)
      - Spherical.2 (Rack.1,Symmetry of Ball joint.1.1)
      - Revolute.3 (nuckle,Ball joint.1)
      - Revolute.4 (nuckle,Wheel_FR)
      - Spherical.6 (nuckle,LCAR)
      - Spherical.7 (nuckle,UCAR)
      - Rigid.7 (Frame,LCAR)
      - Rigid.8 (Frame,UCAR)
      - Revolute.9 (Symmetry of Ball joint.1.1,Symmetry of nuckle.1)
      - Spherical.11 (Symmetry of nuckle.1,Symmetry of LCAR.1)
      - Rigid.12 (Frame,Symmetry of LCAR.1)
      - Rigid.13 (Frame,Symmetry of UCAR.1)
      - Spherical.14 (Symmetry of nuckle.1,Symmetry of UCAR.1)
      - Revolute.16 (Symmetry of Wheel_FR.1,Symmetry of nuckle.1)
      - Rack.23 (Rack.1,Shaft 2.1,Rack Out Cylinder.1)
        - Prismatic.23 (Rack.1,Rack Out Cylinder.1)
        - Revolute.24 (Shaft 2.1,Rack Out Cylinder.1)
      - Rigid.16 (Rack Out Cylinder.1,Frame)
      - U Joint.17 (Shaft 2.1,Shaft 1.1)
      - Rigid.18 (Rack Out Cylinder.1,joint2.1)
      - Revolute.19 (Shaft 1.1,joint2.1)
      - Rigid.20 (Shaft 1.1,Part98.1)
      - Rigid.21 (Part98.1,Part139.1)



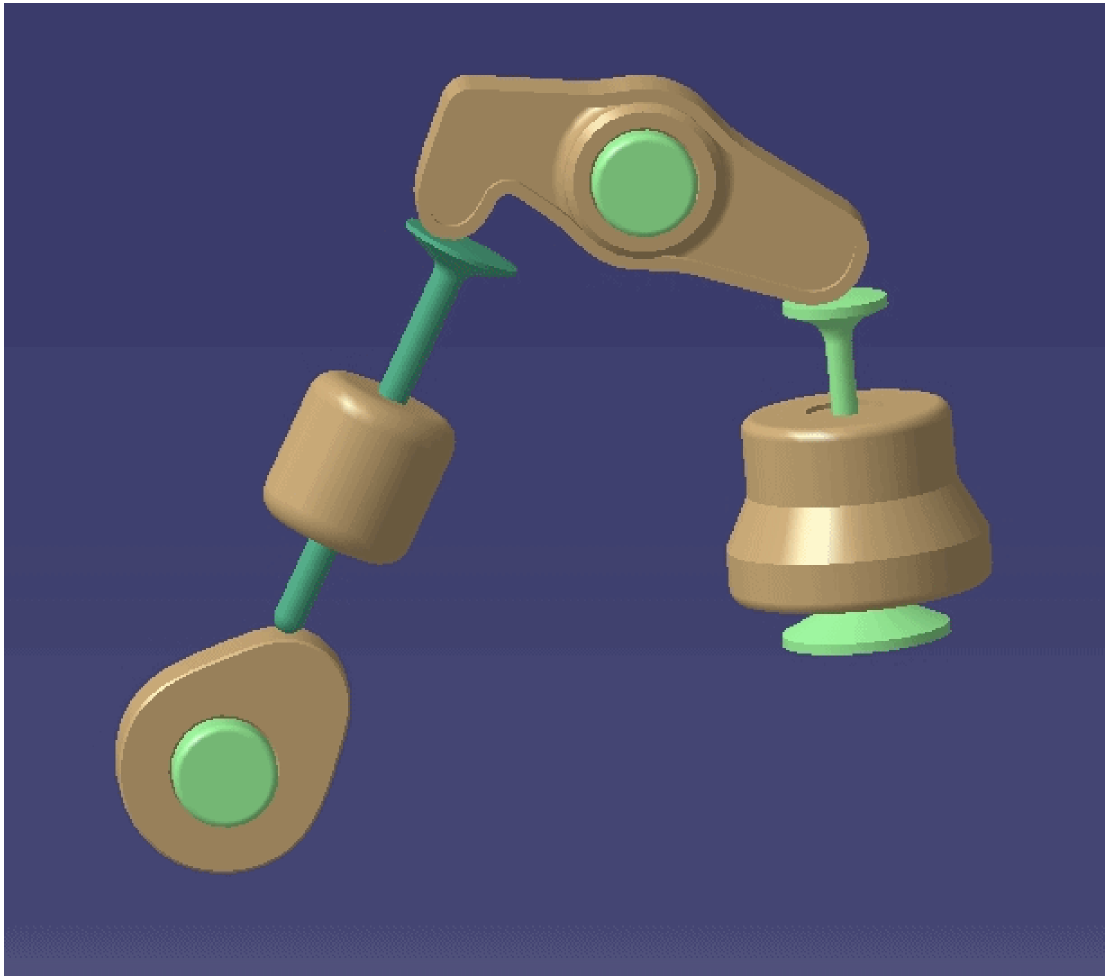
2012 CAD Project – '조석' 팀 수정 자료

실습 예제

홈페이지의 Practice 파일을 이용하여 아래의 그림과 같이 DMU Kinematics 작업을 진행하기

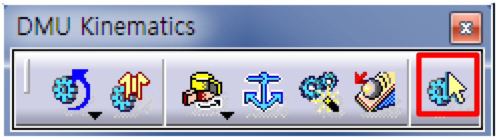


- Mechanism.1, DOF=0
  - Joints
    - Rigid.1 (Pin 1.1,Holder.1)
    - Rigid.2 (Pin 1.1,Pin 2.1)
    - Rigid.3 (Pin 1.1,Block.1)
    - Revolute.4 (Pin 1.1,Cam.1)
    - Point Curve.5 (Push Rod.1,Cam.1)
    - Prismatic.6 (Holder.1,Push Rod.1)
    - Slide Curve.7 (Push Rod.1,Rocker Arm.1)
    - Revolute.8 (Pin 2.1,Rocker Arm.1)
    - Slide Curve.9 (Rocker Arm.1,Valve.1)
    - Prismatic.10 (Valve.1,Block.1)
  - Commands
    - Command.1 (Revolute.4,Angle)
  - Fix Part (Pin 1.1)
    - Fix.31 (Pin 1.1)



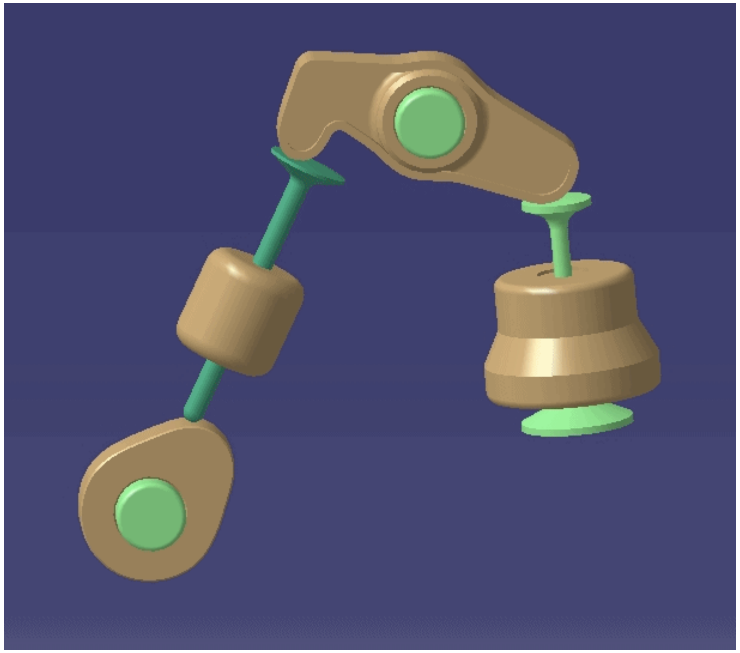
DMU KINEMATICS TOOLS

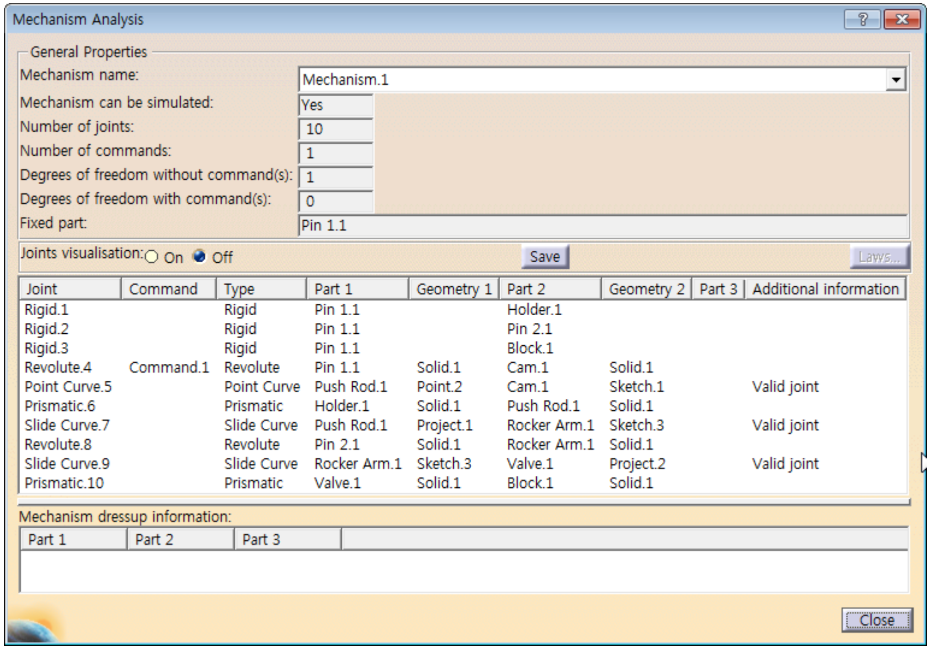
DMU Kinematics



Mechanism Analysis

-생성된 joint들의 연결 상태를 확인함





General Properties

Mechanism name:	Mechanism.1
Mechanism can be simulated:	Yes
Number of joints:	10
Number of commands:	1
Degrees of freedom without command(s):	1
Degrees of freedom with command(s):	0
Fixed part:	Pin 1.1

Joints visualisation: ○ On ● Off

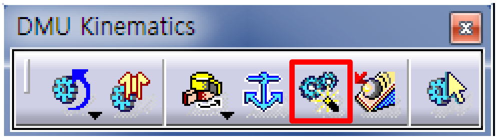
Joint	Command	Type	Part 1	Geometry 1	Part 2	Geometry 2	Part 3	Additional information
Rigid.1		Rigid	Pin 1.1		Holder.1			
Rigid.2		Rigid	Pin 1.1		Pin 2.1			
Rigid.3		Rigid	Pin 1.1		Block.1			
Revolute.4	Command.1	Revolute	Pin 1.1	Solid.1	Cam.1	Solid.1		
Point Curve.5		Point Curve	Push Rod.1	Point.2	Cam.1	Sketch.1		Valid joint
Prismatic.6		Prismatic	Holder.1	Solid.1	Push Rod.1	Solid.1		
Slide Curve.7		Slide Curve	Push Rod.1	Project.1	Rocker Arm.1	Sketch.3		Valid joint
Revolute.8		Revolute	Pin 2.1	Solid.1	Rocker Arm.1	Solid.1		
Slide Curve.9		Slide Curve	Rocker Arm.1	Sketch.3	Valve.1	Project.2		Valid joint
Prismatic.10		Prismatic	Valve.1	Solid.1	Block.1	Solid.1		

Mechanism dressup information:

