CAE
Term Project

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CONTENTS

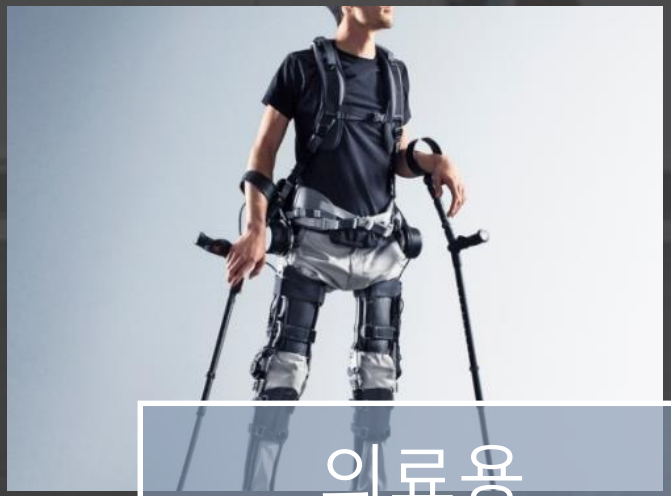
1

로봇 슈트 이해

1

로봇 슈트 이해

산업용

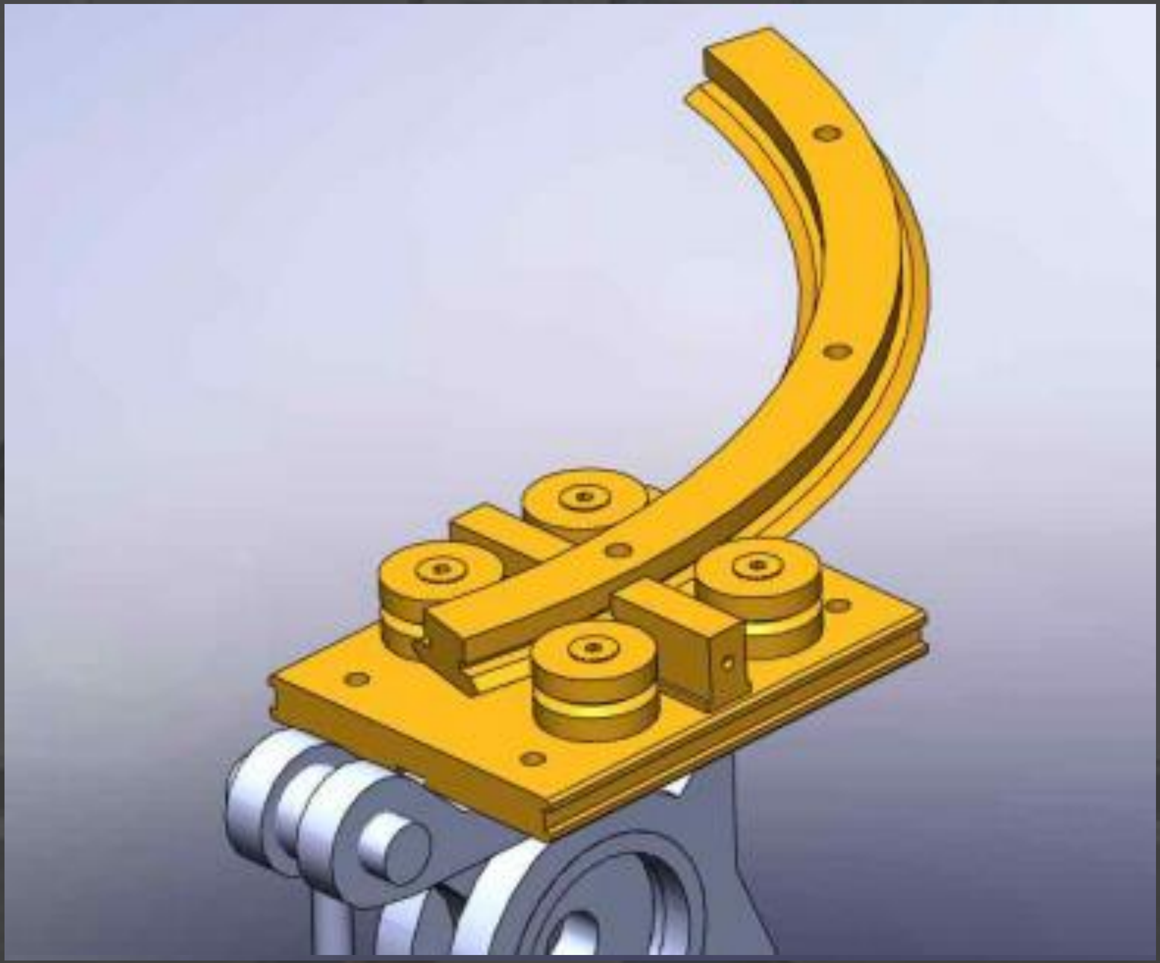


의료용

군사용

1

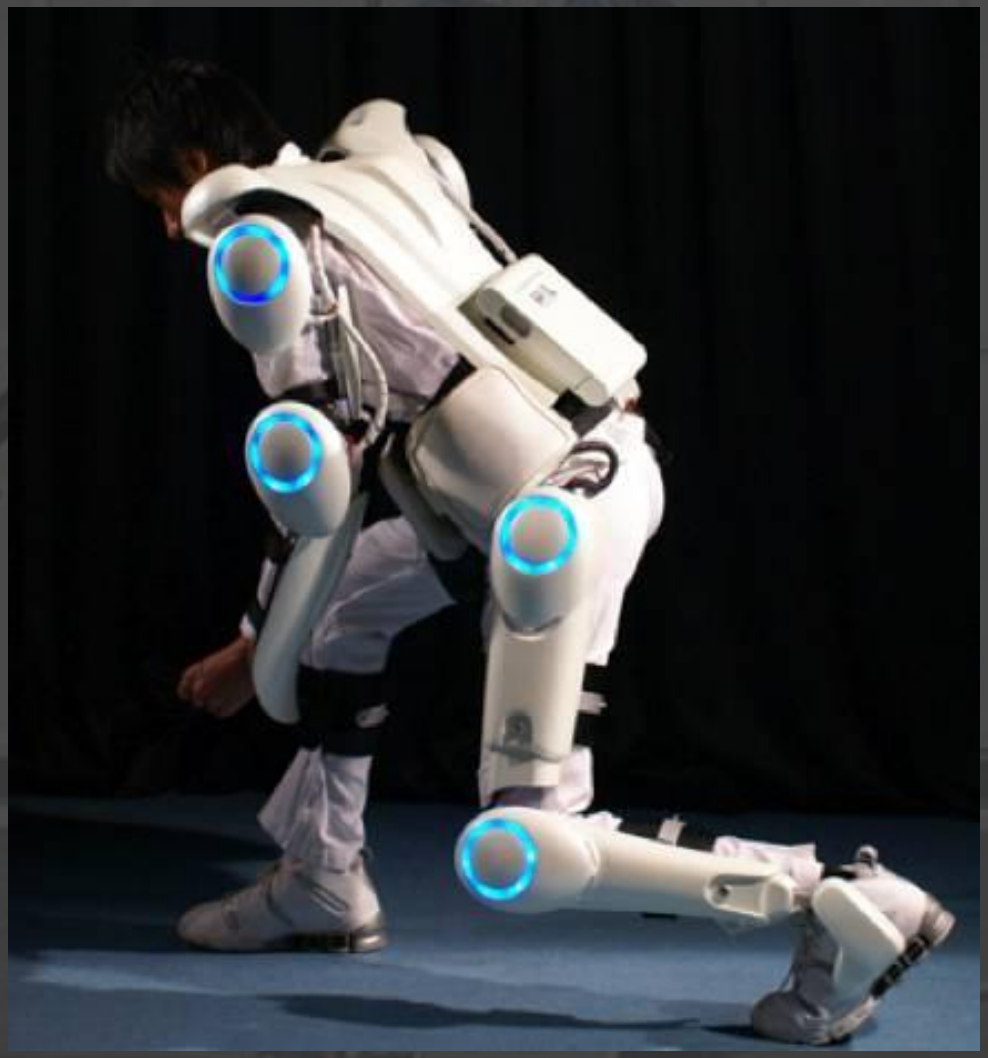
로봇 슈트 이해



족관절

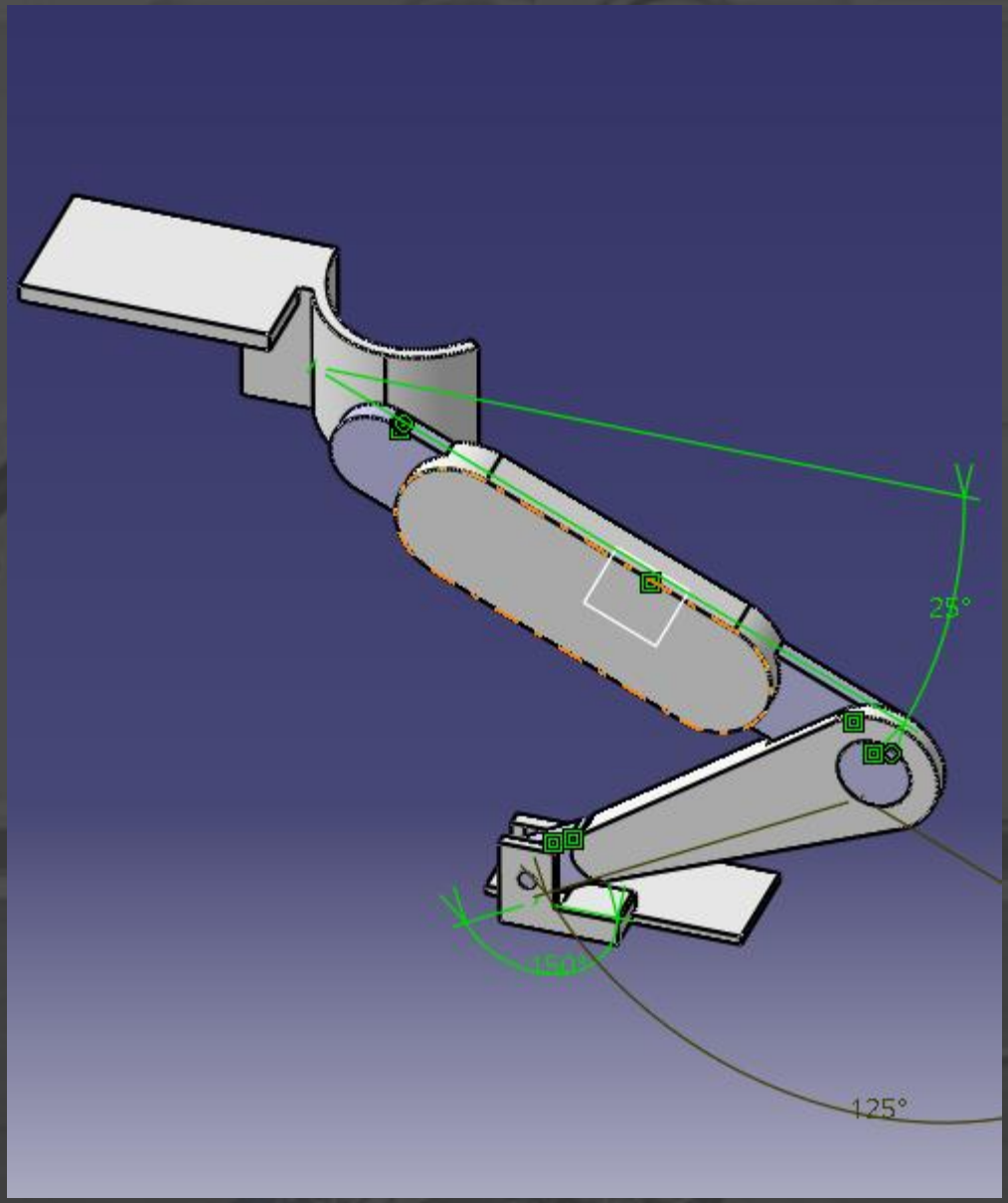
2

CATIA
Modeling



2

COMSOL



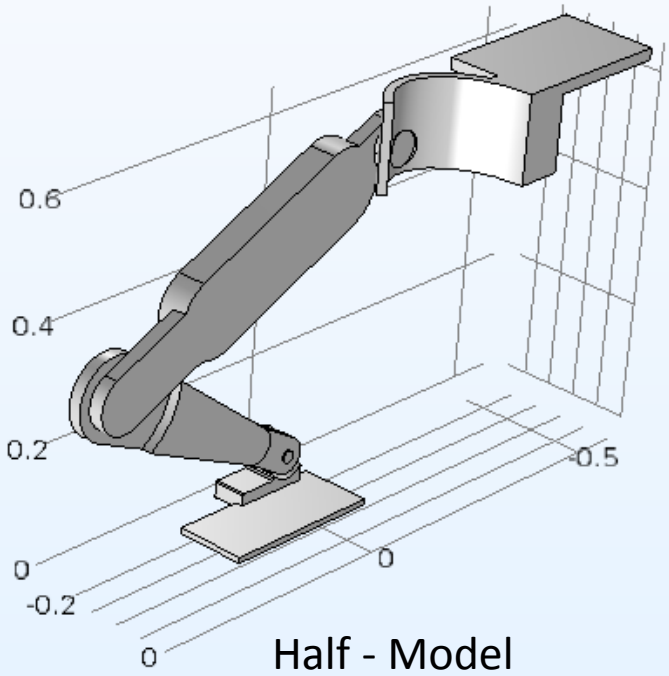
3

MultiBody Dynamics

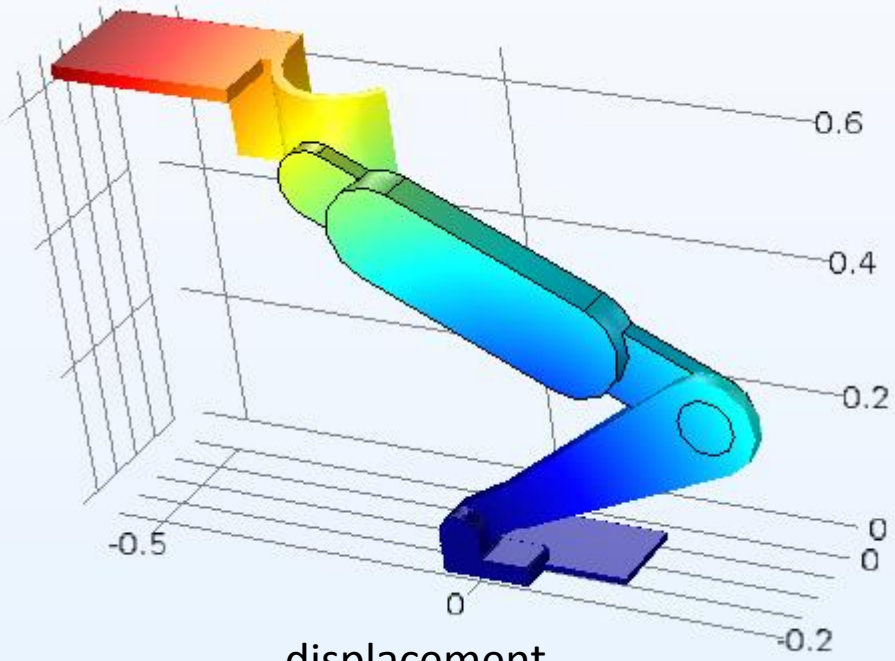
Materials

Structural steel *(mat1)*

Property	Name	Value	Unit
Density	rho	7850[kg...	kg/m³
Young's modulus	E	200e9[Pa]	Pa
Poisson's ratio	nu	0.33	1



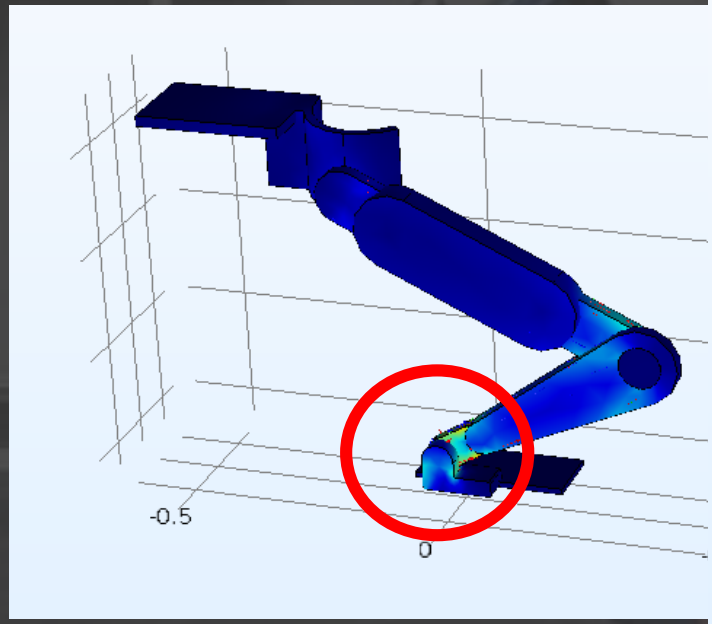
Half - Model

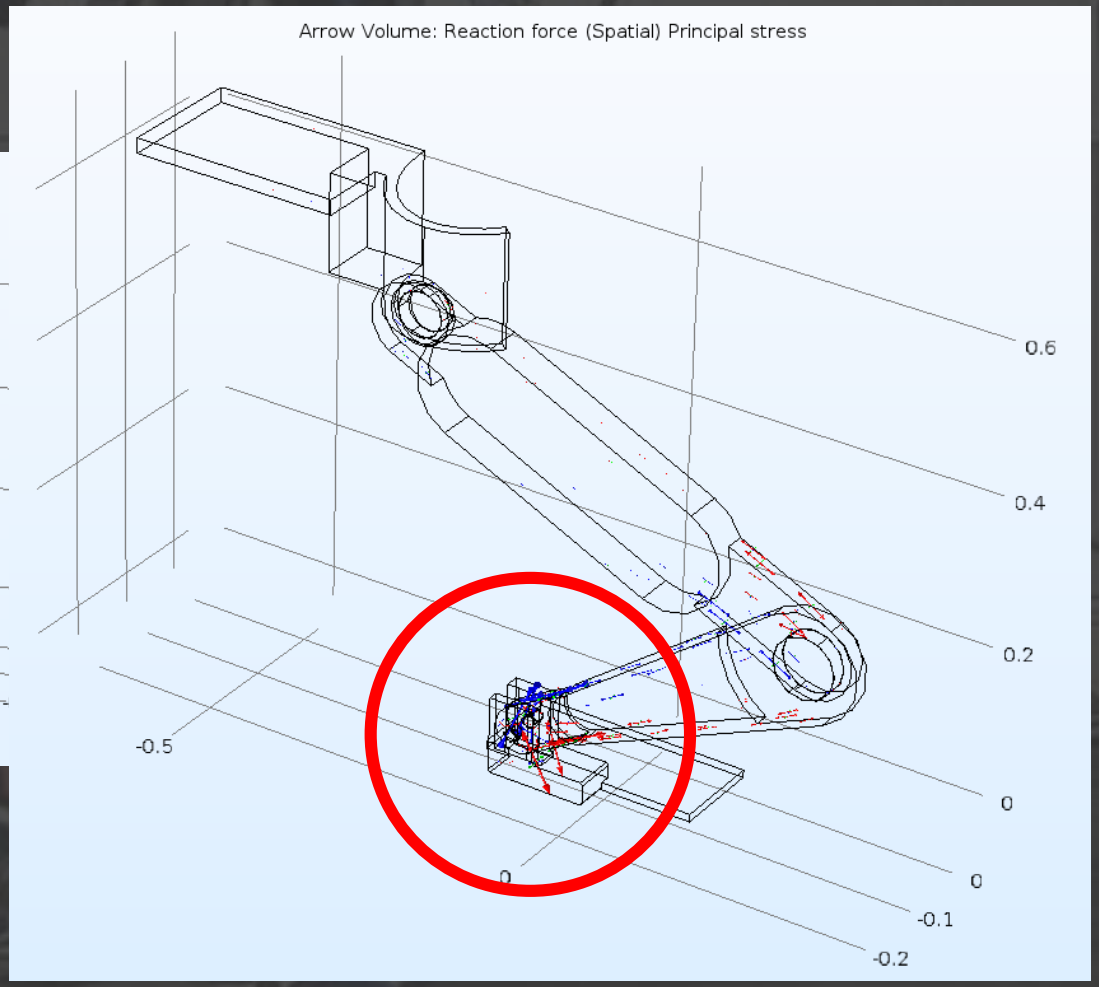


displacement

3

MultiBody Dynamics





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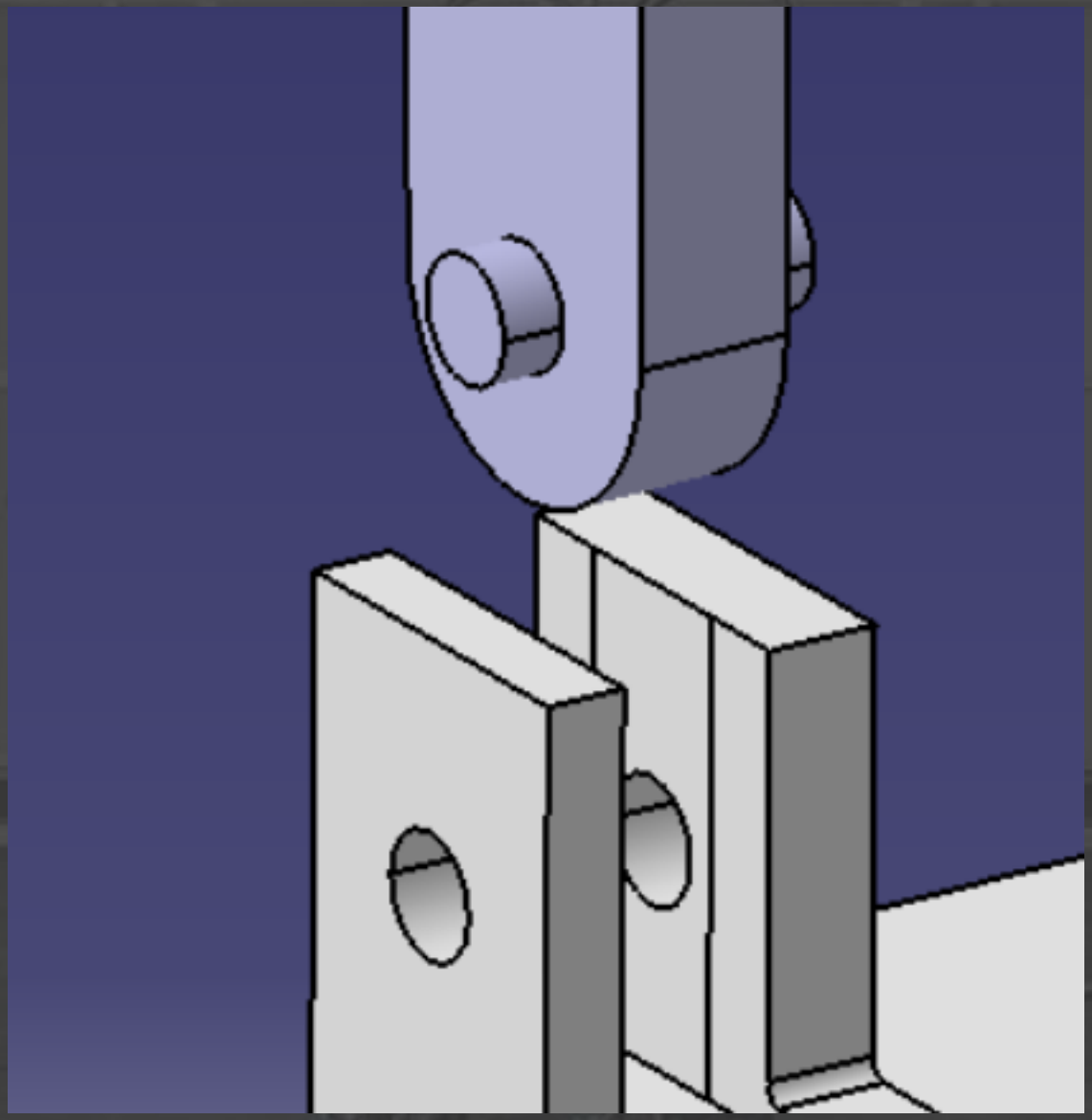

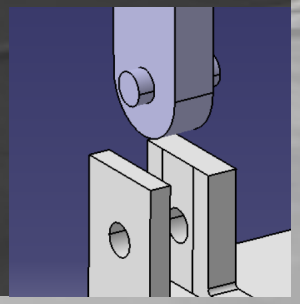

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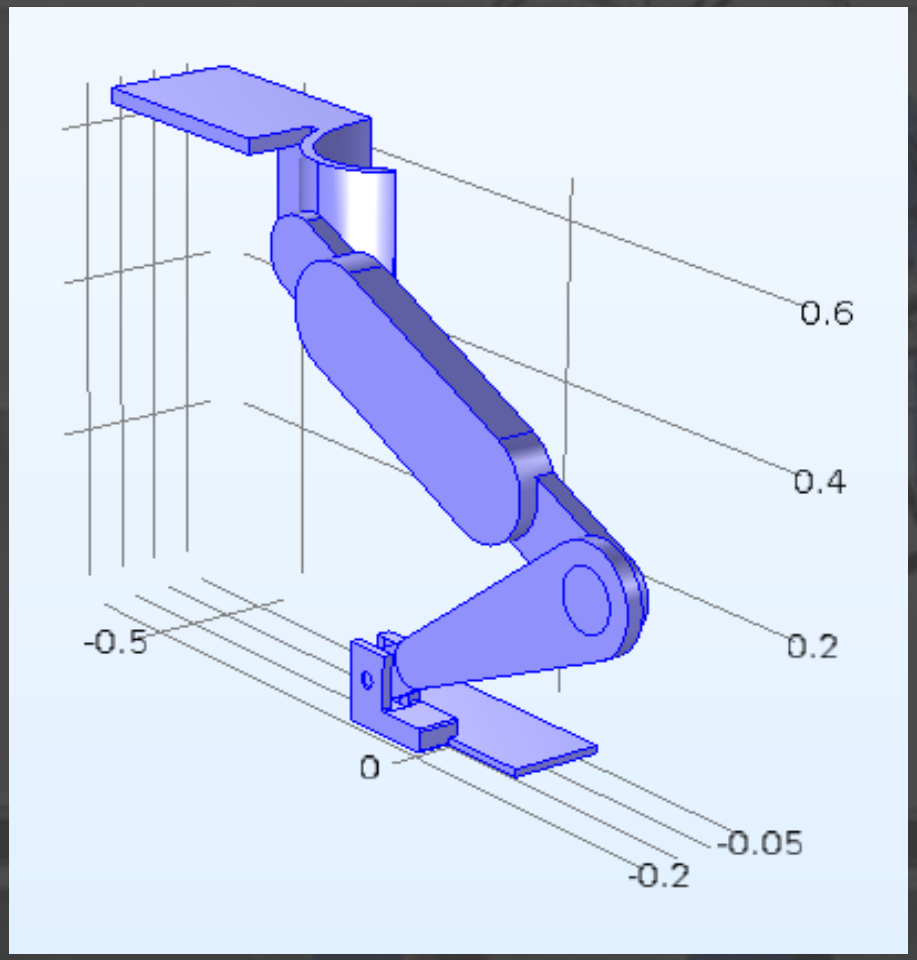


Gravity

Label: Gravity 1

Domain Selection

Selection: Manual

ON

Active

1
2
3
4

Override and Contribution

Equation

Coordinate System Selection

Coordinate system:

Global coordinate system

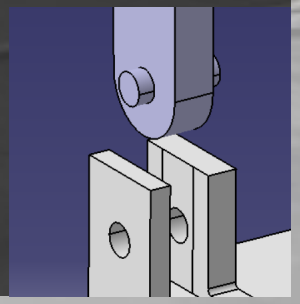
Gravity

g

0	x	m/s²
0	y	
-g_const	z	

전체적인 하중 조건

(Gravity) 부여



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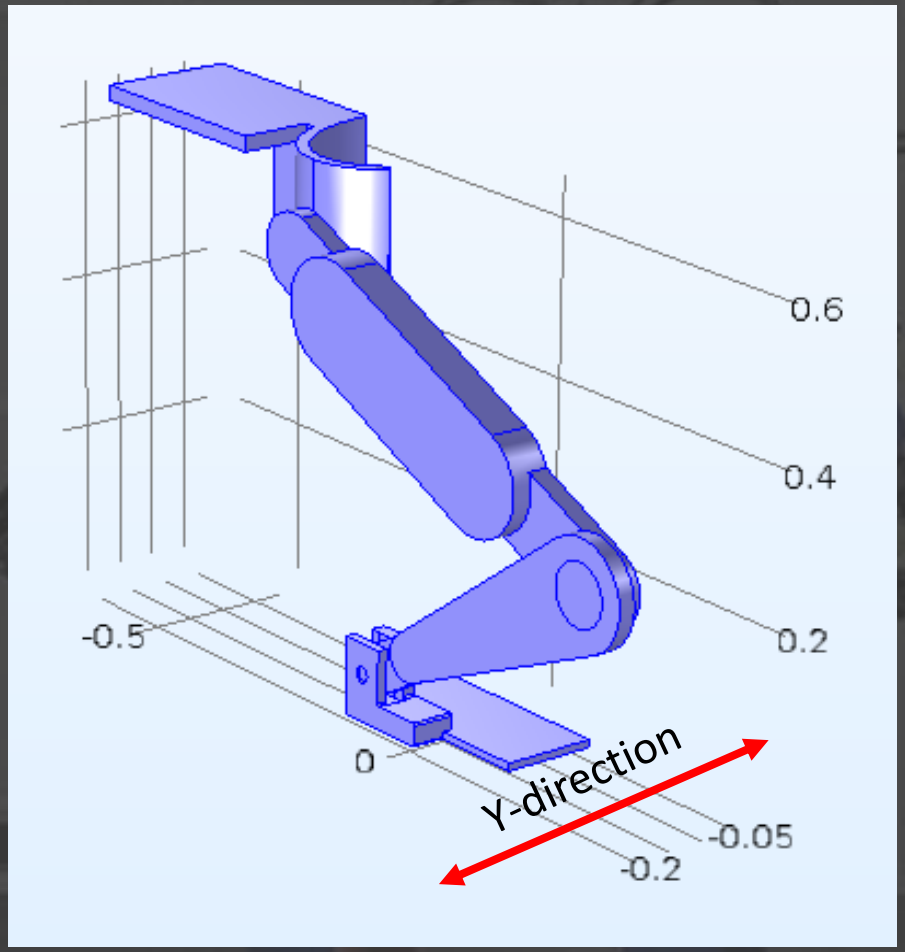