Part 1	Part 2	Part 3

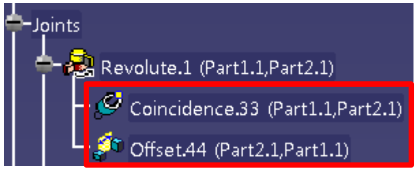
DMU KINEMATICS TOOLS

DMU Kinematics

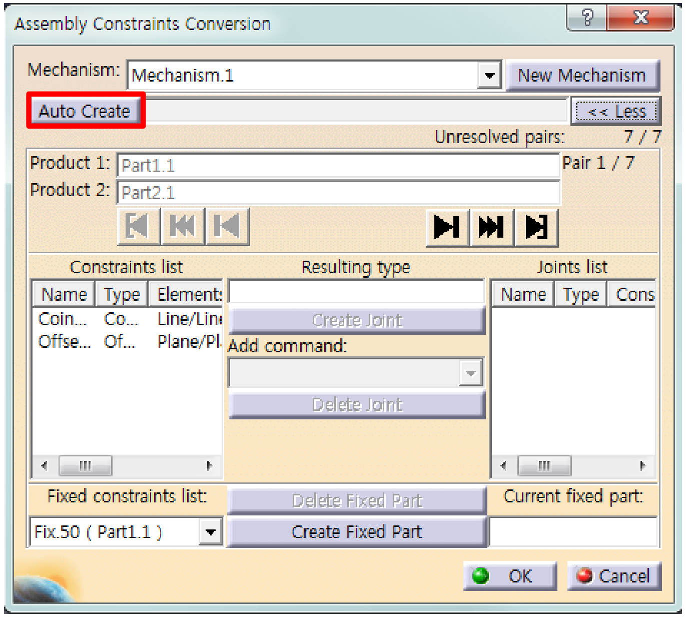

DMU Kinematics

Assembly Constraints Conversion

- Assembly Design에서 생성한 constraint를 Joint로 변경


Joints
Revolute.1 (Part1.1,Part2.1)
Coincidence.33 (Part1.1,Part2.1)
Offset.44 (Part2.1,Part1.1)

여러 개의 constraint로 구성된 joint


Assembly Constraints Conversion

Mechanism: Mechanism.1

Unresolved pairs: 7 / 7

Product 1: Part1.1

Product 2: Part2.1

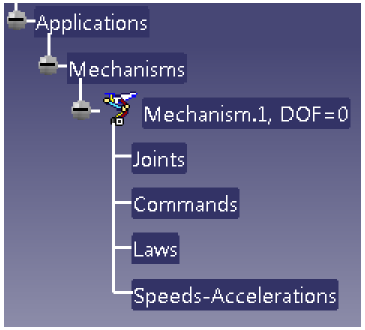
Pair 1 / 7

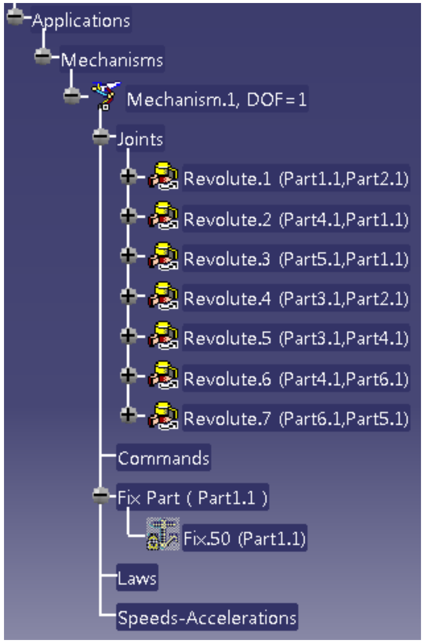
Name	Type	Elements
Coin...	Co...	Line/Line
Offse...	Of...	Plane/Pl...

Fixed constraints list: Fix.50 (Part1.1)

New Mechanism
Auto Create
<< Less
Constraints list
Resulting type
Joints list
Name
Type
Cons
Create Joint
Add command:
Delete Joint
Delete Fixed Part
Create Fixed Part
Current fixed part:
OK
Cancel

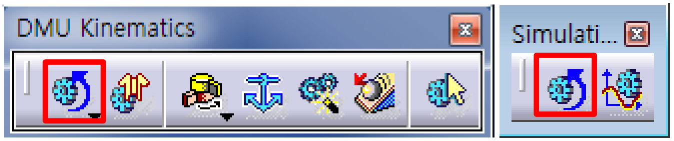
Joint 자동 생성


Applications
Mechanisms
Mechanism.1, DOF=0
Joints
Commands
Laws
Speeds-Accelerations


Applications
Mechanisms
Mechanism.1, DOF=1
Joints
Revolute.1 (Part1.1,Part2.1)
Revolute.2 (Part4.1,Part1.1)
Revolute.3 (Part5.1,Part1.1)
Revolute.4 (Part3.1,Part2.1)
Revolute.5 (Part3.1,Part4.1)
Revolute.6 (Part4.1,Part6.1)
Revolute.7 (Part6.1,Part5.1)
Commands
Fix Part (Part1.1)
Fix.50 (Part1.1)
Laws
Speeds-Accelerations

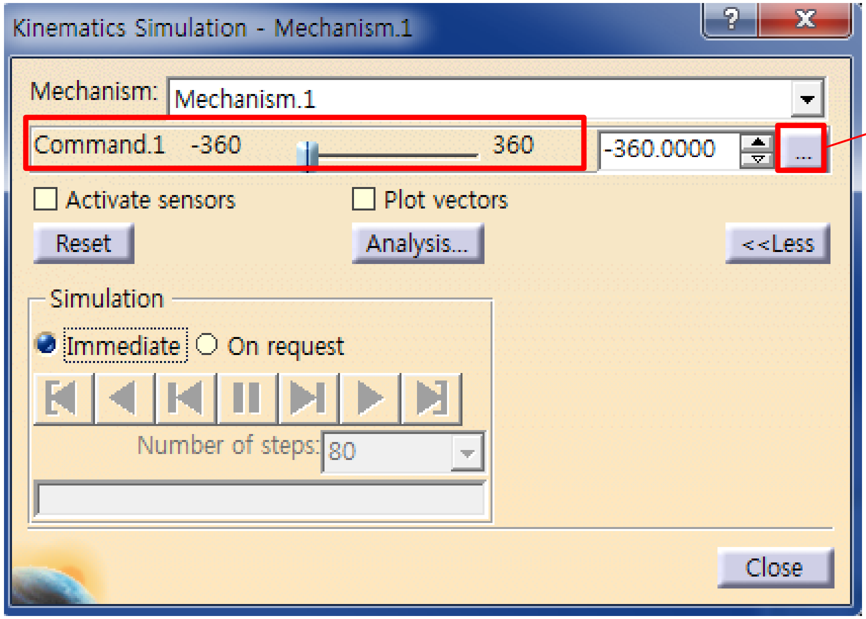
DMU KINEMATICS TOOLS

DMU Kinematics


DMU Kinematics
Simulati...

Simulation with Commands

- 생성된 mechanism이 command를 기준으로 동작


Kinematics Simulation - Mechanism.1
Reset
Analysis...
<<Less
Simulation
Close

Mechanism: Mechanism.1

Command.1 -360 360 -360.0000

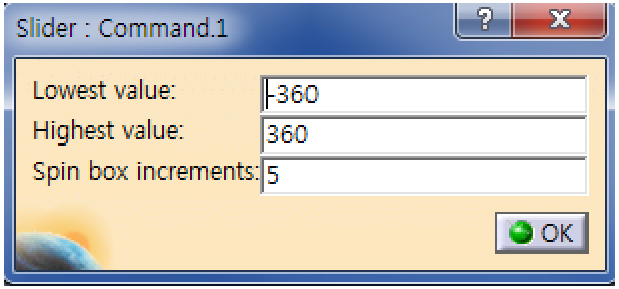
☐ Activate sensors ☐ Plot vectors

● Immediate ○ On request

Number of steps: 80

Joint에서의 Angle/Length driven 수만큼 Command가 생성됨

Command의 Limits 조절 가능

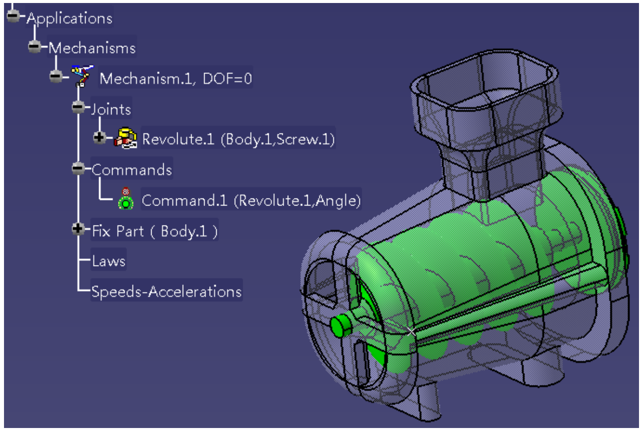

Slider : Command.1
OK

Lowest value: -360

Highest value: 360

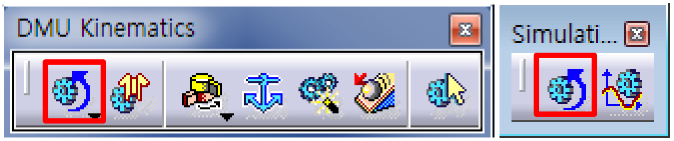
Spin box increments: 5

Revolute Joint 모델


Applications
Mechanisms
Mechanism.1, DOF=0
Joints
Revolute.1 (Body.1,Screw.1)
Commands
Command.1 (Revolute.1,Angle)
Fix Part (Body.1)
Laws
Speeds-Accelerations

DMU KINEMATICS TOOLS

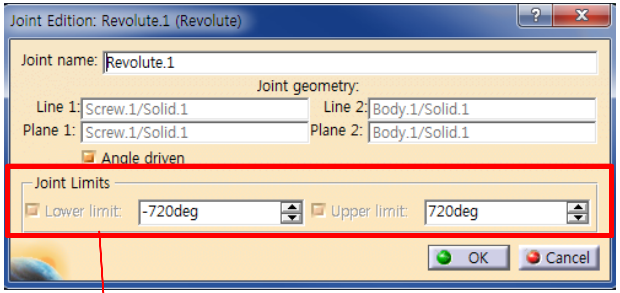
DMU Kinematics



Simulation with Commands

- 생성된 mechanism이 command를 기준으로 동작

생성한 Joint를 더블 클릭하여 Limits 조절 가능


Joint Edition: Revolute.1 (Revolute)

Joint name: Revolute.1

Joint geometry:

Line 1: Screw.1/Solid.1 Line 2: Body.1/Solid.1

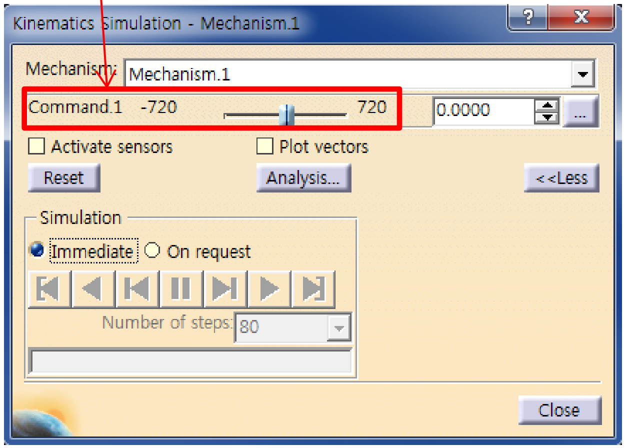
Plane 1: Screw.1/Solid.1 Plane 2: Body.1/Solid.1