Prescribed Displacement

Label: Prescribed Displacement 1

Domain Selection

Selection: All domains

ON

Active

1
2
3
4

Override and Contribution

Equation

Coordinate System Selection

Coordinate system:

Global coordinate system

Prescribed Displacement

Standard notation

Prescribed in x direction

u_{0x} 0 m

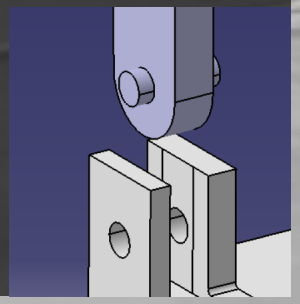
Prescribed in y direction

u_{0y} 0 m

Prescribed in z direction

u_{0z} 0 m

Y-direction 이동 제약



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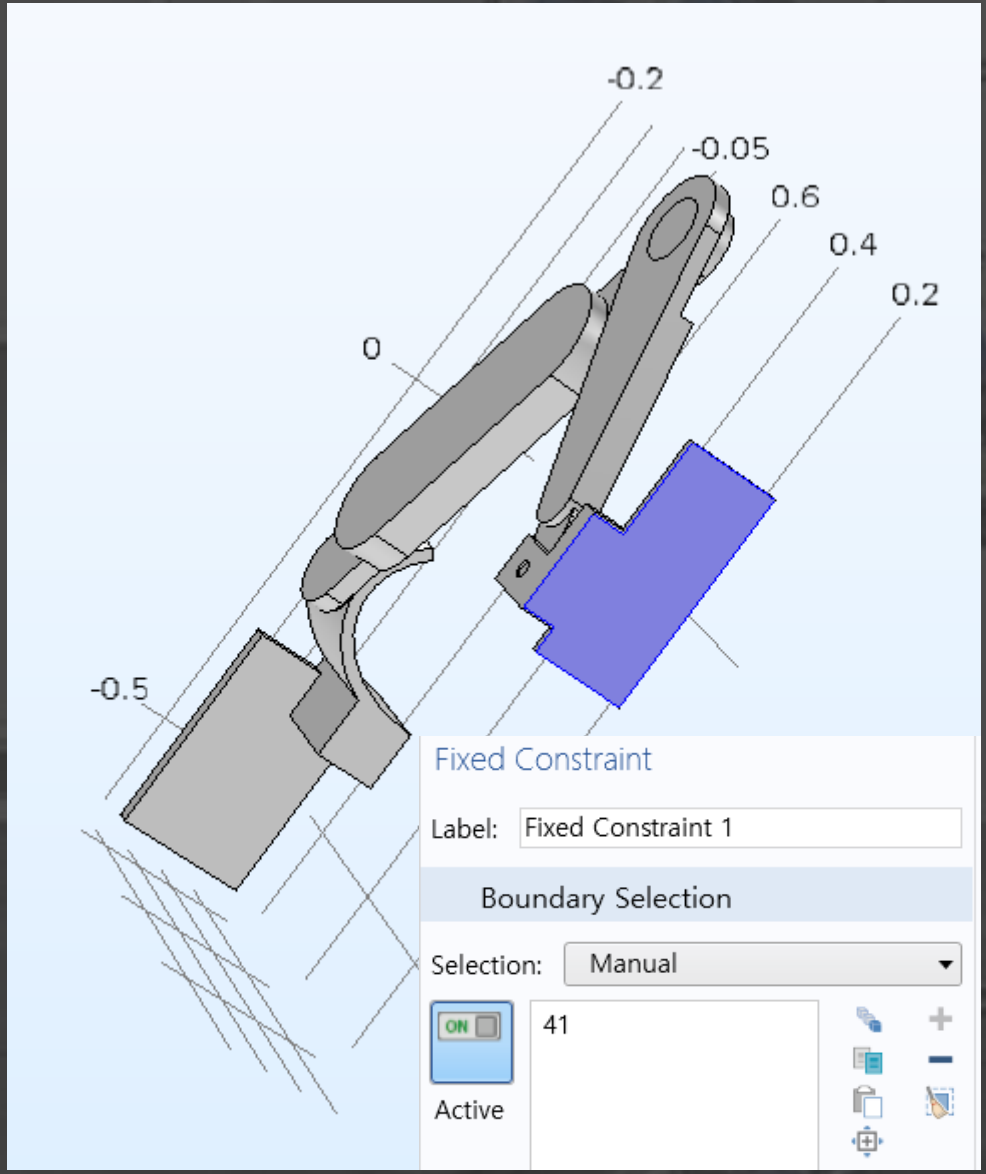
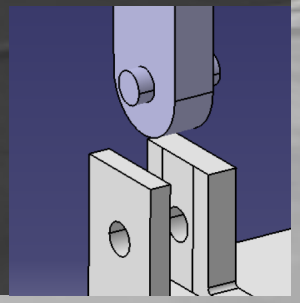
HINGE #1



발바닥 – 땅에 고정



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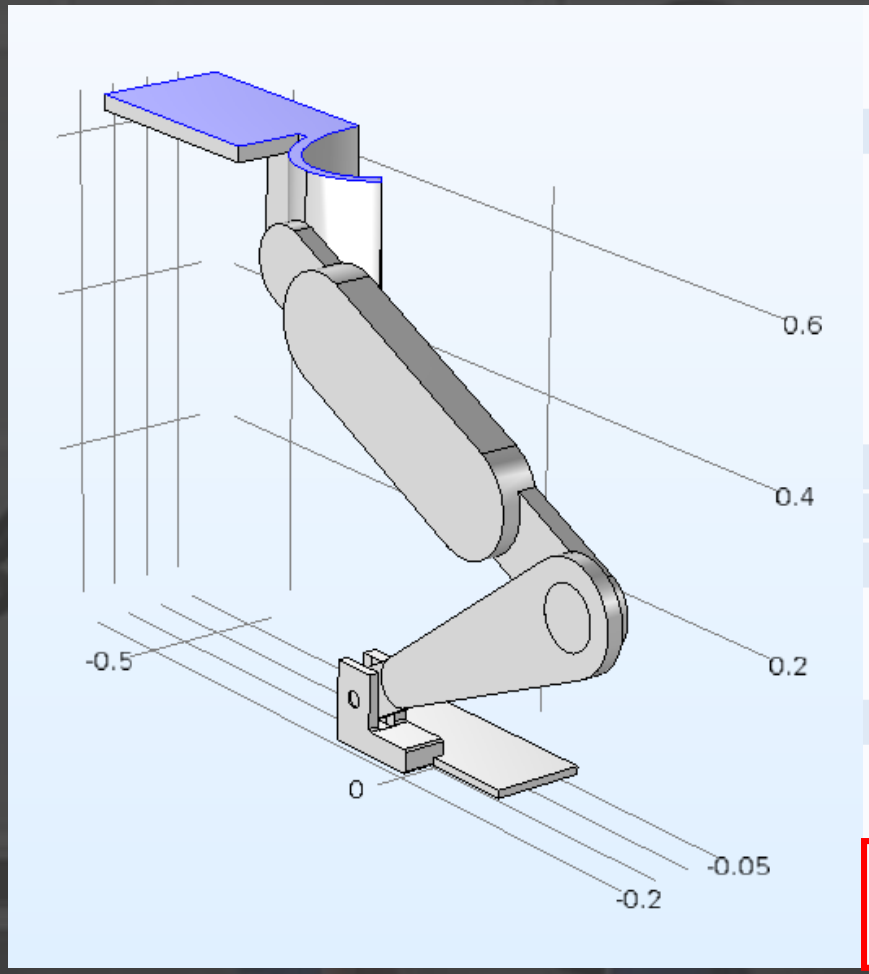


Boundary Load

Label: Boundary Load 1

Boundary Selection

Selection: Manual

ON

Active

4

Override and Contribution

Equation

Coordinate System Selection

Coordinate system:

Global coordinate system

Force

Load type:

Total force

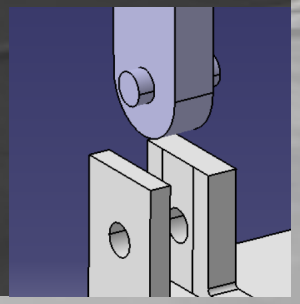
F_{tot}

0	x
0	y
-120*9.8	z

N

120kg의 하중을 지탱하고 있다고 가정

사람(80Kg) + 본인 짐(20Kg) + 타인 짐(20Kg)



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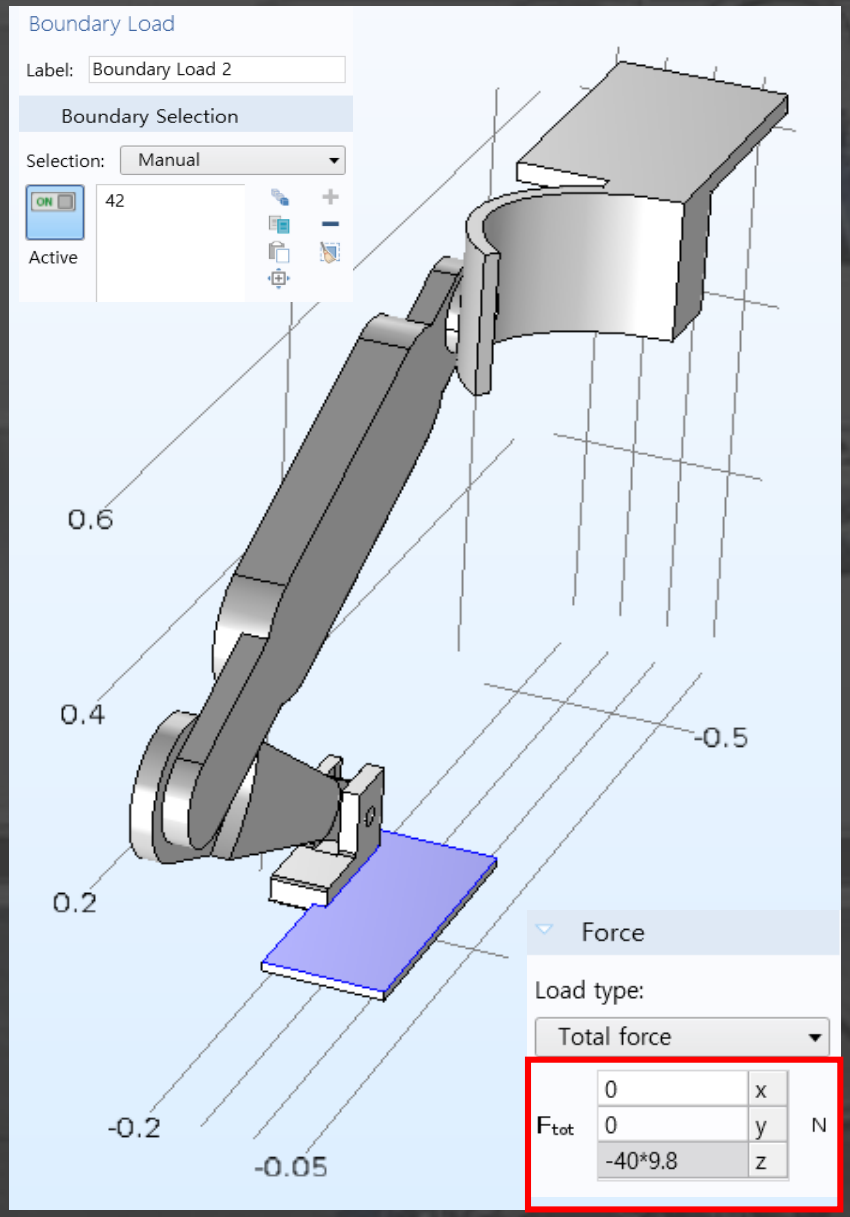
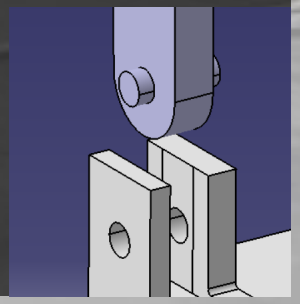
HINGE #1

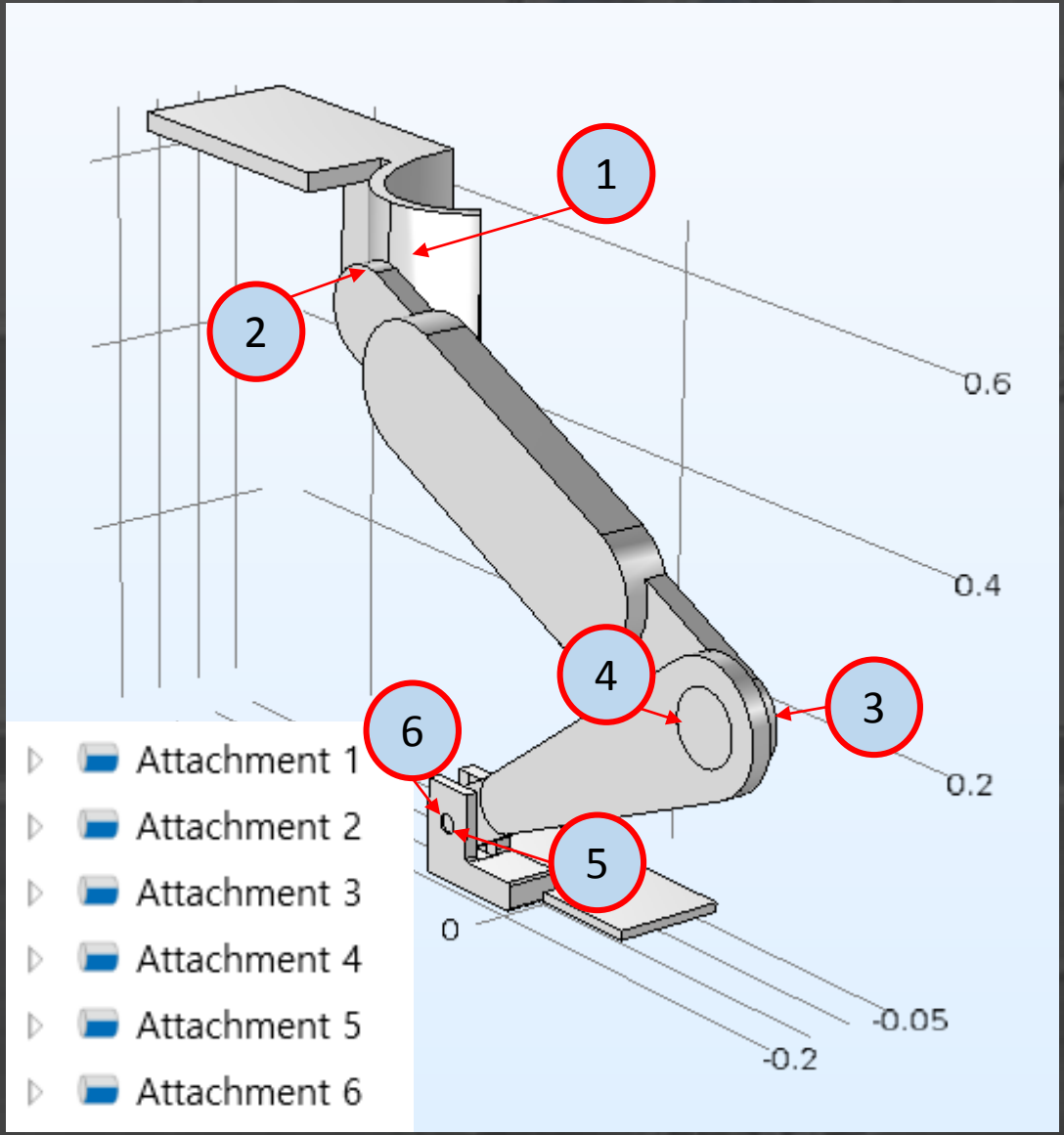


사람의 몸무게(40Kg)
조건 부여



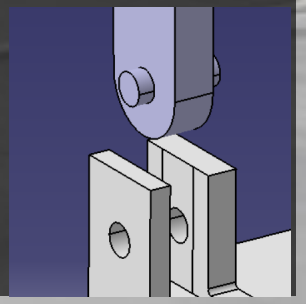
3

HINGE #1



Joint 생성을 위한

Attachment 설정



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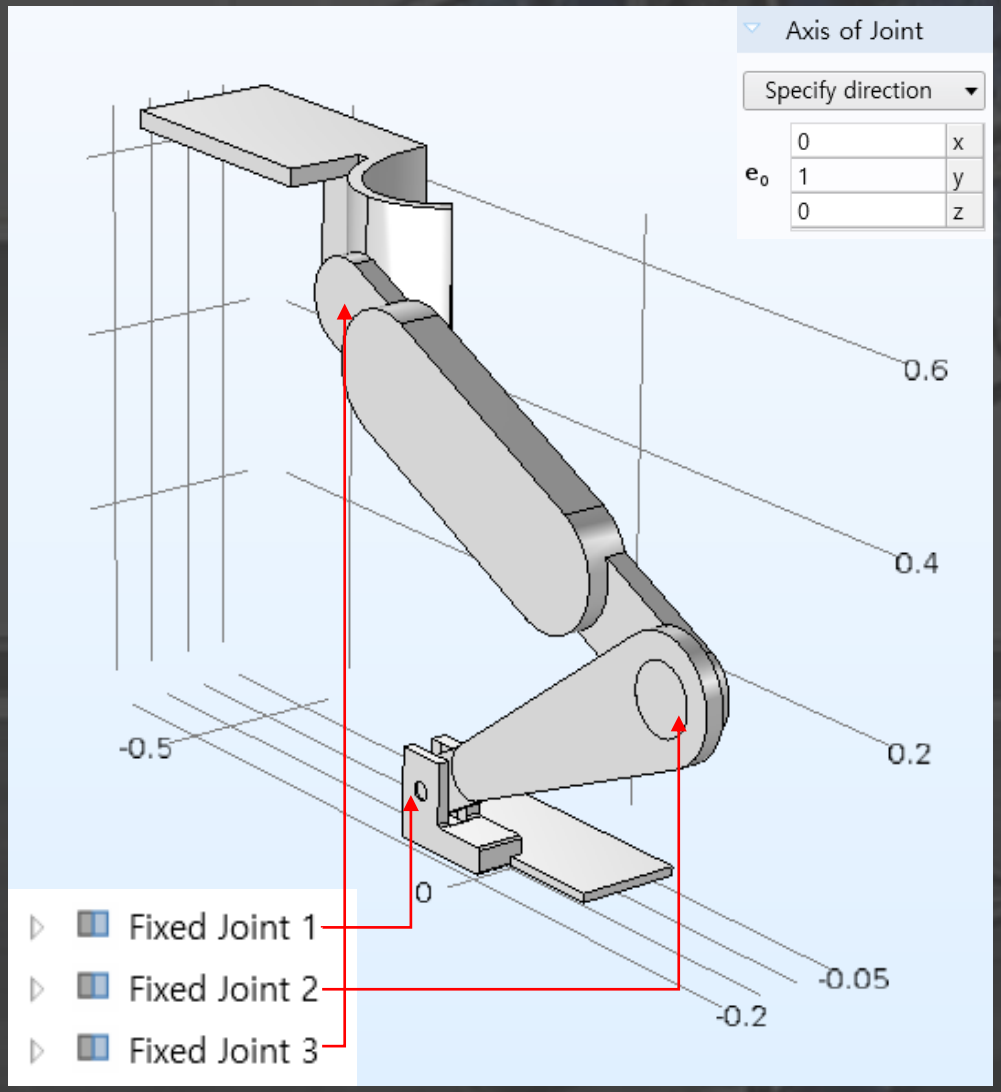
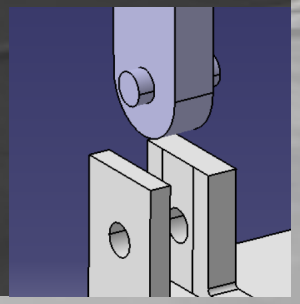


Stationary 해석을 위한

Fixed Joint 부여



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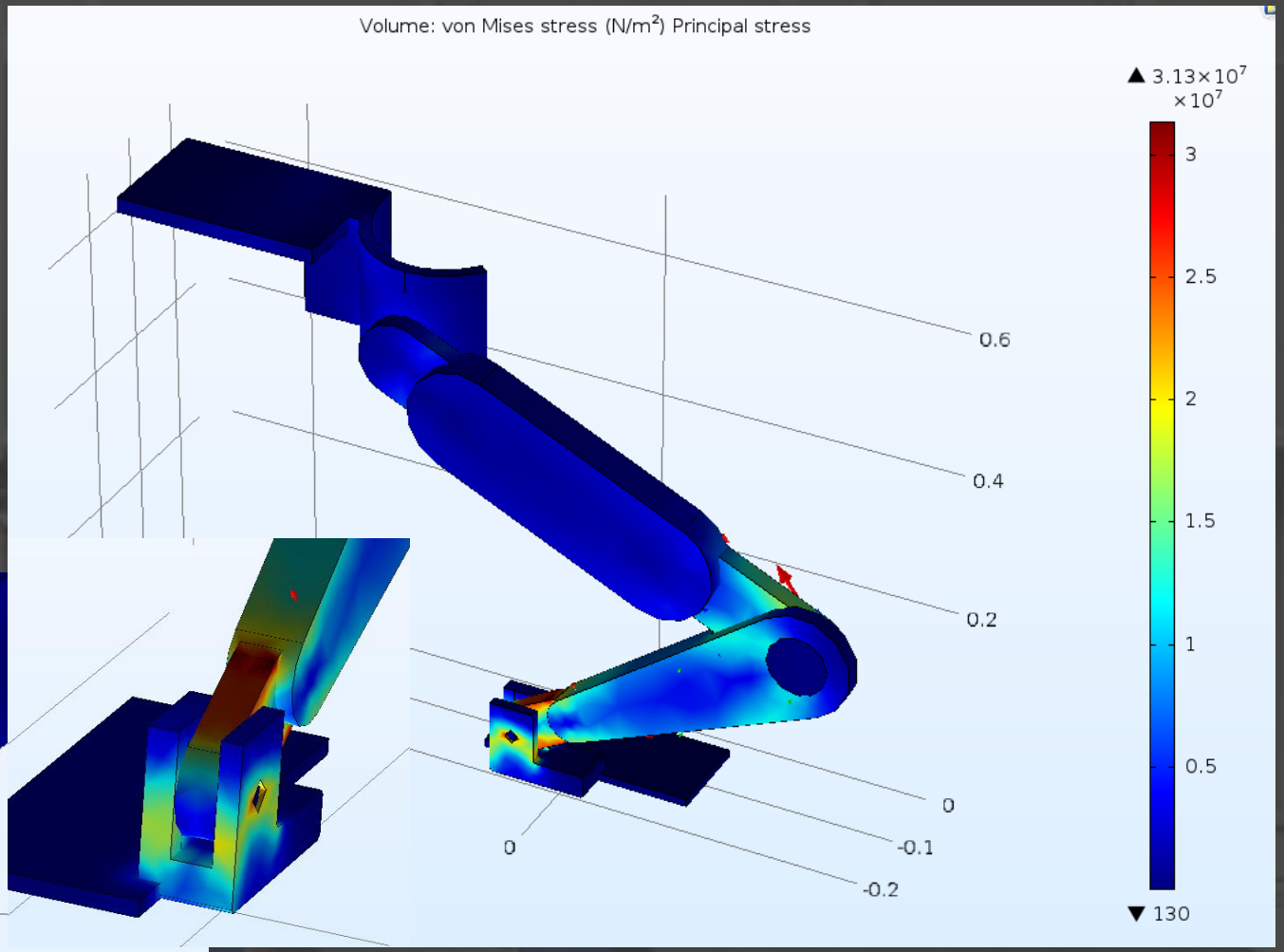
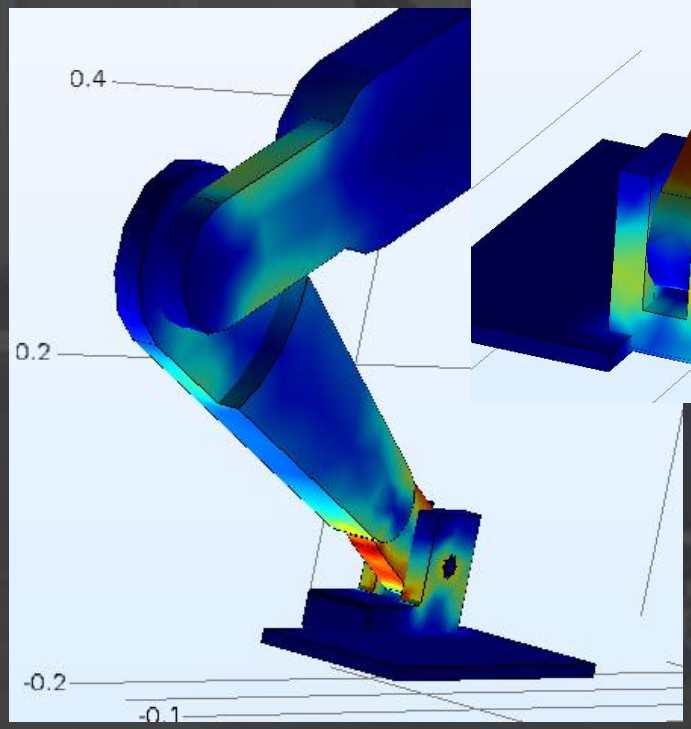
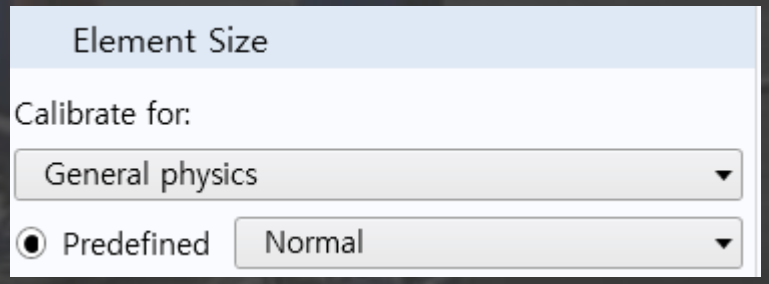
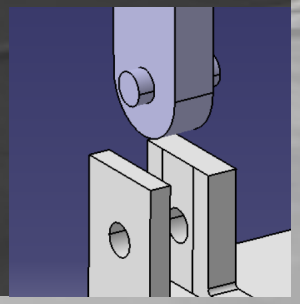
HINGE #1


Volume: von Mises stress (N/m²) Principal stress
▲ 3.13×10⁷
×10⁷
3
2.5
2
1.5
1
0.5
▼ 130
0.6
0.4
0.2
0
-0.1
-0.2