☑ Angle driven

Joint Limits

☐ Lower limit: -720deg ☐ Upper limit: 720deg

Simulation Command의 Limits이 됨


Kinematics Simulation - Mechanism.1

Mechanism: Mechanism.1

Command.1 -720 720 0.0000

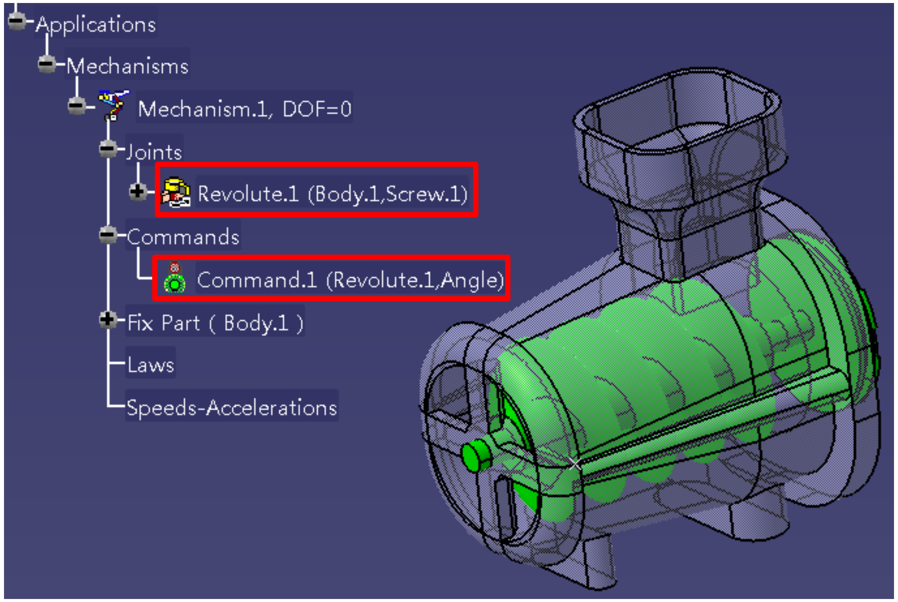
☐ Activate sensors ☐ Plot vectors

Simulation

● Immediate ○ On request

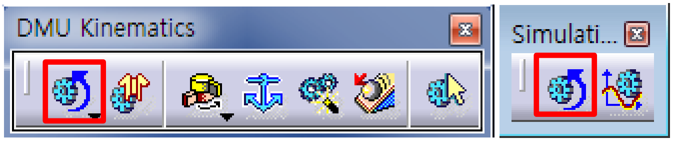
Number of steps: 80

Revolute Joint 모델


Applications
Mechanisms
Mechanism.1, DOF=0
Joints
Revolute.1 (Body.1,Screw.1)
Commands
Command.1 (Revolute.1,Angle)
Fix Part (Body.1)
Laws
Speeds-Accelerations

DMU KINEMATICS TOOLS

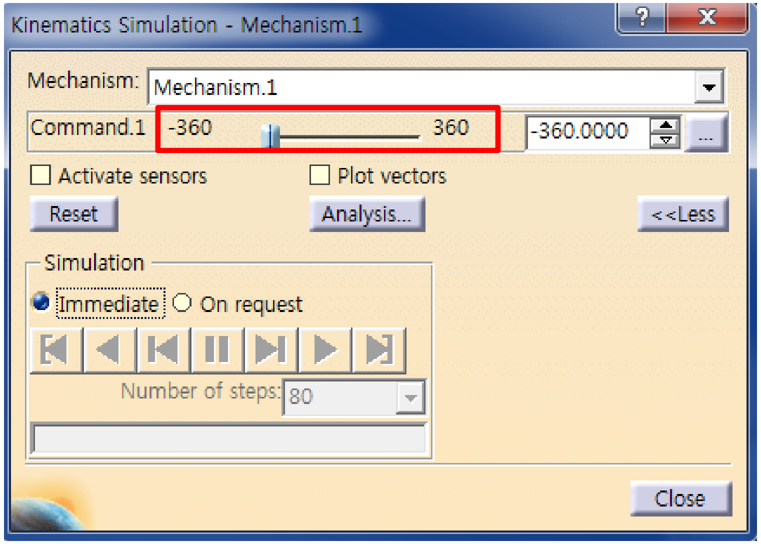
DMU Kinematics


DMU Kinematics
Simulati...

Simulation with Commands

- 생성된 mechanism이 command를 기준으로 동작

스크롤이 이동하는 만큼 mechanism이 구동


Kinematics Simulation - Mechanism.1
Reset
Analysis...
<<Less
Close

Mechanism: Mechanism.1

Command.1 -360 360 -360.0000

☐ Activate sensors ☐ Plot vectors

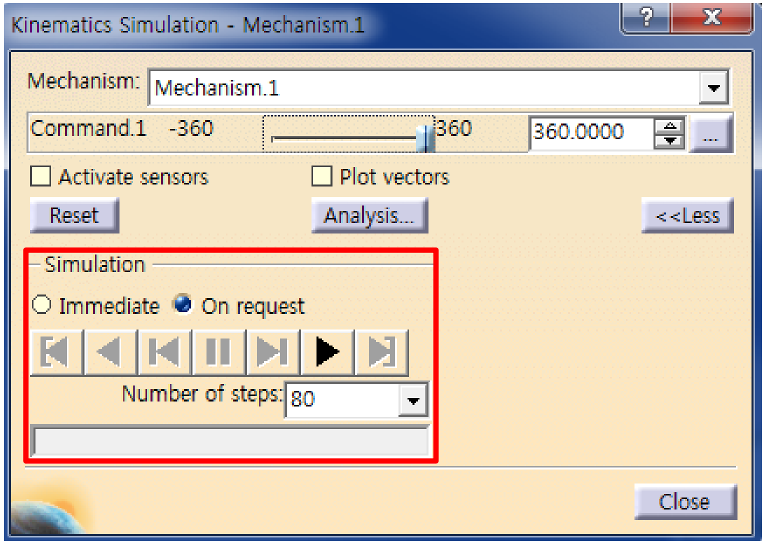
Simulation

● Immediate ○ On request

Number of steps: 80

Simulation: Immediate

움직인 command 값을 steps수로 나누어 연속적으로 구동


Kinematics Simulation - Mechanism.1
Reset
Analysis...
<<Less
Close

Mechanism: Mechanism.1

Command.1 -360 360 360.0000

☐ Activate sensors ☐ Plot vectors

Simulation

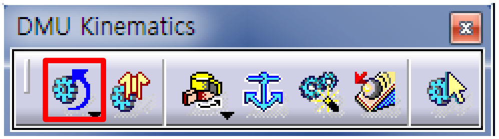
○ Immediate ● On request

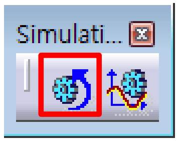
Number of steps: 80

Simulation: On request

DMU KINEMATICS TOOLS

DMU Kinematics

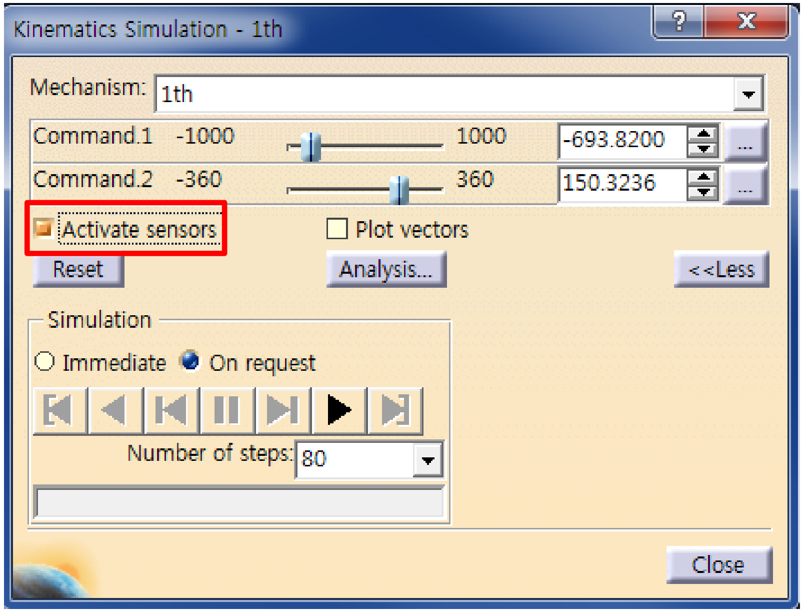

DMU Kinematics



Simulation with Commands

- 생성된 mechanism이 command를 기준으로 동작

Command를 통해 움직인 Joint의 변화량을 그래프로 확인 가능


Kinematics Simulation - 1th
Reset
Analysis...
<<Less
Close

Mechanism: 1th

Command	Min	Max	Value
Command.1	-1000	1000	-693.8200
Command.2	-360	360	150.3236

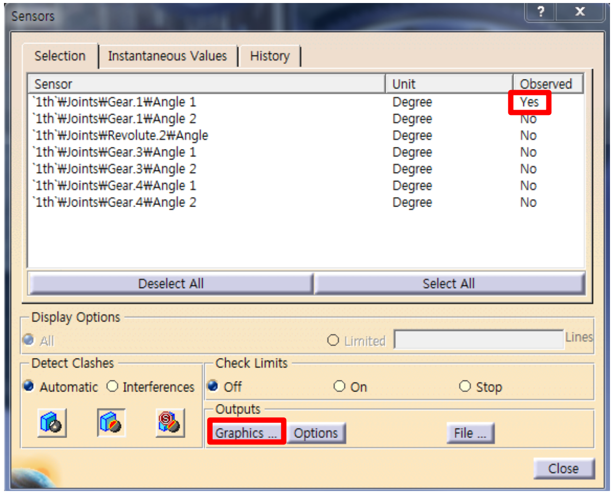
☑ Activate sensors ☐ Plot vectors

Simulation

○ Immediate ● On request

Number of steps: 80

측정하고자 하는 Joint를 No→Yes로 변경 (클릭)

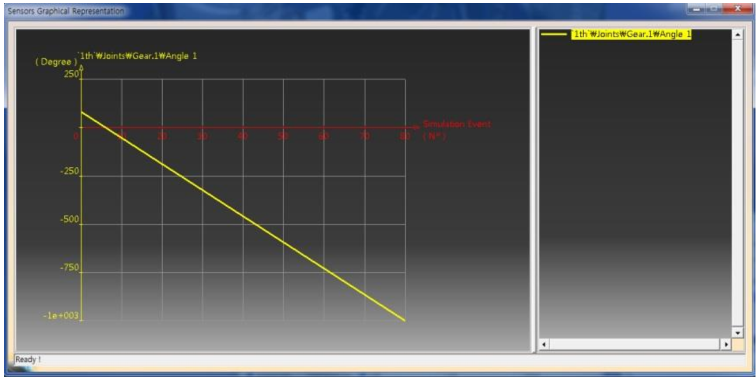

Sensors
Selection
Instantaneous Values
History
Deselect All
Select All
Display Options
All
Limited
Lines
Detect Clashes
Automatic
Interferences
Check Limits
Off
On
Stop
Outputs
Graphics ...
Options
File ...
Close

Sensor	Unit	Observed
\`1th\`₩Joints₩Gear.1₩Angle 1	Degree	Yes
\`1th\`₩Joints₩Gear.1₩Angle 2	Degree	No
\`1th\`₩Joints₩Revolute.2₩Angle	Degree	No
\`1th\`₩Joints₩Gear.3₩Angle 1	Degree	No
\`1th\`₩Joints₩Gear.3₩Angle 2	Degree	No
\`1th\`₩Joints₩Gear.4₩Angle 1	Degree	No
\`1th\`₩Joints₩Gear.4₩Angle 2	Degree	No

Detect Clashes: ● Automatic ○ Interferences

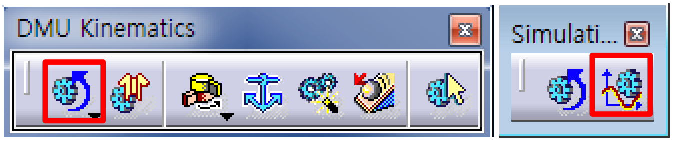
Check Limits: ● Off ○ On ○ Stop

시뮬레이션 재생 후 위 그림의 Graphics를 클릭하면 결과 값이 그래프로 나타남



DMU KINEMATICS TOOLS

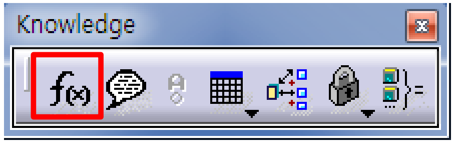
DMU Kinematics


DMU Kinematics
Simulati...

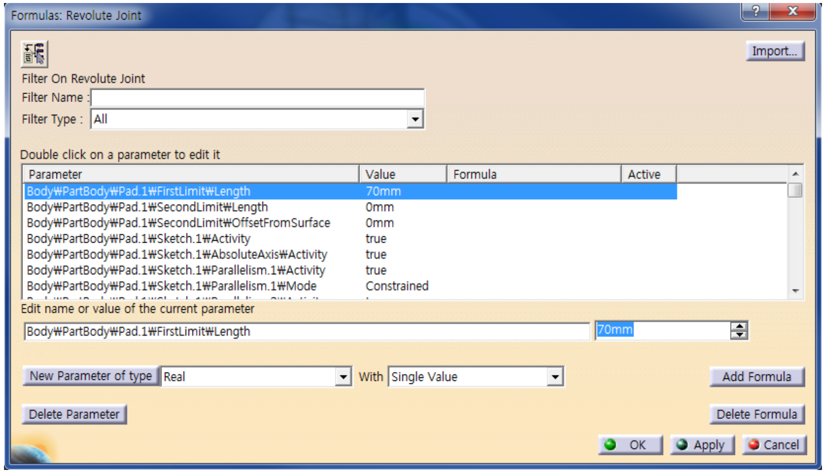
Simulation with Laws

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

①화면 하단의 툴바에서 Formula 선택


Knowledge
f(x)

Formula 초기 화면


Formulas: Revolute Joint
Import...

Filter On Revolute Joint
Filter Name :
Filter Type : All

Double click on a parameter to edit it

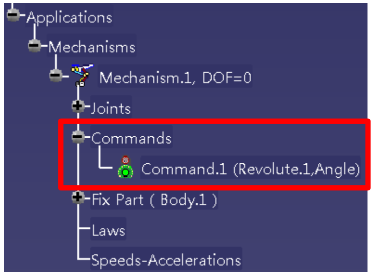
Parameter	Value	Formula	Active
Body₩PartBody₩Pad.1₩FirstLimit₩Length	70mm		
Body₩PartBody₩Pad.1₩SecondLimit₩Length	0mm		
Body₩PartBody₩Pad.1₩SecondLimit₩OffsetFromSurface	0mm		
Body₩PartBody₩Pad.1₩Sketch.1₩Activity	true		
Body₩PartBody₩Pad.1₩Sketch.1₩AbsoluteAxis₩Activity	true		
Body₩PartBody₩Pad.1₩Sketch.1₩Parallelism.1₩Activity	true		
Body₩PartBody₩Pad.1₩Sketch.1₩Parallelism.1₩Mode	Constrained		

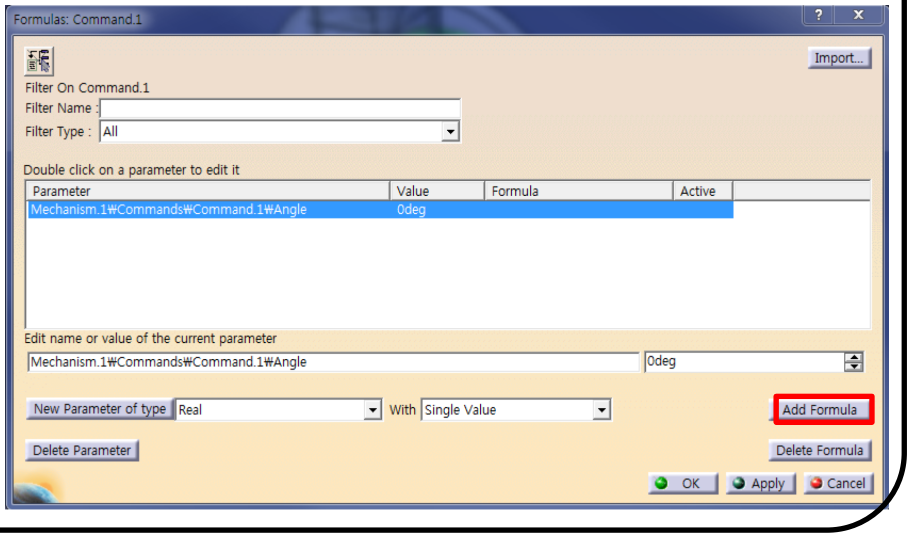
Edit name or value of the current parameter
Body₩PartBody₩Pad.1₩FirstLimit₩Length 70mm

New Parameter of type: Real With: Single Value

Add Formula
Delete Parameter
Delete Formula
OK
Apply
Cancel

② 적용할 command를 더블클릭 후 Add Formula 클릭


Applications
Mechanisms
Mechanism.1, DOF=0
Joints
Commands
Command.1 (Revolute.1,Angle)
Fix Part (Body.1)
Laws
Speeds-Accelerations


Formulas: Command.1
Import...

Filter On Command.1
Filter Name :
Filter Type : All

Double click on a parameter to edit it

Parameter	Value	Formula	Active
Mechanism.1₩Commands₩Command.1₩Angle	0deg		

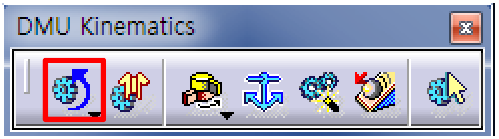
Edit name or value of the current parameter
Mechanism.1₩Commands₩Command.1₩Angle 0deg

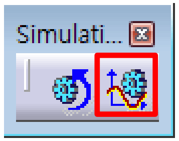
New Parameter of type: Real With: Single Value

Add Formula
Delete Parameter
Delete Formula
OK
Apply
Cancel

DMU KINEMATICS TOOLS

DMU Kinematics

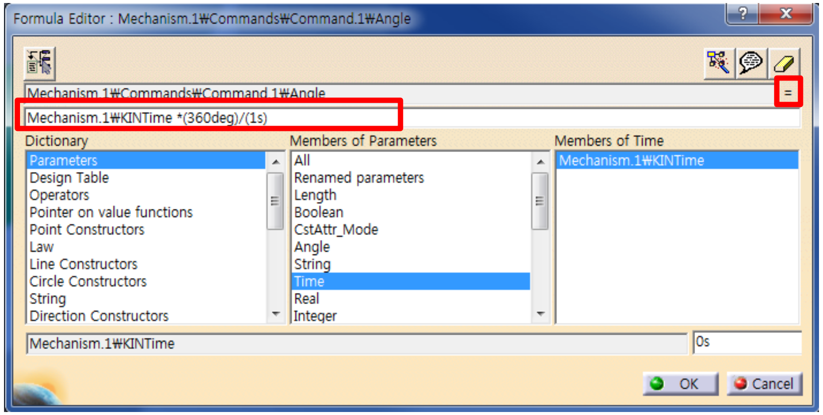




Simulation with Laws

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

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



Formula Editor : Mechanism.1₩Commands₩Command.1₩Angle

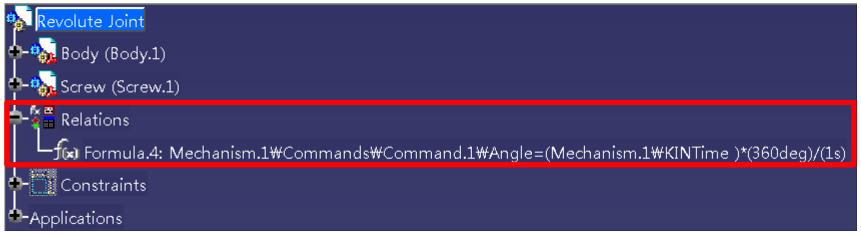
Mechanism.1₩Commands₩Command.1₩Angle

Mechanism.1₩KINTime *(360deg)/(1s)

Dictionary	Members of Parameters	Members of Time
Parameters	All	Mechanism.1₩KINTime
Design Table	Renamed parameters	
Operators	Length	
Pointer on value functions	Boolean	
Point Constructors	CstAttr_Mode	
Law	Angle	
Line Constructors	String	
Circle Constructors	Time	
String	Real	
Direction Constructors	Integer	

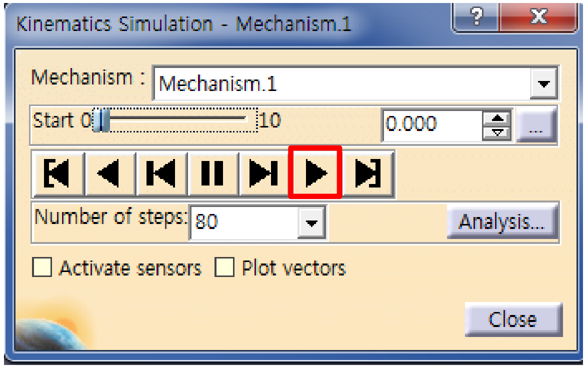
Mechanism.1₩KINTime 0s

④ Formula 생성 확인



Revolute Joint
- Body (Body.1)
- Screw (Screw.1)
- Relations
  - Formula.4: Mechanism.1₩Commands₩Command.1₩Angle=(Mechanism.1₩KINTime)*(360deg)/(1s)
- Constraints
- Applications