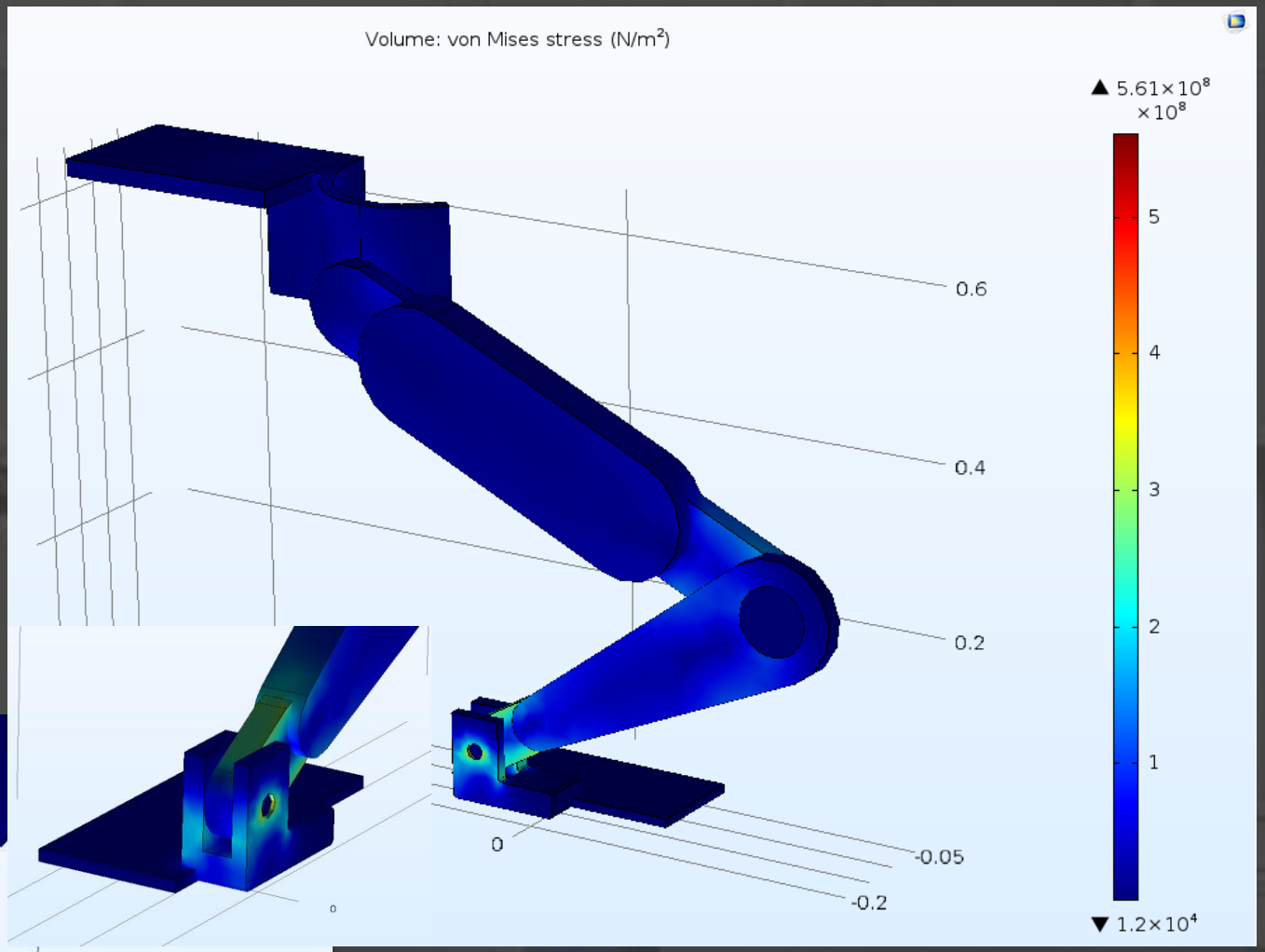

0.4
0.2
-0.2
-0.1

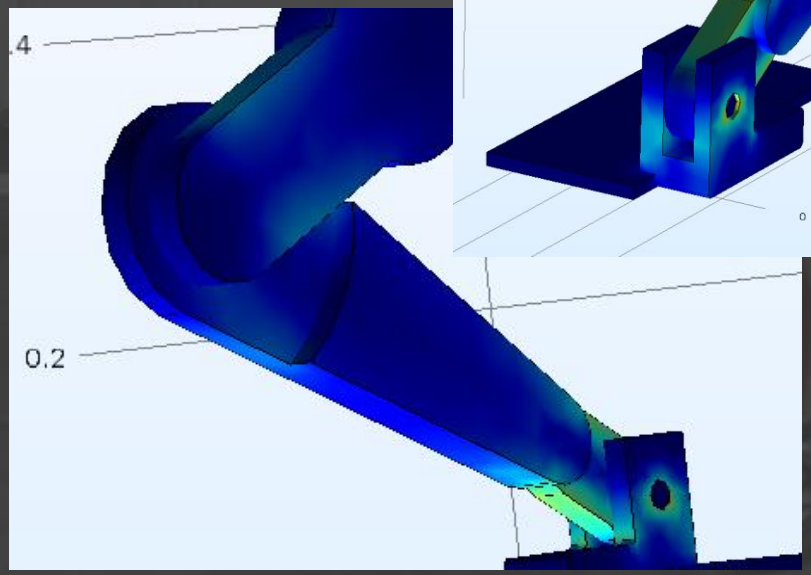

Element Size
Calibrate for:
General physics
Predefined
Normal

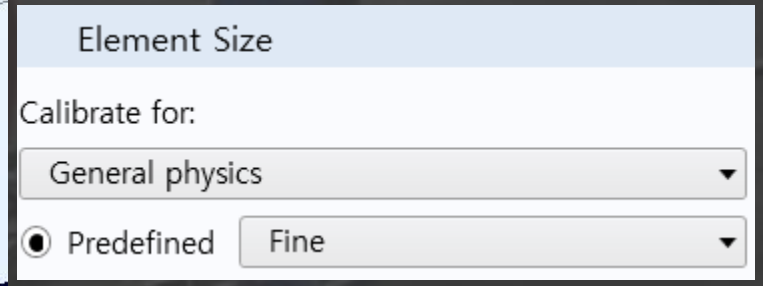


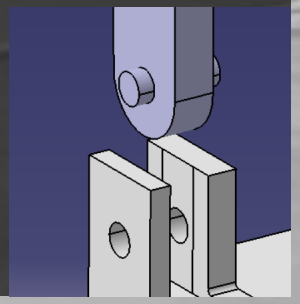
3

HINGE #1


Volume: von Mises stress (N/m²)
▲ 5.61×10⁸
×10⁸
5
4
3
2
1
▼ 1.2×10⁴
0.6
0.4
0.2
0
-0.05
-0.2


.4
0.2


Element Size
Calibrate for:
General physics
Predefined
Fine



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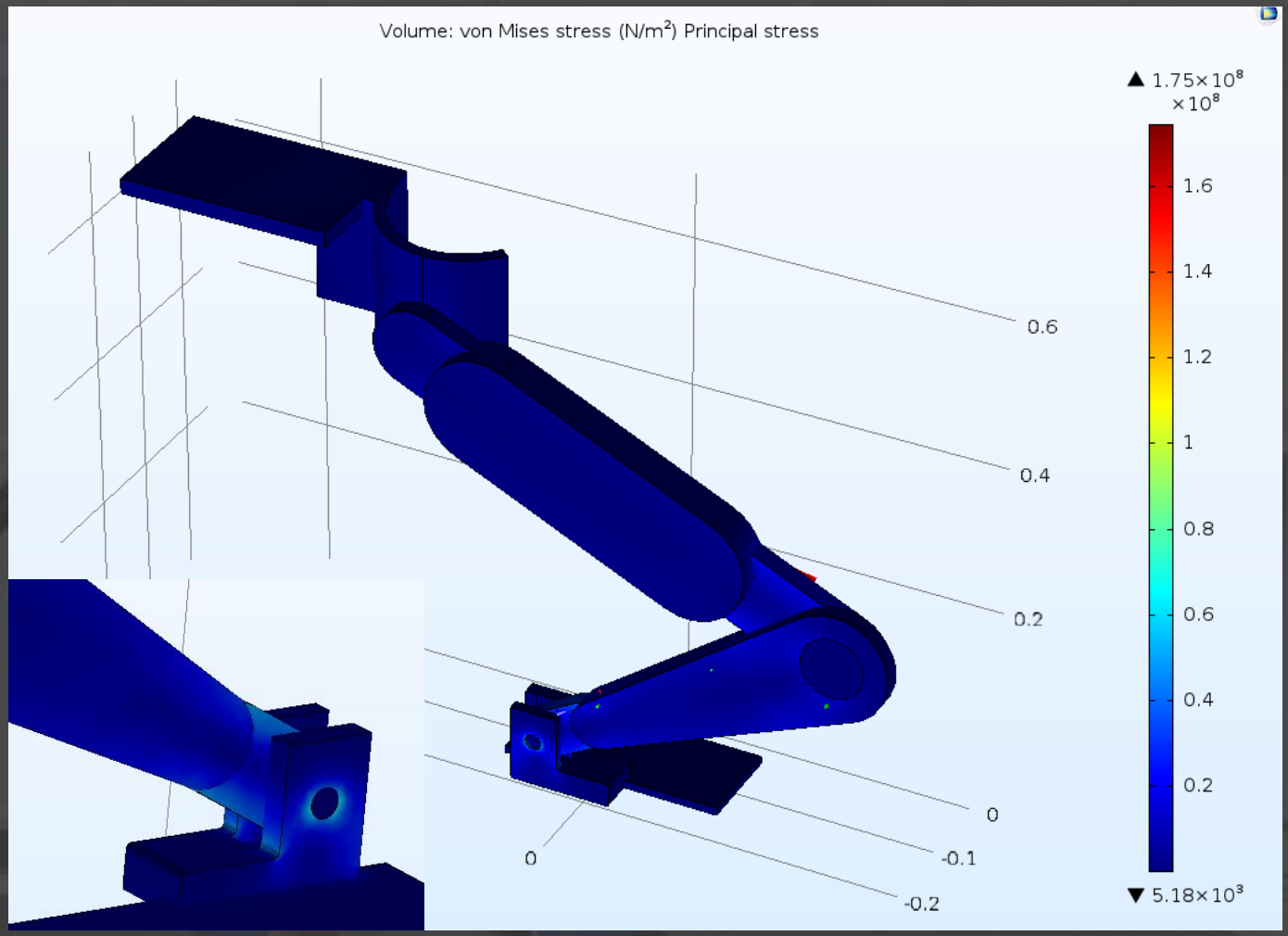
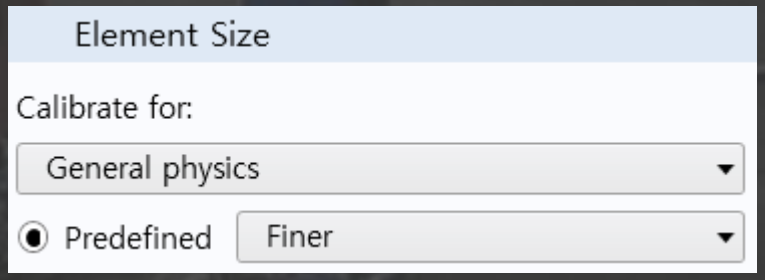
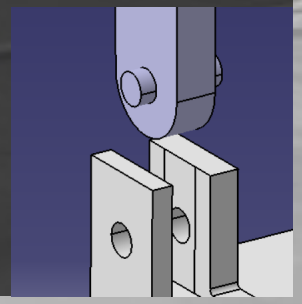
HINGE #1


Volume: von Mises stress (N/m²) Principal stress
▲ 1.75×10⁸
×10⁸
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
▼ 5.18×10³
0.6
0.4
0.2
0
-0.1
-0.2
0


Element Size
Calibrate for:
General physics
Predefined
Finer



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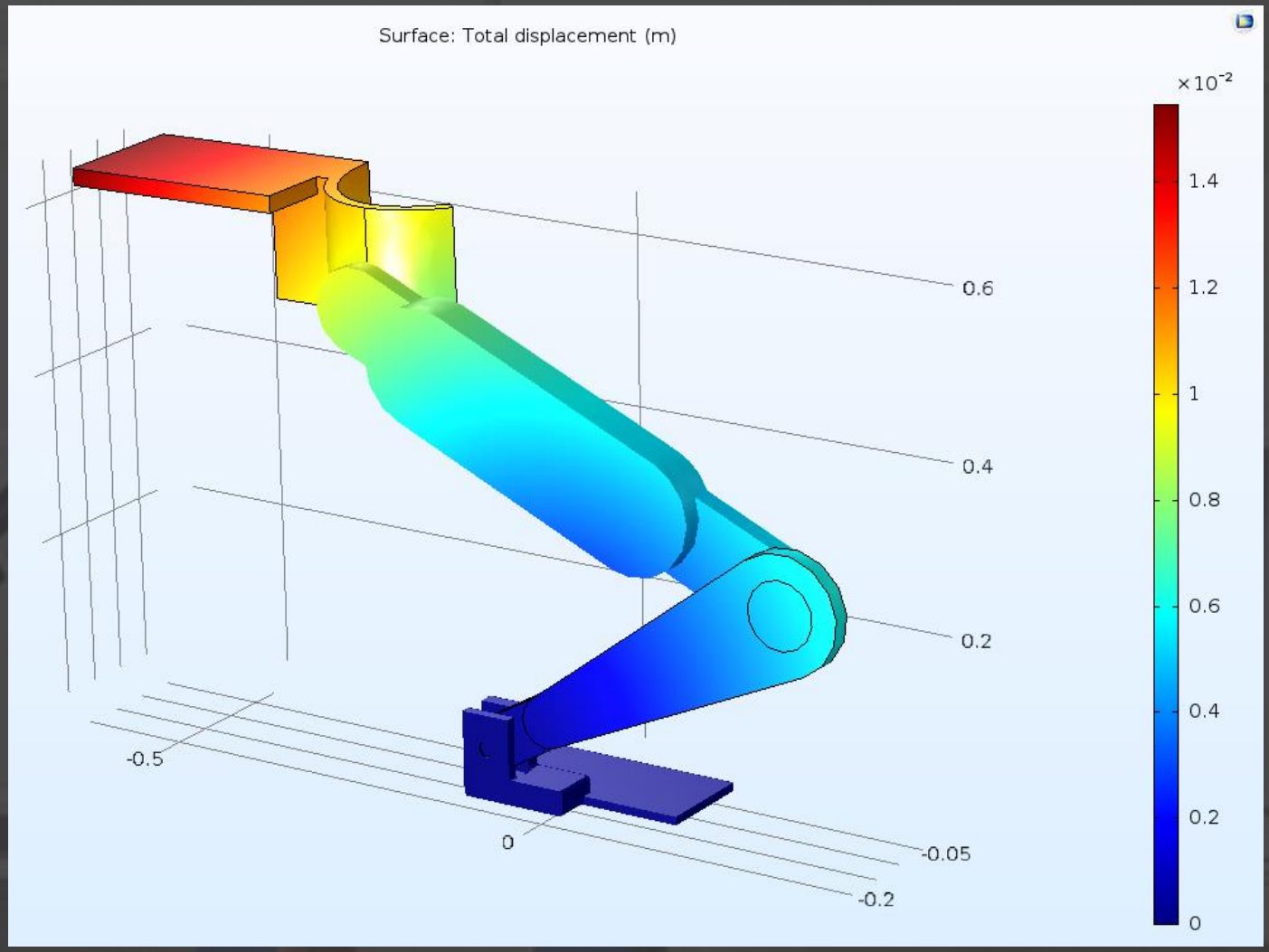
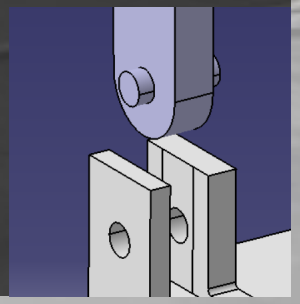
HINGE #1


Surface: Total displacement (m)
×10^-2
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.6
0.4
0.2
-0.05
-0.2
0
-0.5



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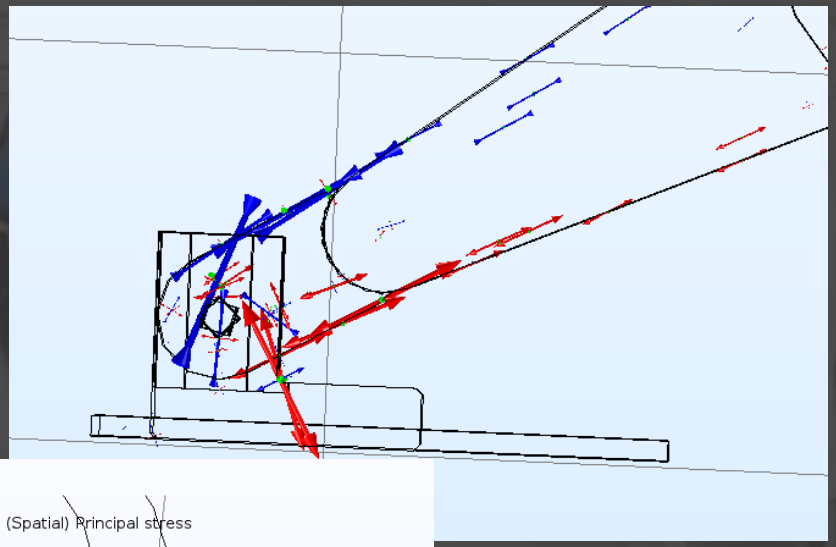
HINGE #1