⑤ 실행 후 적용됐는지 확인



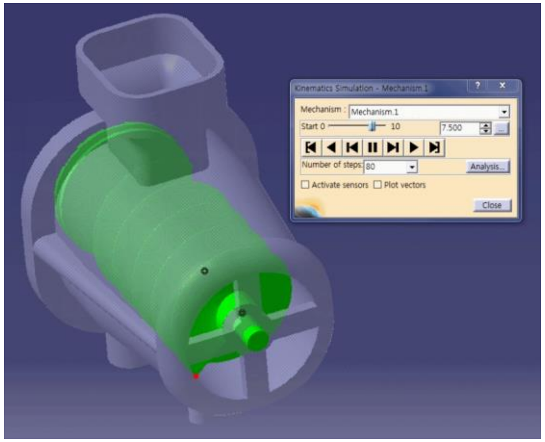
Kinematics Simulation - Mechanism.1

Mechanism : Mechanism.1

Start 0 10 0.000

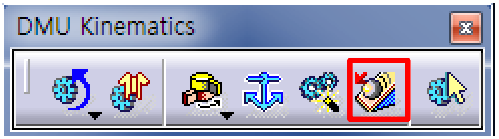
Number of steps: 80

☐ Activate sensors ☐ Plot vectors



DMU KINEMATICS TOOLS

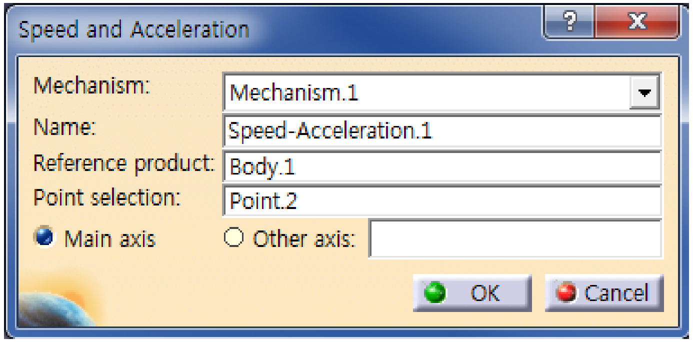
DMU Kinematics


DMU Kinematics

Speed and Acceleration

- 특정 위치의 속도, 가속도 등을 확인함

① 실행 후 Reference product와 측정 Point 선택



Speed and Acceleration

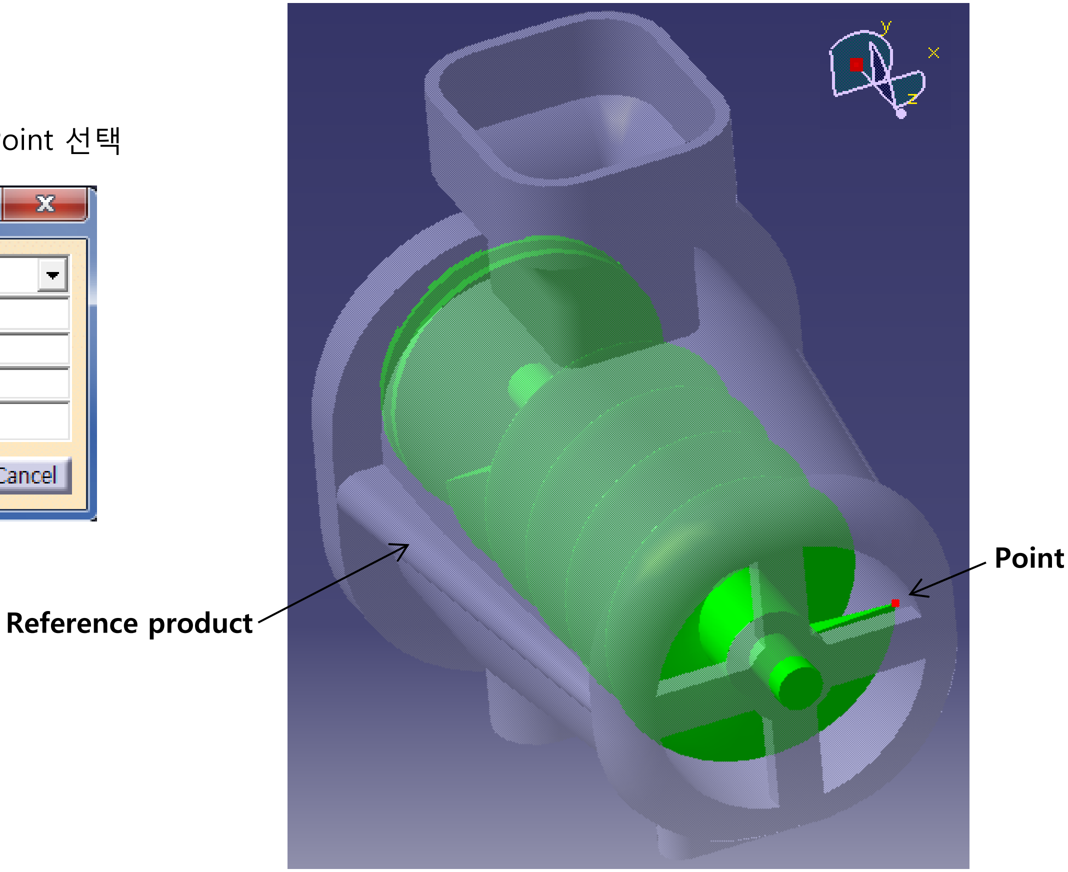
Mechanism: Mechanism.1

Name: Speed-Acceleration.1

Reference product: Body.1

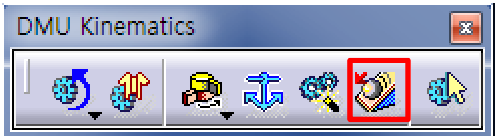
Point selection: Point.2

● Main axis ○ Other axis:


Point
Reference product

DMU KINEMATICS TOOLS

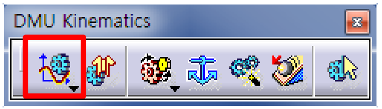
DMU Kinematics


DMU Kinematics

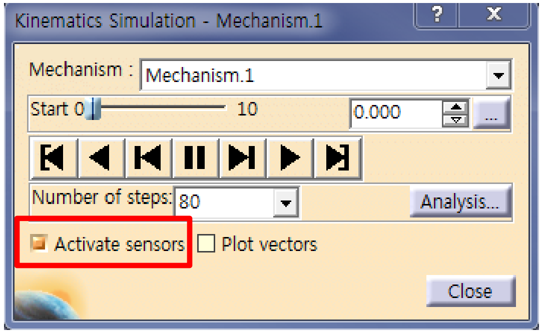
Speed and Acceleration

- 특정 위치의 속도, 가속도 등을 확인함

② Simulation with Laws 선택


DMU Kinematics

③ Activate sensors 선택


Kinematics Simulation - Mechanism.1
?
X
|◀
◀
⏮
⏸
⏭
▶
▶|
Analysis...
Close

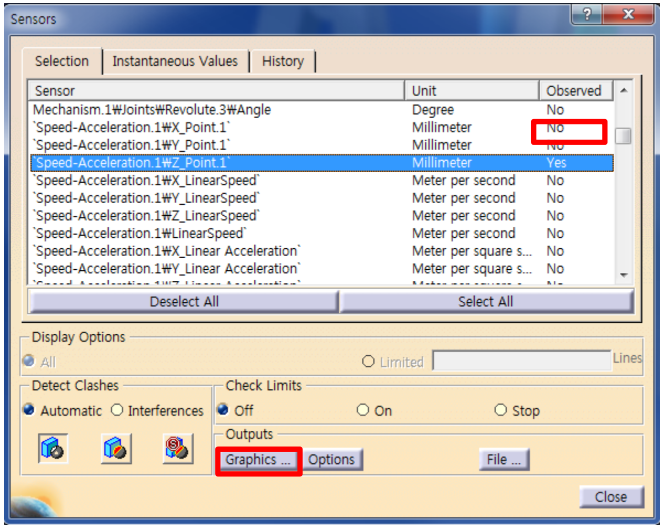
Mechanism : Mechanism.1

Start 0 10 0.000

Number of steps: 80

☑ Activate sensors ☐ Plot vectors

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


Sensors
?
X
Selection
Instantaneous Values
History
Deselect All
Select All
Graphics ...
Options
File ...
Close

Sensor	Unit	Observed
Mechanism.1₩Joints₩Revolute.3₩Angle	Degree	No
`Speed-Acceleration.1₩X_Point.1`	Millimeter	No
`Speed-Acceleration.1₩Y_Point.1`	Millimeter	No
`Speed-Acceleration.1₩Z_Point.1`	Millimeter	Yes
`Speed-Acceleration.1₩X_LinearSpeed`	Meter per second	No
`Speed-Acceleration.1₩Y_LinearSpeed`	Meter per second	No
`Speed-Acceleration.1₩Z_LinearSpeed`	Meter per second	No
`Speed-Acceleration.1₩LinearSpeed`	Meter per second	No
`Speed-Acceleration.1₩X_Linear Acceleration`	Meter per square s...	No
`Speed-Acceleration.1₩Y_Linear Acceleration`	Meter per square s...	No

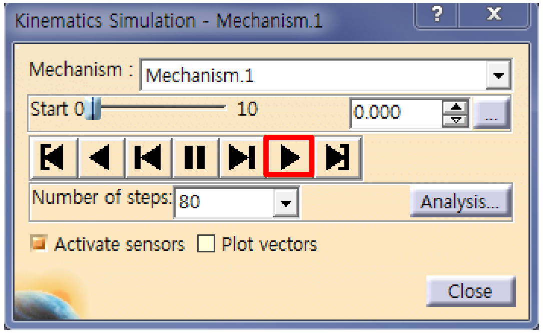
Display Options: ● All ○ Limited Lines

Detect Clashes: ● Automatic ○ Interferences

Check Limits: ● Off ○ On ○ Stop

Outputs

⑤ **시뮬레이션 실행 후** (4)의 Graphics ... 클릭


Kinematics Simulation - Mechanism.1
?
X
|◀
◀
⏮
⏸
⏭
▶
▶|
Analysis...
Close

Mechanism : Mechanism.1

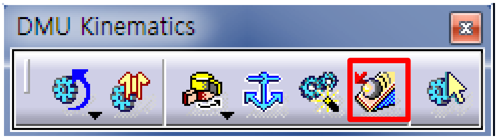
Start 0 10 0.000

Number of steps: 80

☑ Activate sensors ☐ Plot vectors

DMU KINEMATICS TOOLS

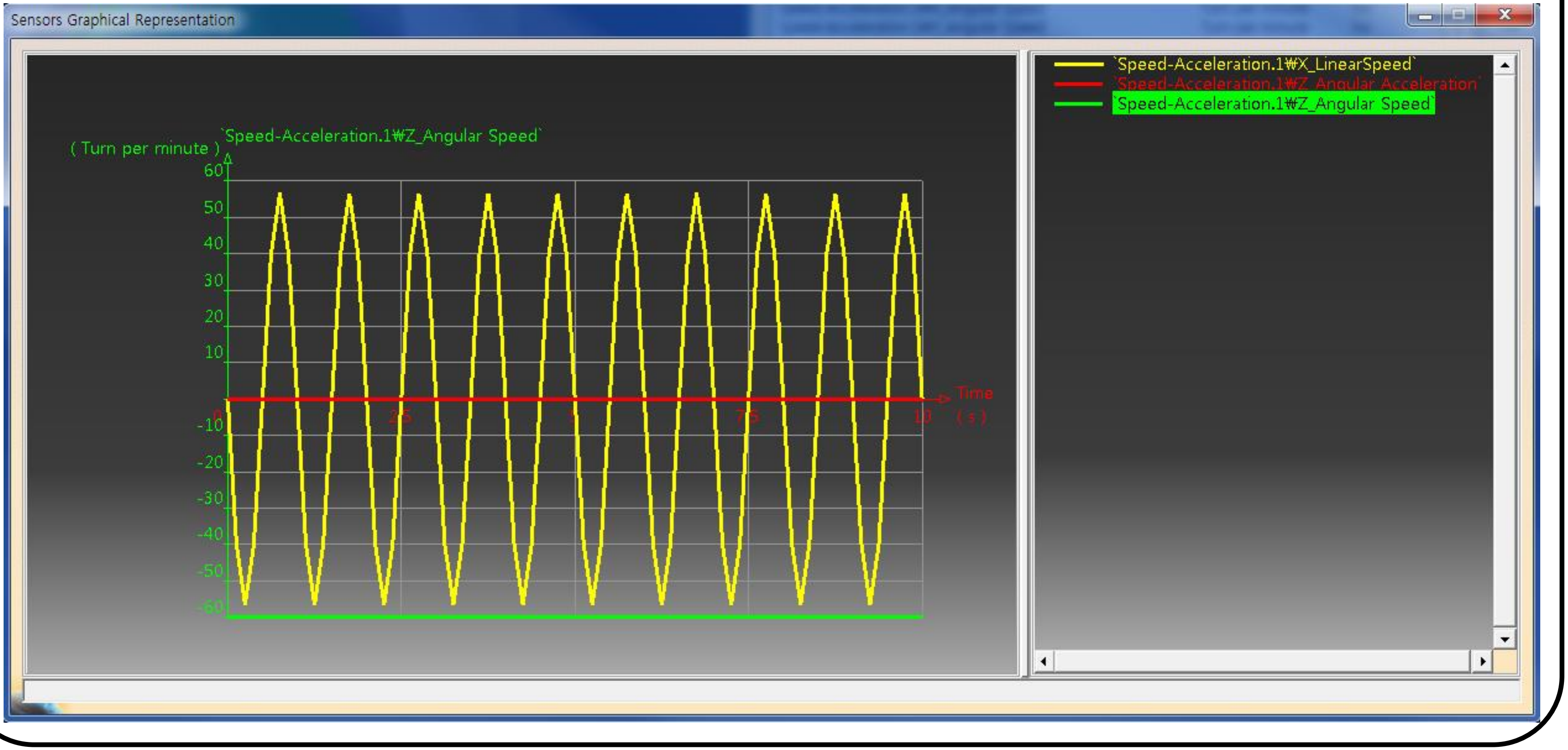
DMU Kinematics


DMU Kinematics

Speed and Acceleration

- 특정 위치의 속도, 가속도 등을 확인함

⑥ 속도/가속도 결과

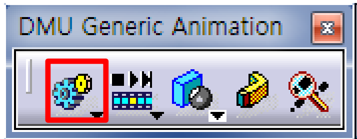

Sensors Graphical Representation
`Speed-Acceleration.1₩X_LinearSpeed`
`Speed-Acceleration.1₩Z_Angular Acceleration`
`Speed-Acceleration.1₩Z_Angular Speed`
`Speed-Acceleration.1₩Z_Angular Speed`
(Turn per minute)
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
2.5
5
7.5
10
Time
(s)

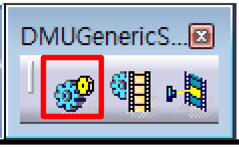
CONTENTS

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

DMU KINEMATICS TOOLS

DMU Generic Animation

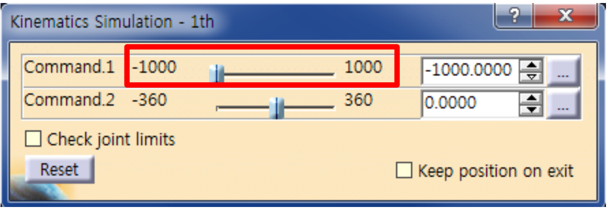

DMU Generic Animation


DMUGenericS...

Simulation

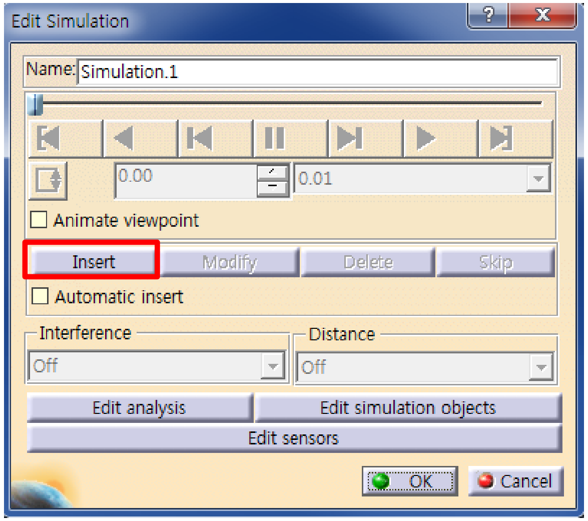
- 변화된 command 값 만큼 mechanism을 동작시킴

① 원하는 동작을 설정


Kinematics Simulation - 1th
Reset

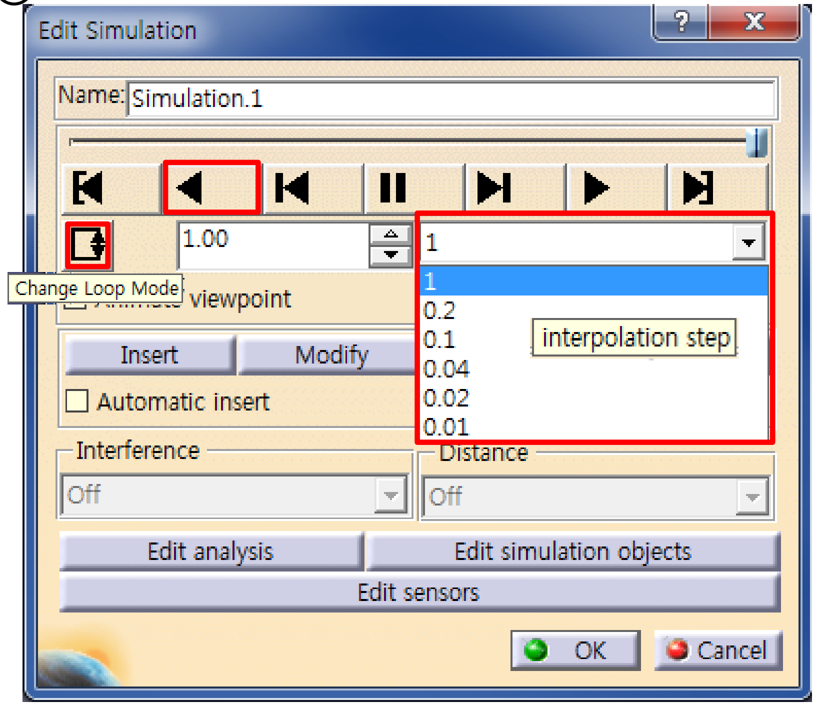
Command.1 -1000 1000 -1000.0000
Command.2 -360 360 0.0000
☐ Check joint limits
☐ Keep position on exit

② Insert


Edit Simulation
Insert
Modify
Delete
Skip
Interference
Distance
Edit analysis
Edit simulation objects
Edit sensors
OK
Cancel

Name: Simulation.1
0.00 0.01
☐ Animate viewpoint
☐ Automatic insert
Interference: Off
Distance: Off

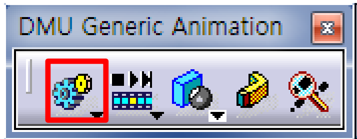
③ Loop Mode 및 Step 선택 후 재생

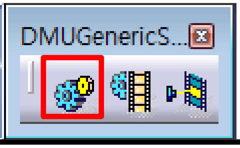

Edit Simulation
Change Loop Mode
interpolation step
Insert
Modify
Interference
Distance
Edit analysis
Edit simulation objects
Edit sensors
OK
Cancel

Name: Simulation.1
1.00
1
1
0.2
0.1
0.04
0.02
0.01
viewpoint
☐ Automatic insert
Interference: Off
Distance: Off

DMU KINEMATICS TOOLS

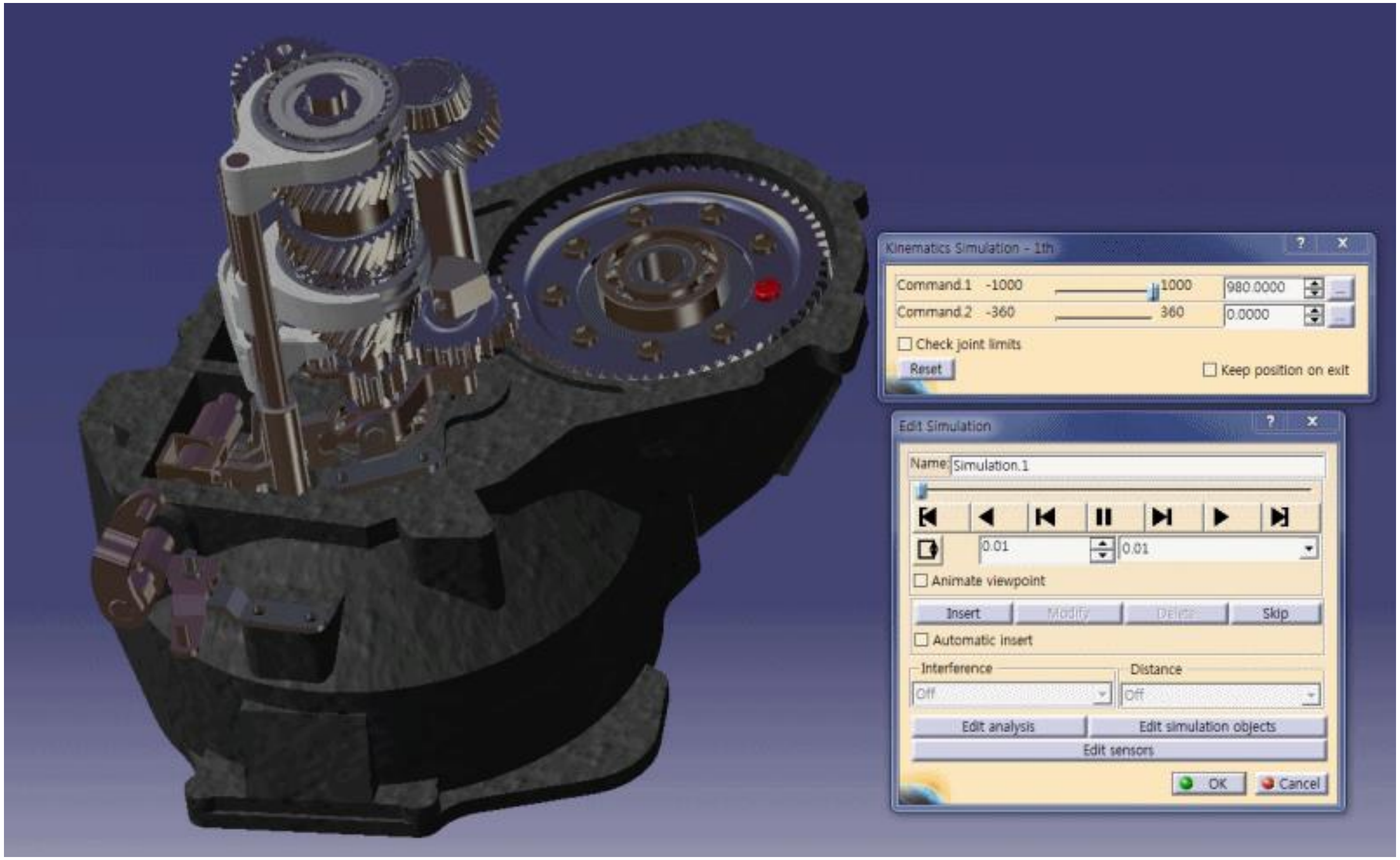
DMU Generic Animation


DMU Generic Animation


DMUGenericS...

Simulation

- 변화된 command 값 만큼 mechanism을 동작시킴


Kinematics Simulation - 1th
Reset
Edit Simulation
Insert
Modify
Delete
Skip
Edit analysis
Edit simulation objects
Edit sensors
OK
Cancel

Command.1 -1000 1000 980.0000

Command.2 -360 360 0.0000

☐ Check joint limits

☐ Keep position on exit

Name: Simulation.1

0.01 0.01

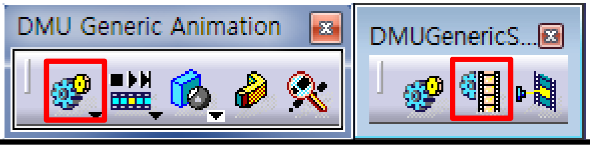
☐ Animate viewpoint

☐ Automatic insert

Interference: Off

Distance: Off

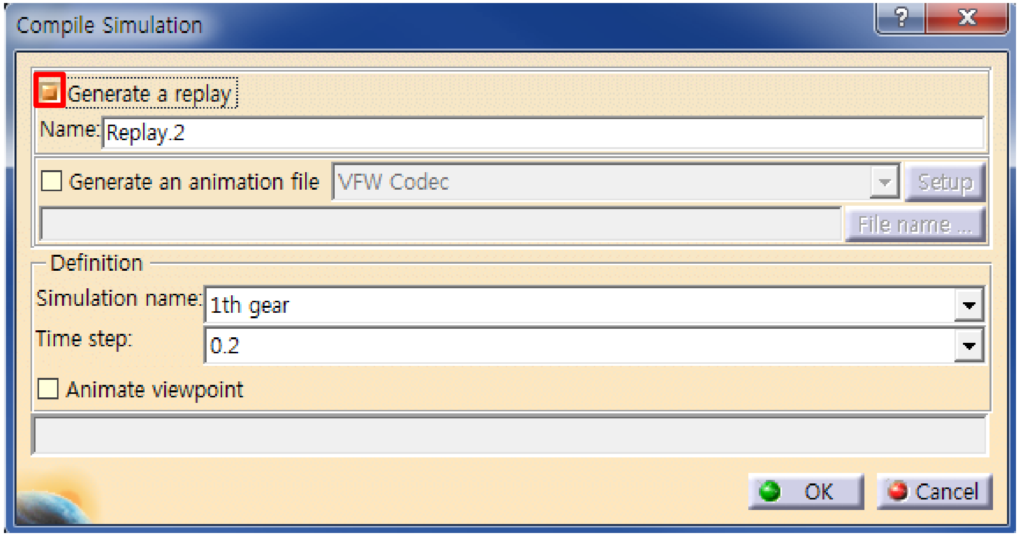
DMU Generic Animation



Compile Simulation

- 만들어진 시뮬레이션을 Replay 또는 동영상 파일로 저장함

Replay 생성



Compile Simulation

☐ Generate a replay

Name: Replay.2

☐ Generate an animation file VFW Codec Setup

File name ...