Principal Stress Surface

Plot

Data

Data set: Study 1/Solution 1 (sol1)

Principal Components

Type: Principal stress

Principal values

	First:	Second:	Third:
Value:	mbd.sp1	mbd.sp2	mbd.sp3

Principal directions

	First:	Second:	Third:
X:	mbd.sp1x	mbd.sp2x	mbd.sp3x
Y:	mbd.sp1y	mbd.sp2y	mbd.sp3y
Z:	mbd.sp1z	mbd.sp2z	mbd.sp3z

Parameters

Name	Value	Unit	Description
mbd.refpntx	0		Reference po
mbd.refpnty	0		Reference po
mbd.refpntz	0		Reference po

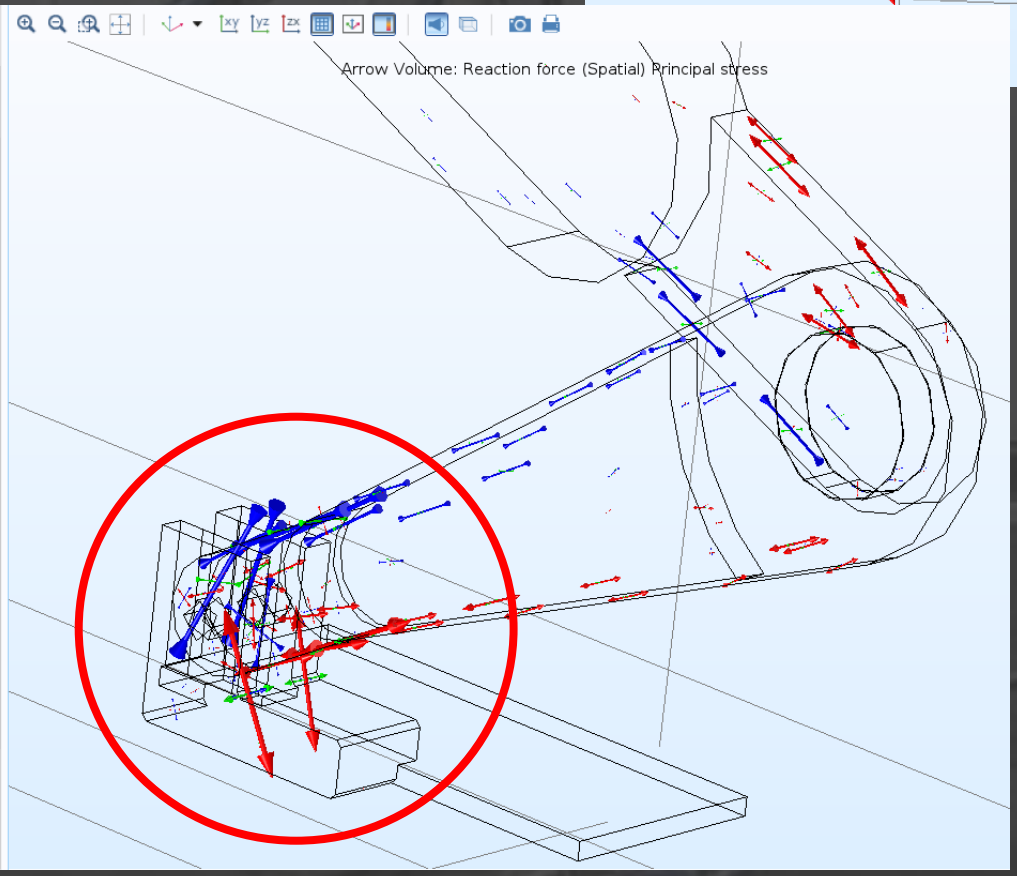
Title

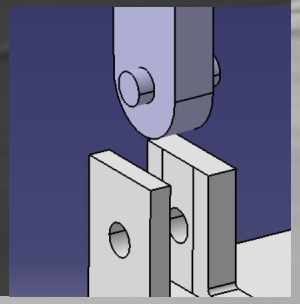
Coloring and Style

Arrow type: Arrow

Arrow length: Proportional

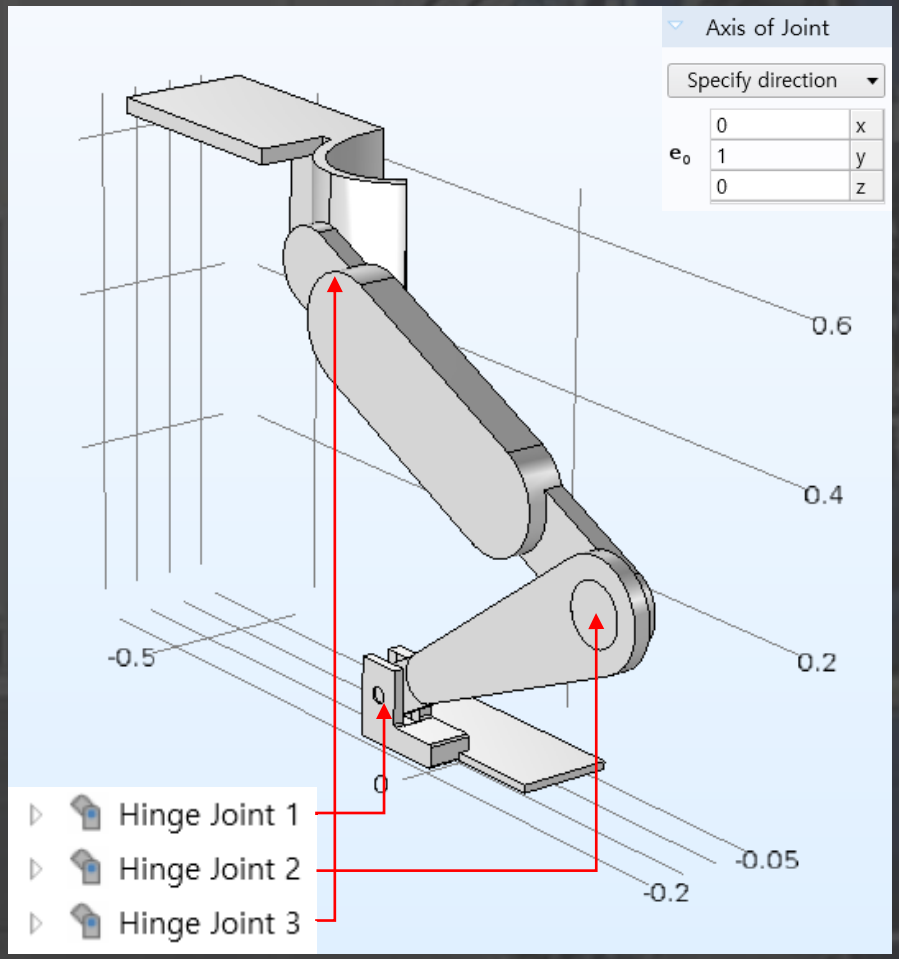
Scale factor: 1.47928E-9





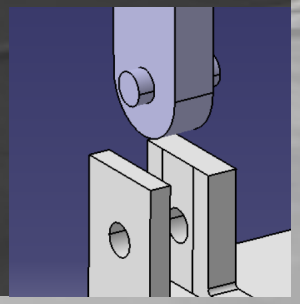
3

HINGE #1



Dynamics 해석을 위한

Hinge Joint 부여



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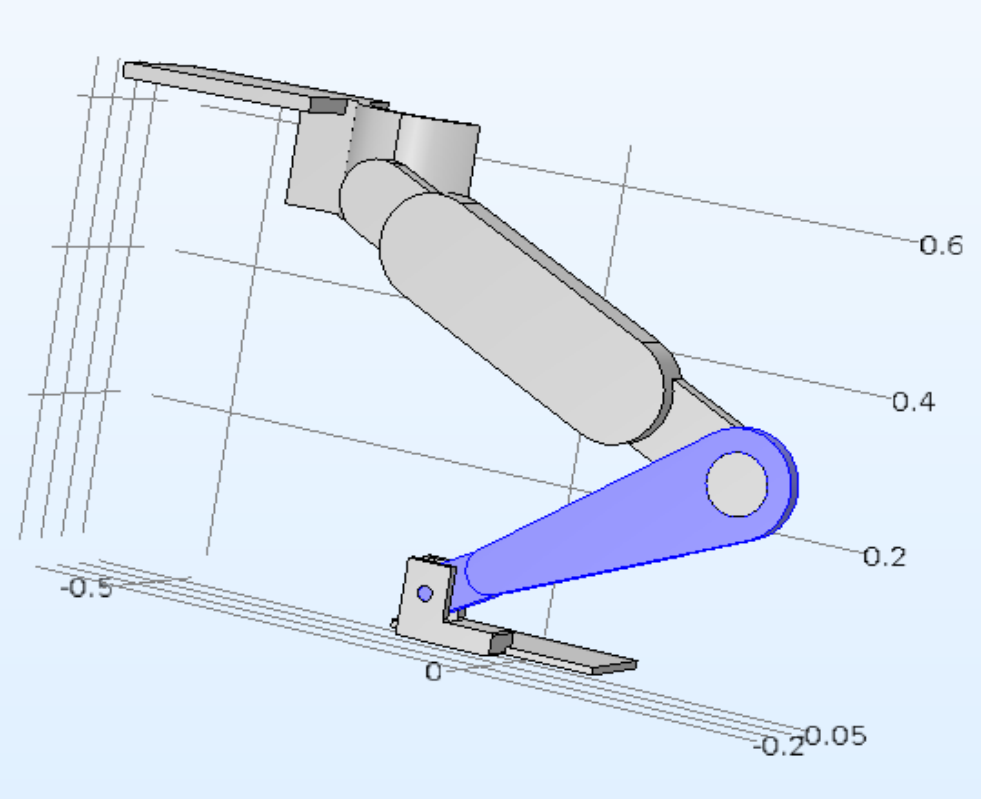
HINGE #1



Rotating Frame

Axis of rotation:

User defined

Rotation axis base point:

r_{bp}	(-0.05829353857-0.03829353857)/2	x	m
	-0.2346603236	y	
	0.0641106066	z	

Rotation axis direction:

e_{ax}	0	x	1
	1	y	
	0	z	

Rotational direction:

Counterclockwise

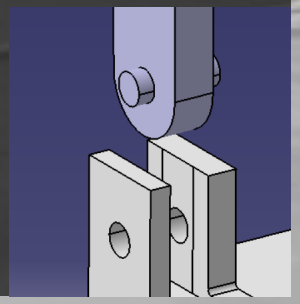
Rotational frequency:

Angular velocity

Angular velocity magnitude:

Ω	3.14/(3*0.05)	rad/s

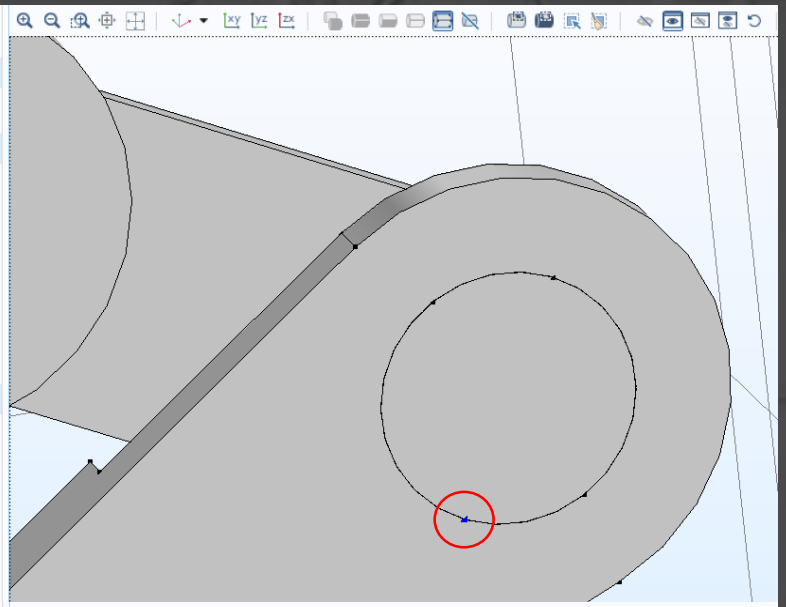
Rotating Frame – 기준점, 회전 Axis 설정



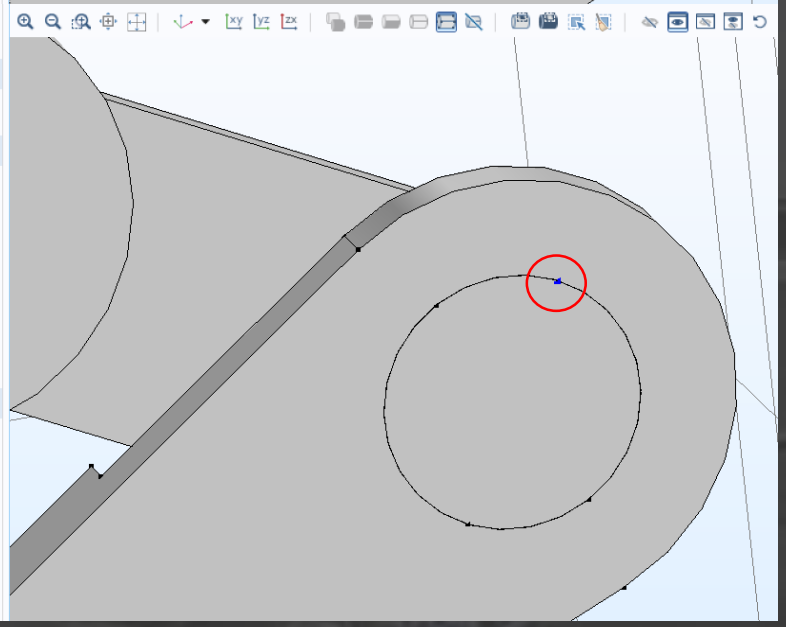
3

HINGE #1

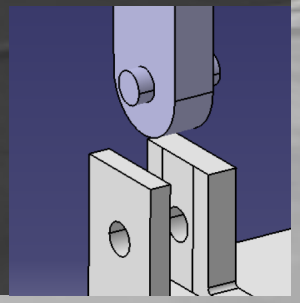
Measure
Build All
Geometry Type
Type of geometry: Geometry objects
Selection
Geometric entity level: Point
Selection:
Active
fin
60
Measurements
Coordinates
x: 0.4151265444 m
y: -0.2531596053 m
z: 0.2142203947 m



Measure
Build All
Geometry Type
Type of geometry: Geometry objects
Selection
Geometric entity level: Point
Selection:
Active
fin
62
Measurements
Coordinates
x: 0.4509010095 m
y: -0.2531596053 m
z: 0.2857758812 m