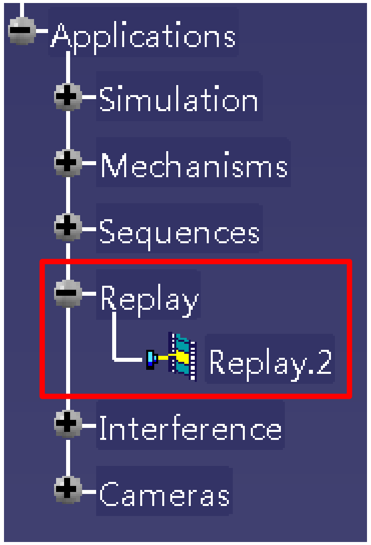
Definition

Simulation name: 1th gear

Time step: 0.2

☐ Animate viewpoint

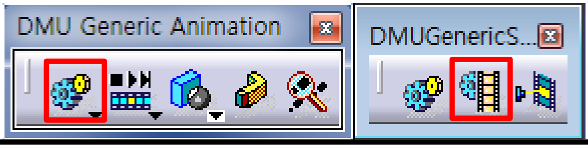
OK Cancel



- Applications
  - Simulation
  - Mechanisms
  - Sequences
  - Replay
    - Replay.2
  - Interference
  - Cameras

DMU KINEMATICS TOOLS

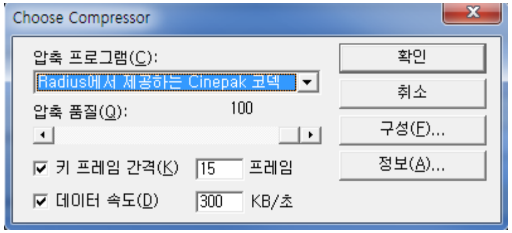
DMU Generic Animation


DMU Generic Animation
DMUGenericS...

Compile Simulation

- 만들어진 시뮬레이션을 Replay 또는 동영상 파일로 저장함

압축 코덱 /프레임 설정



Choose Compressor

압축 프로그램(C): Radius에서 제공하는 Cinepak 코덱

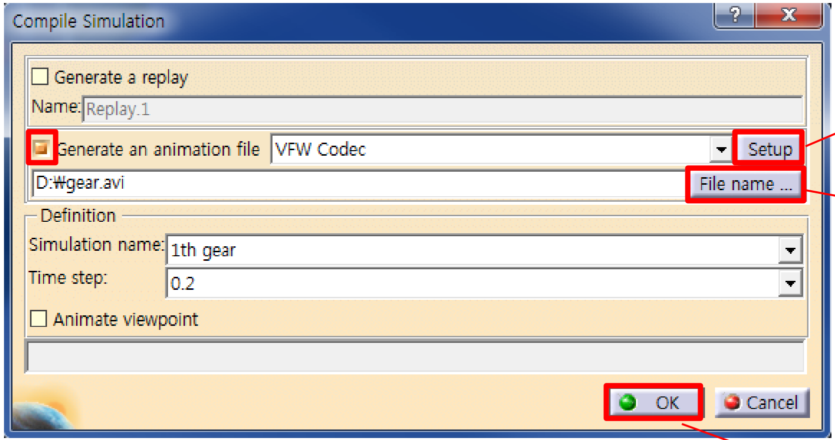
압축 품질(Q): 100

☑ 키 프레임 간격(K) 15 프레임

☑ 데이터 속도(D) 300 KB/초

확인
취소
구성(F)...
정보(A)...

동영상 파일 생성



Compile Simulation

☐ Generate a replay

Name: Replay.1

☑ Generate an animation file VFW Codec

D:₩gear.avi

Definition

Simulation name: 1th gear

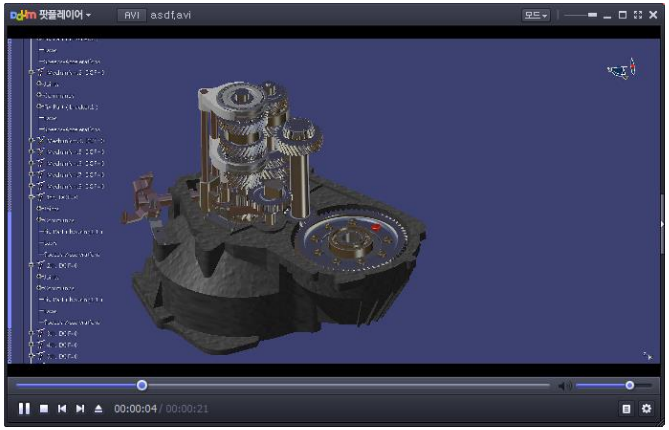
Time step: 0.2

☐ Animate viewpoint

Setup
File name ...
OK
Cancel

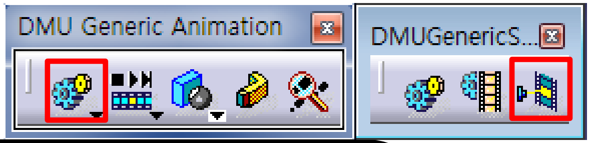
파일 경로 설정

동영상 파일 생성


asdf.avi
00:00:04 / 00:00:21

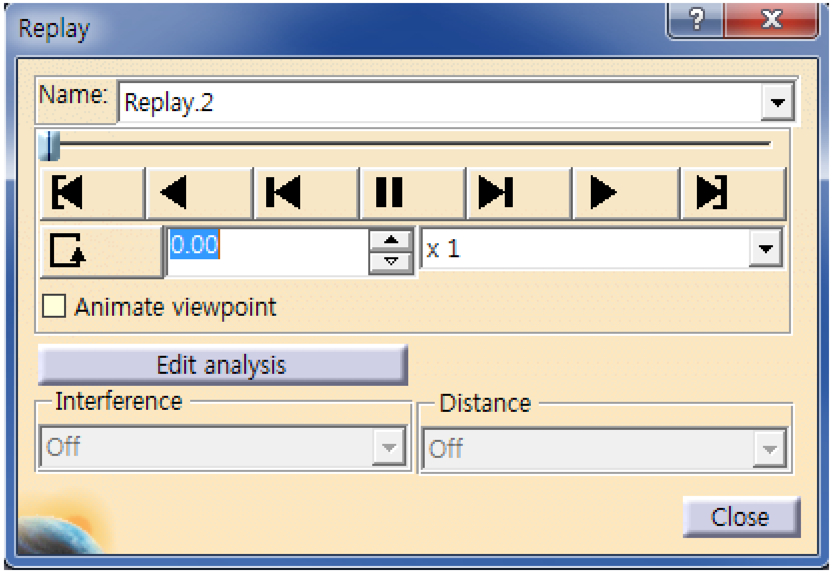
DMU KINEMATICS TOOLS

DMU Generic Animation


DMU Generic Animation
DMUGenericS...

Replay

- 만들어진 시뮬레이션의 Replay를 실행함


Replay
Edit analysis
Close

Name: Replay.2

0.00

x 1

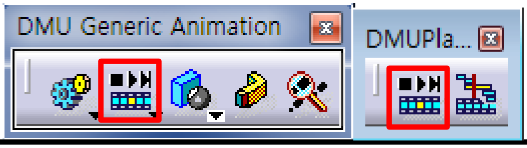
☐ Animate viewpoint

Interference: Off

Distance: Off

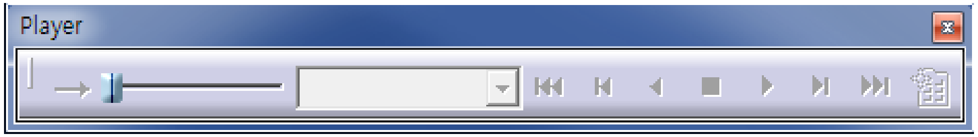
DMU KINEMATICS TOOLS

DMU Generic Animation

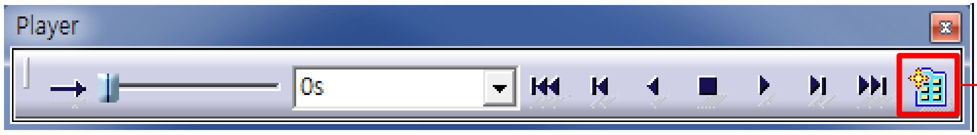

DMU Generic Animation
DMUPla...

Simulation Player

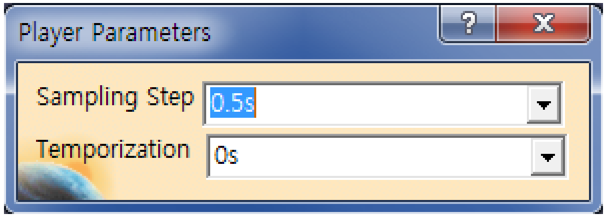
- 만들어진 simulation, replay, sequences를 실행시킴



Simulation 또는 Replay 선택



Step 입력


Player Parameters

Sampling Step: 0.5s

Temporization: 0s

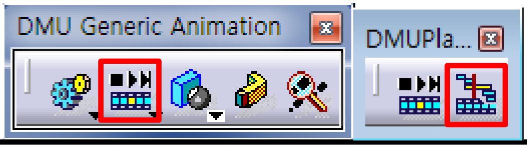
→ corresponds to the single loop mode

corresponds to the one way loop mode

corresponds to the return simulation mode.

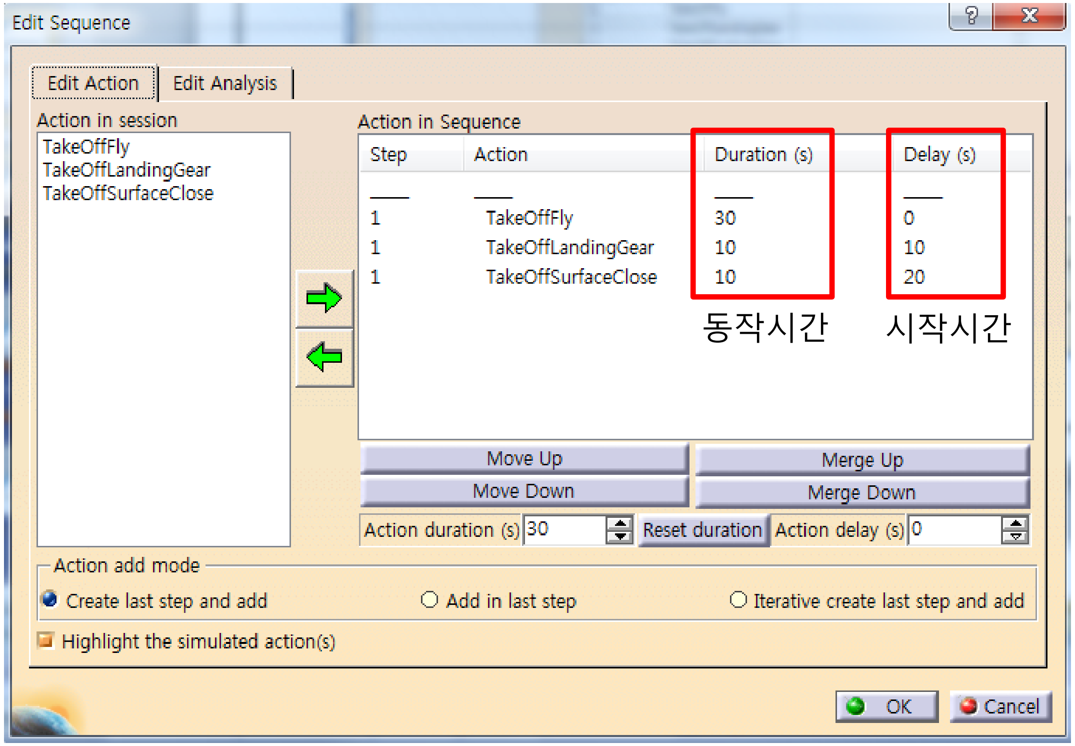
DMU KINEMATICS TOOLS

DMU Generic Animation


DMU Generic Animation
DMUPla...

Edit Sequence

- 만들어진 시뮬레이션들의 시간을 조절하여 하나의 시뮬레이션으로 구성함


Edit Sequence
Edit Action
Edit Analysis
Move Up
Merge Up
Move Down
Merge Down
Reset duration
OK
Cancel

Action in session

TakeOffFly
TakeOffLandingGear
TakeOffSurfaceClose

Action in Sequence

Step	Action	Duration (s)	Delay (s)
1	TakeOffFly	30	0
1	TakeOffLandingGear	10	10
1	TakeOffSurfaceClose	10	20

동작시간 시작시간

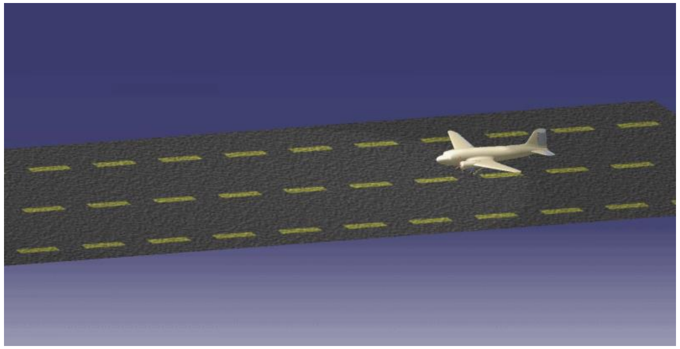
Action duration (s) 30

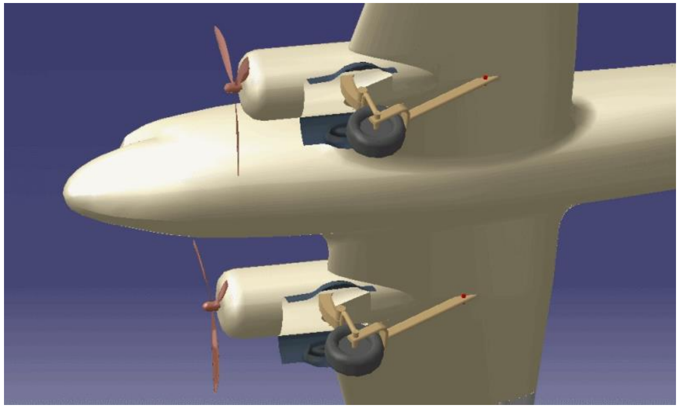
Action delay (s) 0

Action add mode

● Create last step and add ○ Add in last step ○ Iterative create last step and add

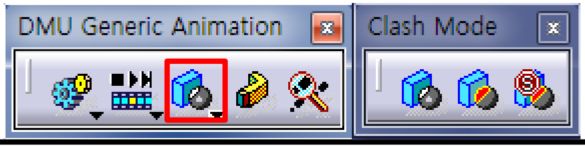
☐ Highlight the simulated action(s)





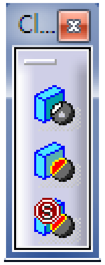
DMU KINEMATICS TOOLS

DMU Generic Animation


DMU Generic Animation
Clash Mode

Clash Mode

- 시뮬레이션을 실행할 때 간섭여부를 확인함

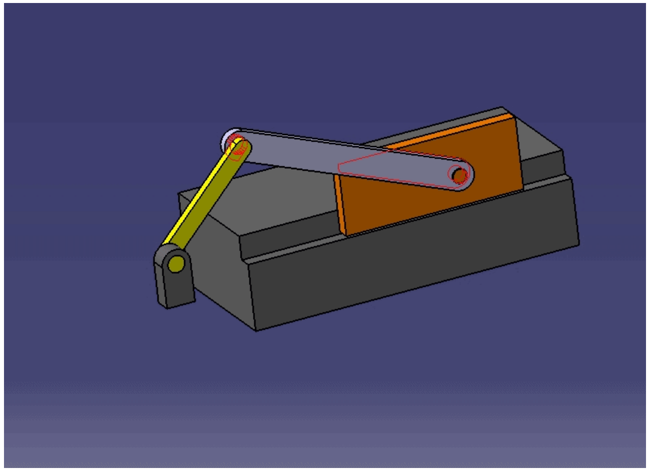


Deactivates automatic clash detection for simulation

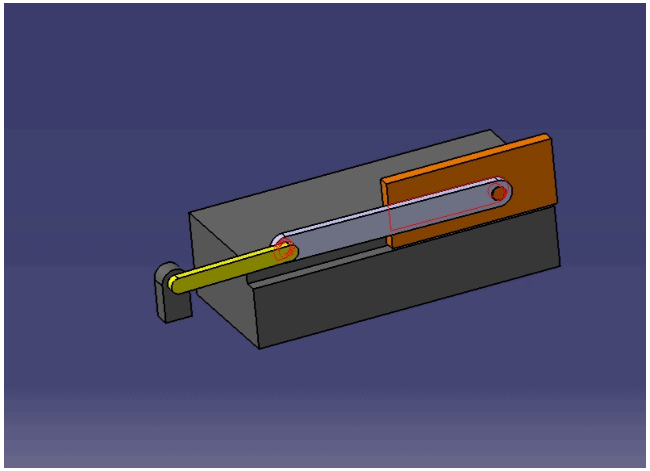
Activates automatic clash detection for simulation

Activates automatic clash detection stop mode for simulation

기존의 Slider-Crank 모델

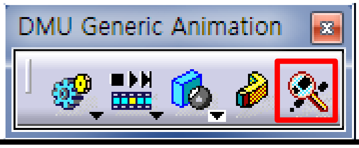


간섭이 일어나는 모델



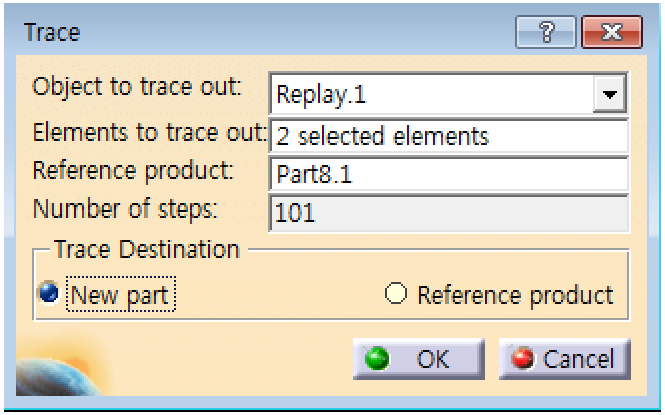
DMU KINEMATICS TOOLS

DMU Generic Animation


DMU Generic Animation

Trace

- 선택한 elements의 이동을 replay를 기준으로 표시함.


Trace

Object to trace out: Replay.1

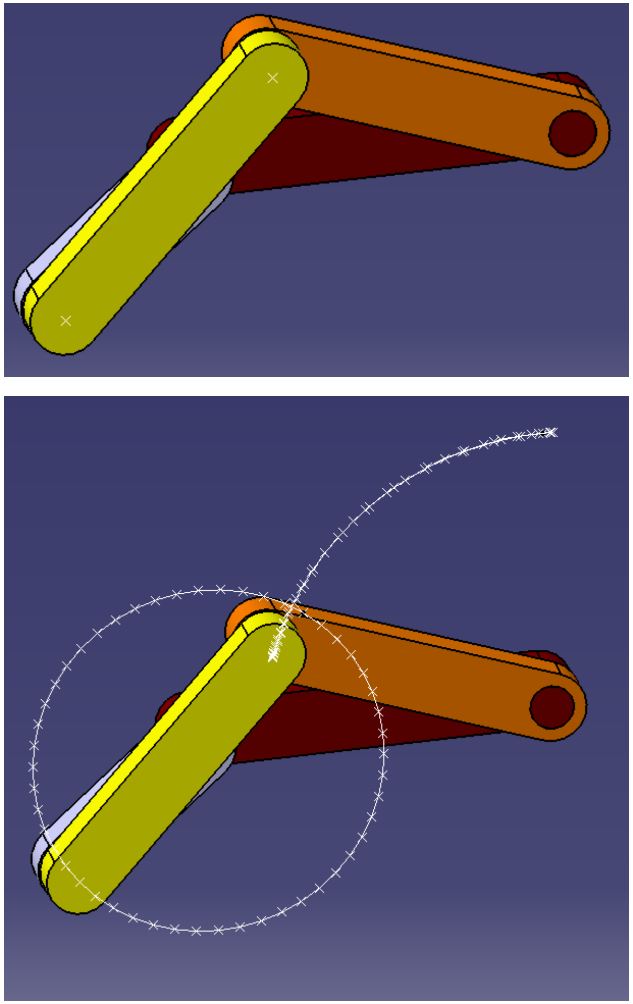
Elements to trace out: 2 selected elements

Reference product: Part8.1

Number of steps: 101

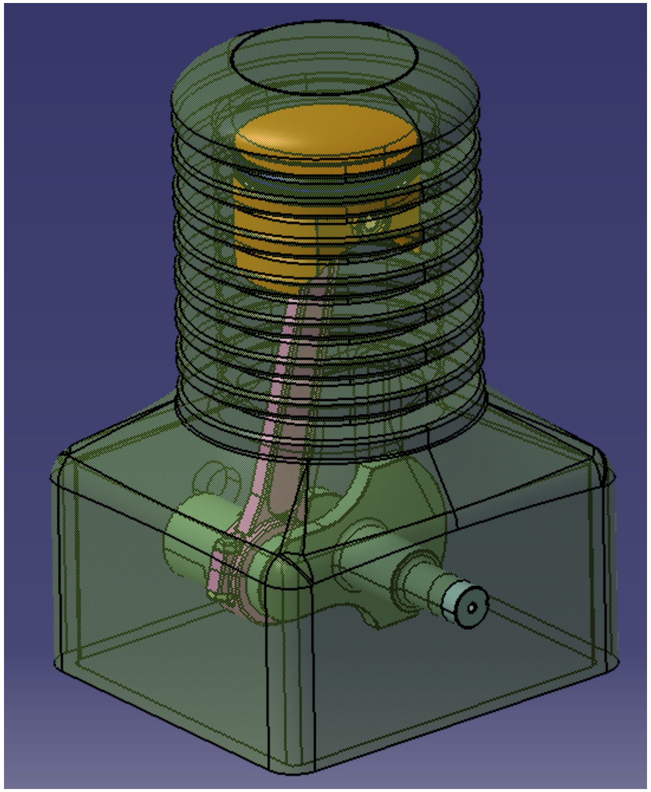
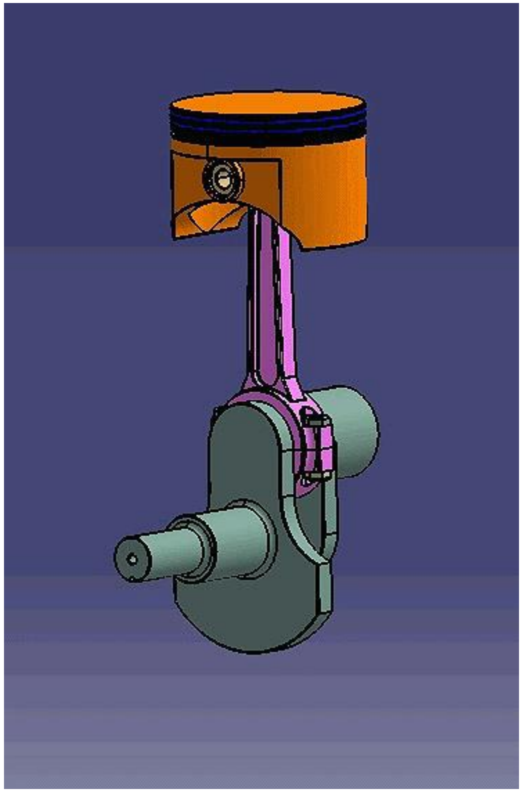
Trace Destination

● New part ○ Reference product



실습 과제

Assembly Design의 Piston 모델을 이용하여 아래와 같이 DMU Kinematics 작업 진행하기

(Simulation 동영상 + Product + Part 파일들 압축하여 업로드)