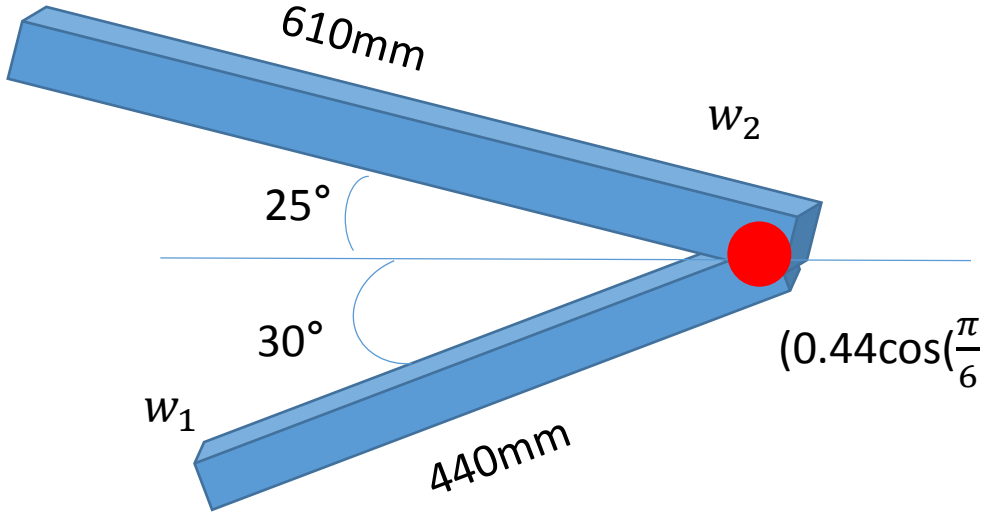
Geometry -> Measure이용, 두 점의 좌표를 각각 확인함



3

HINGE #1

$$(0.44\cos(\frac{\pi}{6} + w_1 t) - 0.61\cos(\frac{25\pi}{180} + w_2\, t),$$
$$0.44\sin(\frac{\pi}{6} + w_1 t) + 0.61\sin(\frac{25\pi}{180} + w_2\, t))$$



$$(0.44\cos(\frac{\pi}{6} + w_1 t), 0.44\sin(\frac{\pi}{6} + w_1 t))$$

정기구학 – 말단장치의 직교좌표상의 위치 파악

3

HINGE #1

Rotating Frame

Axis of rotation:

User defined

Rotation axis base point:

r_{bp}	(-0.05829353857-0.03829353857)/2+0.44*cos(3.14/6+3.14*t/(3*0.05))	x	m
	-0.2346603236	y	
	0.0641106066+0.44*sin(3.14/6+3.14*t/(3*0.05))	z	

Rotation axis direction:

e_{ax}	0	x	1
	1	y	
	0	z	

Rotational direction:

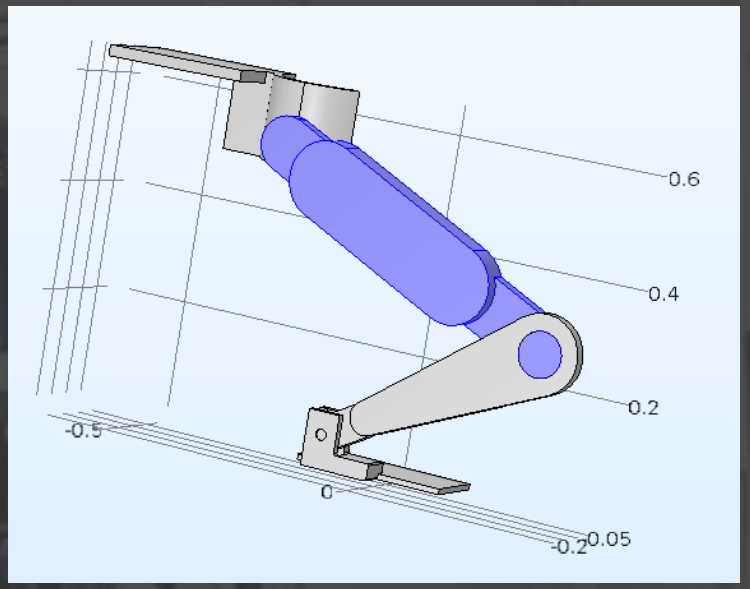
Clockwise

Rotational frequency:

Angular velocity

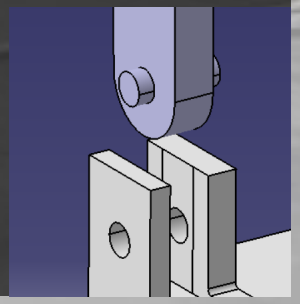
Angular velocity magnitude:

Ω	185*3.14/(180*0.05)	rad/s



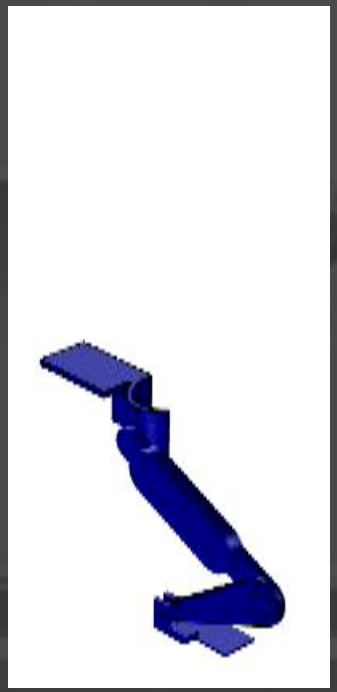
변화하는 회전 기준점을

삼각함수로 입력



3

HINGE #1



Global Evaluation

Evaluate

Label: Global Evaluation 1

Data

Data set: Study 2/Solution 2 (sol2)

Time selection: All

Expression

Expression:

mbd.hgj1.Mx

Unit:

N*m

Description:

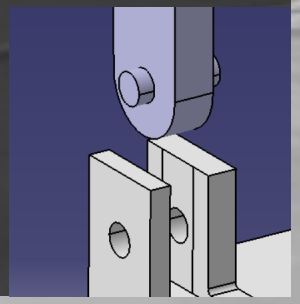
Joint moment, x component

Parameters

Name	Value	Unit	Description
mbd.refpntx	0		Reference point f...
mbd.refpnty	0		Reference point f...
mbd.refpntz	0		Reference point f...

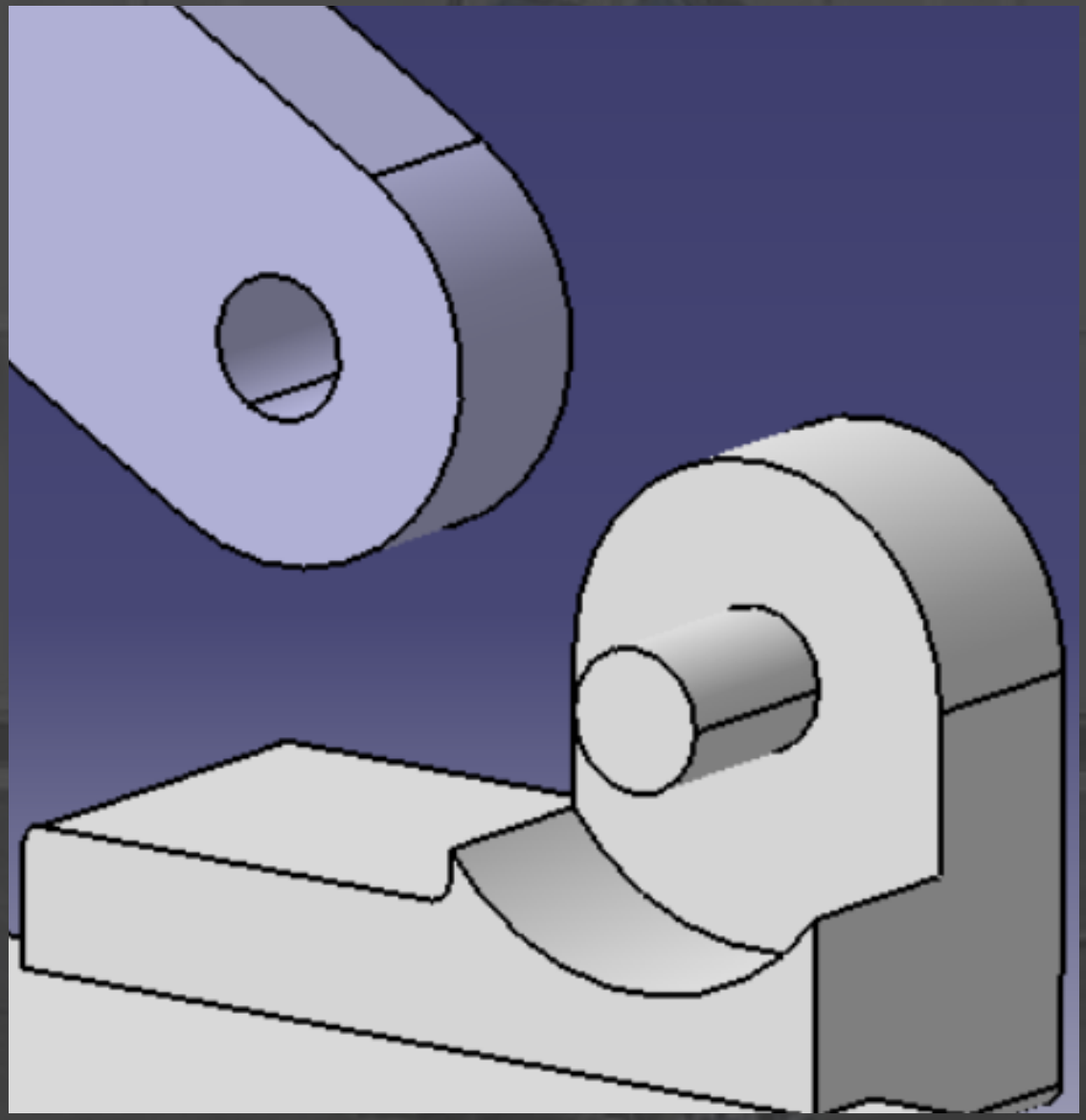
Time (s)	Joint moment, x component (N*m)
0.065000	180.16
0.066000	196.36
0.067000	214.95
0.068000	236.50
0.069000	261.80
0.070000	291.85
0.071000	328.05
0.072000	372.24
0.073000	426.82
0.074000	494.78
0.075000	579.17
0.076000	681.52
0.077000	797.80
0.078000	911.35
0.079000	987.79
0.080000	986.63
0.081000	895.41
0.082000	749.35
0.083000	600.62
0.084000	477.28
0.085000	381.56
0.086000	307.76
0.087000	250.76

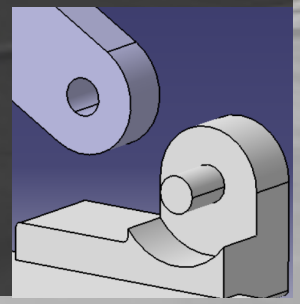
Joint 1에서의 Moment 최대값 확인



3

HINGE #2





3

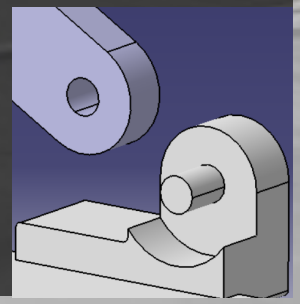
HINGE #2

- Gravity 1
- Fixed Constraint 1
- Attachment 1
- Attachment 2
- Attachment 3
- Attachment 4
- Attachment 5
- Attachment 6
- Prescribed Displacement 3
- Boundary Load 1
- Fixed Joint 1
- Fixed Joint 2
- Fixed Joint 3
- Hinge Joint 1
- Hinge Joint 2
- Hinge Joint 3
- Rotating Frame 1
- Rotating Frame 2
- Prescribed Displacement 2
- Boundary Load 2
- Equation View

초기 조건은 동일

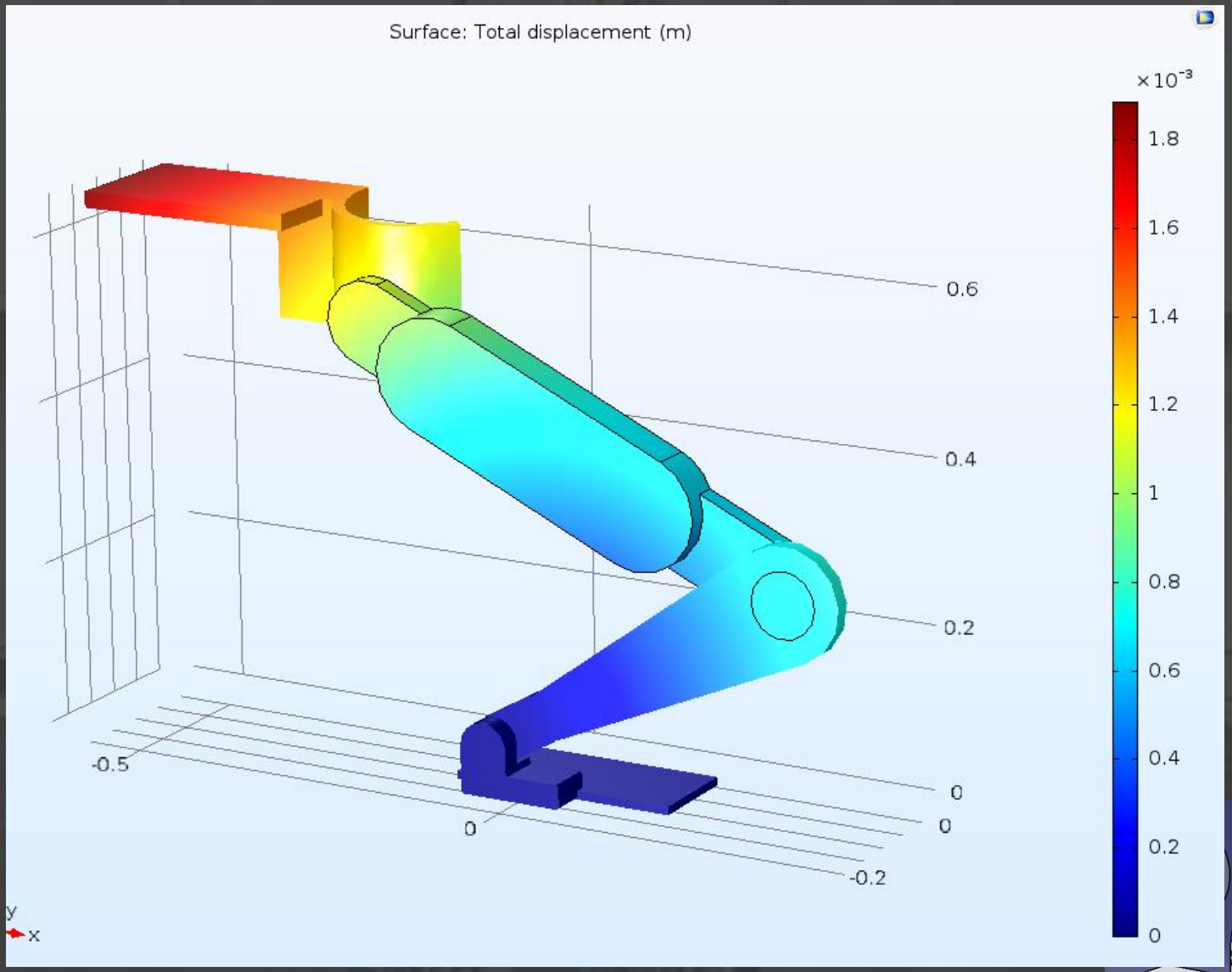
Stationary용 Joint

Dynamics용 Joint&제약조건



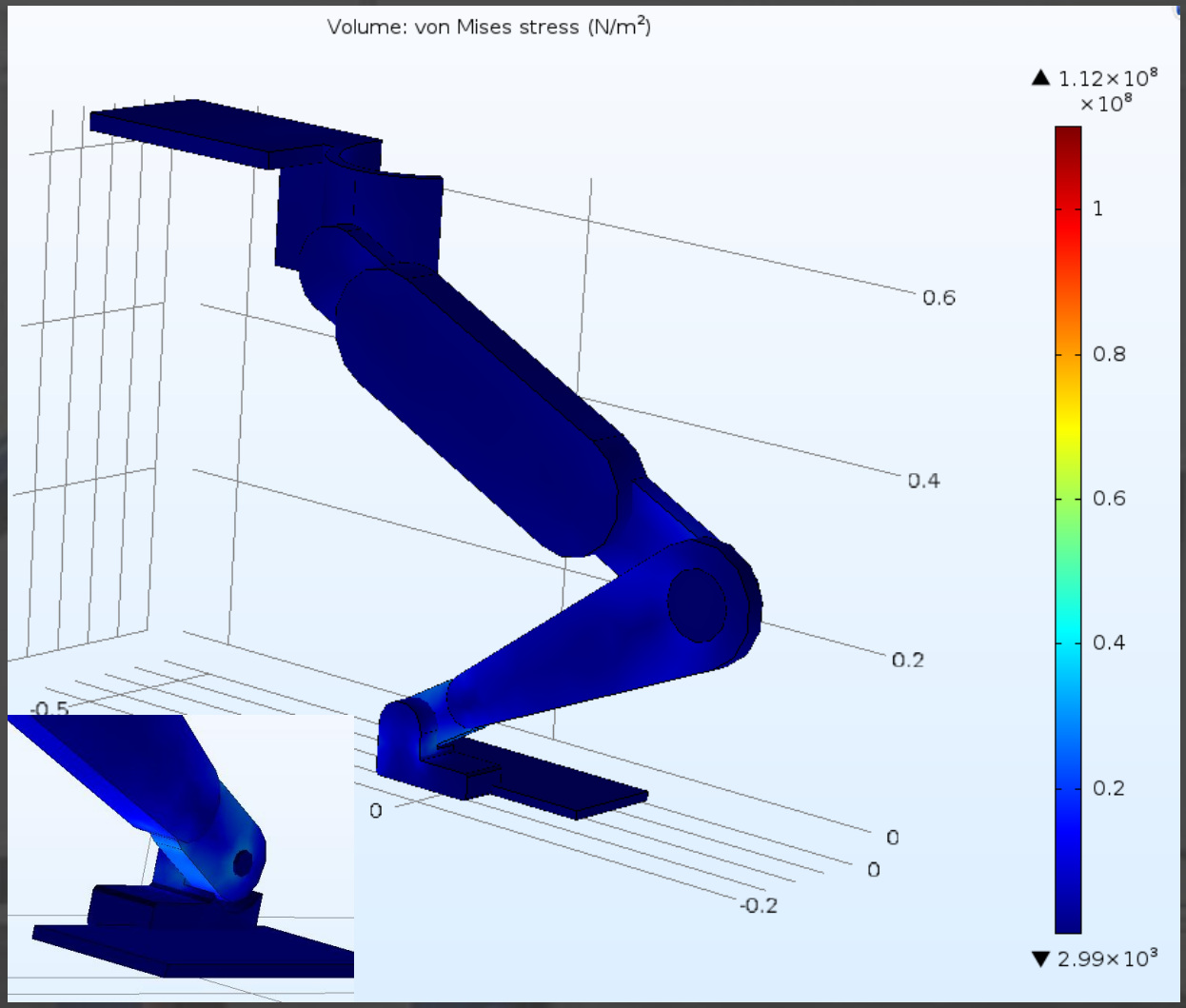
3

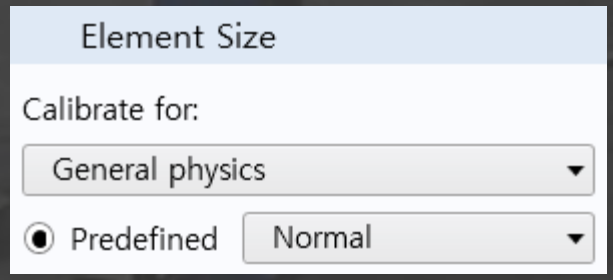
HINGE #2

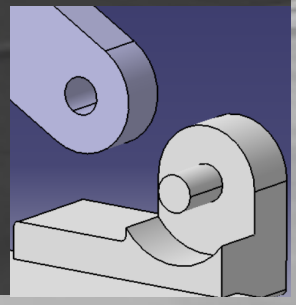

Surface: Total displacement (m)
×10⁻³
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.6
0.4
0.2
0
0
-0.2
-0.5
0
y
x

3

HINGE #2

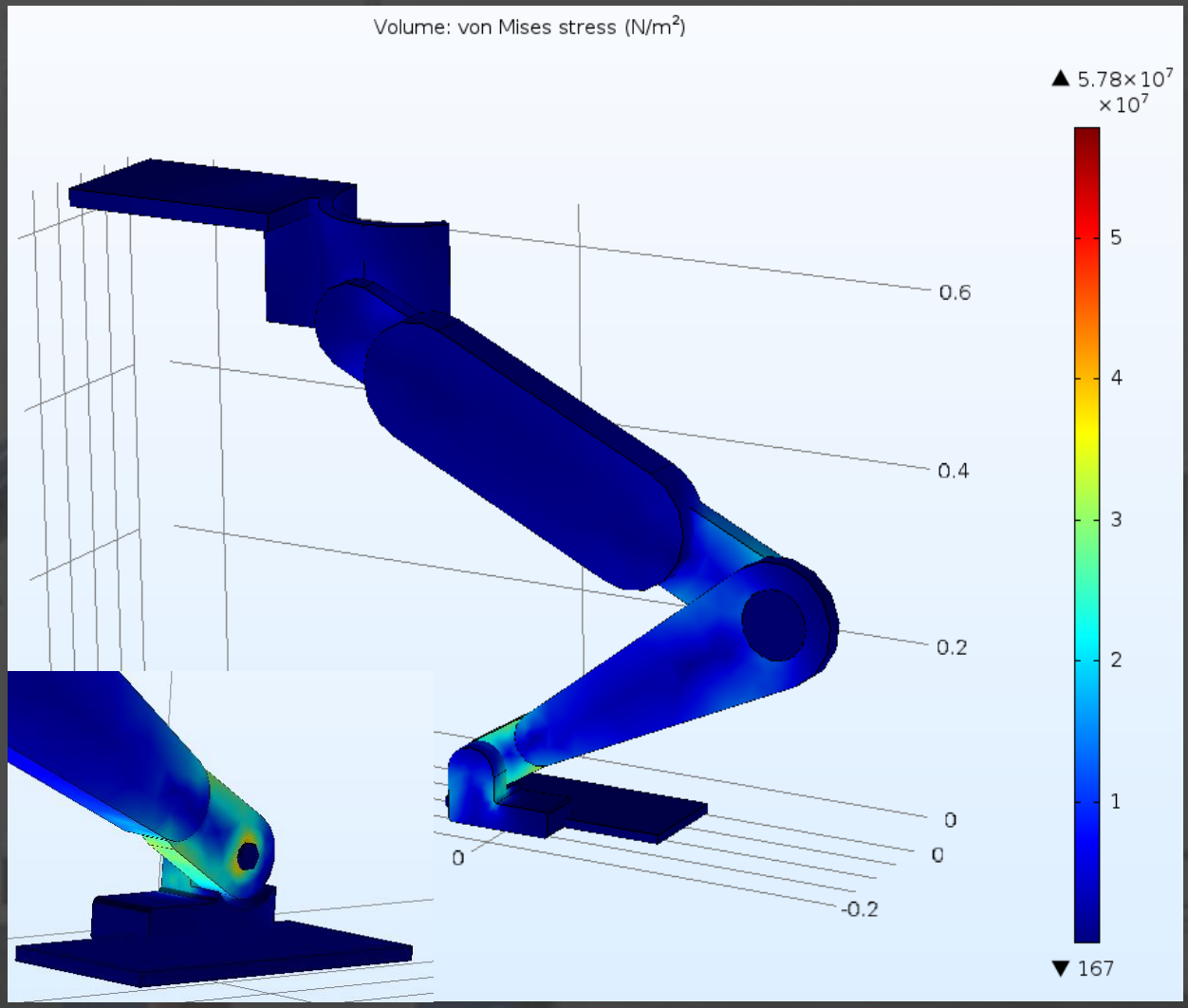

Volume: von Mises stress (N/m²)
▲ 1.12×10⁸
×10⁸
1
0.8
0.6
0.4
0.2
▼ 2.99×10³
0.6
0.4
0.2
0
0
0
-0.2
-0.5

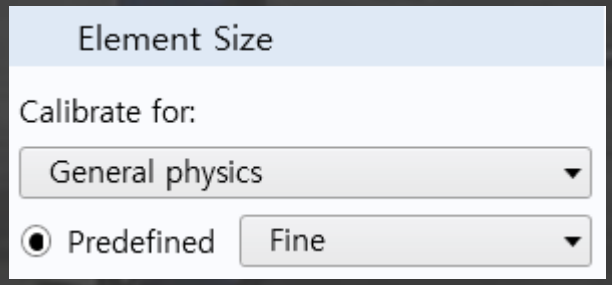

Element Size
Calibrate for:
General physics
Predefined
Normal

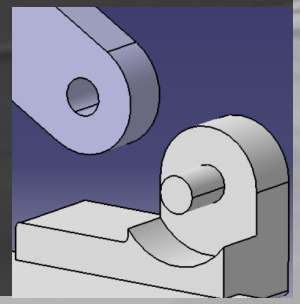


3

HINGE #2

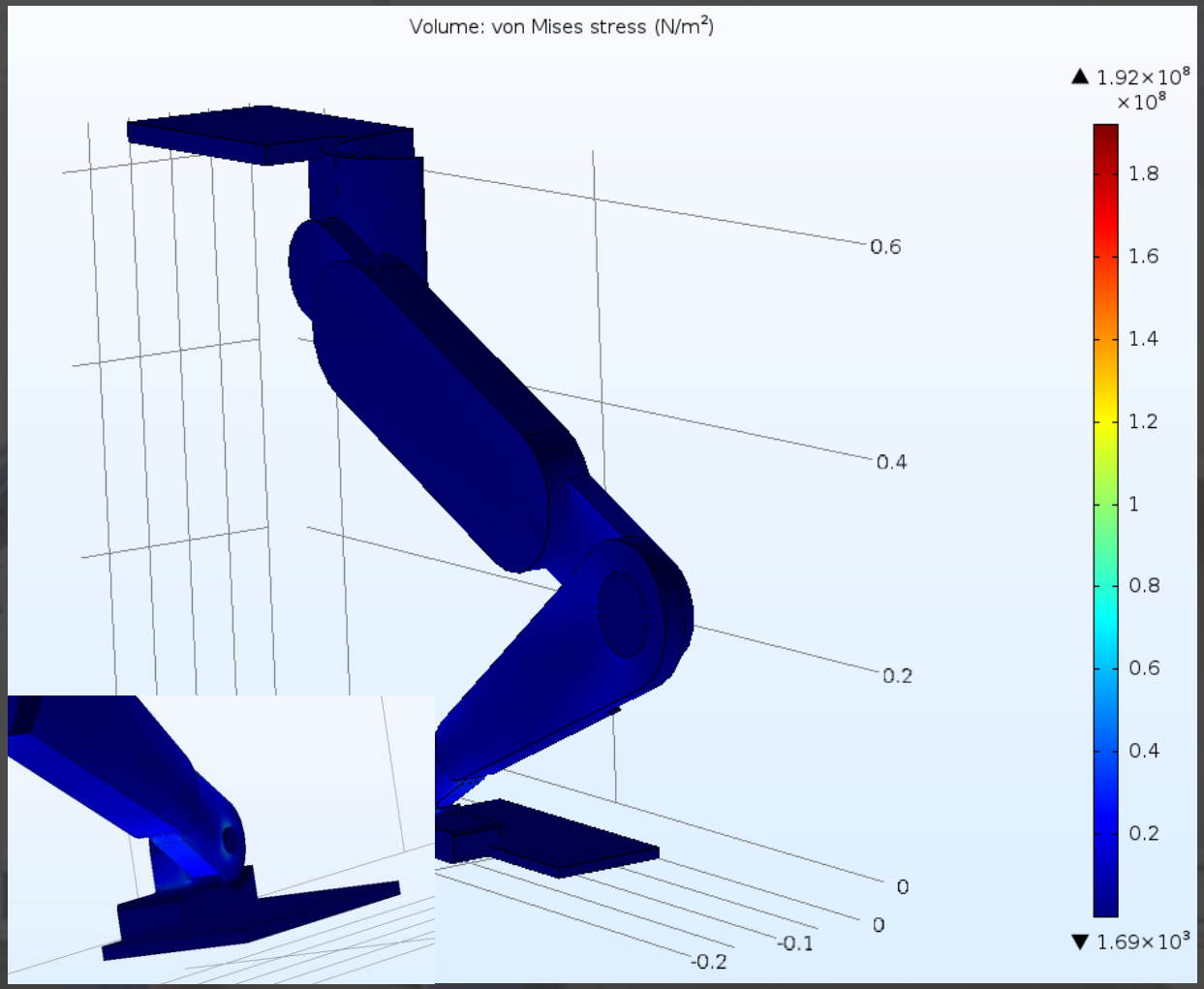

Volume: von Mises stress (N/m²)
▲ 5.78×10⁷
×10⁷
5
4
3
2
1
▼ 167
0.6
0.4
0.2
0
0
0
-0.2

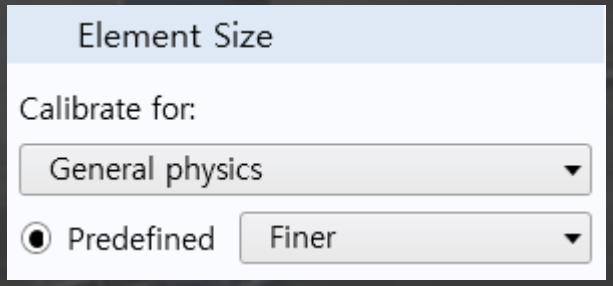

Element Size
Calibrate for:
General physics
Predefined
Fine

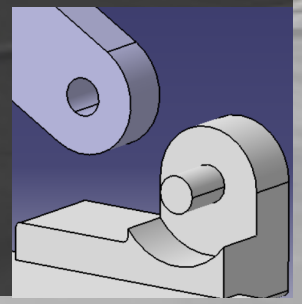


3

HINGE #2

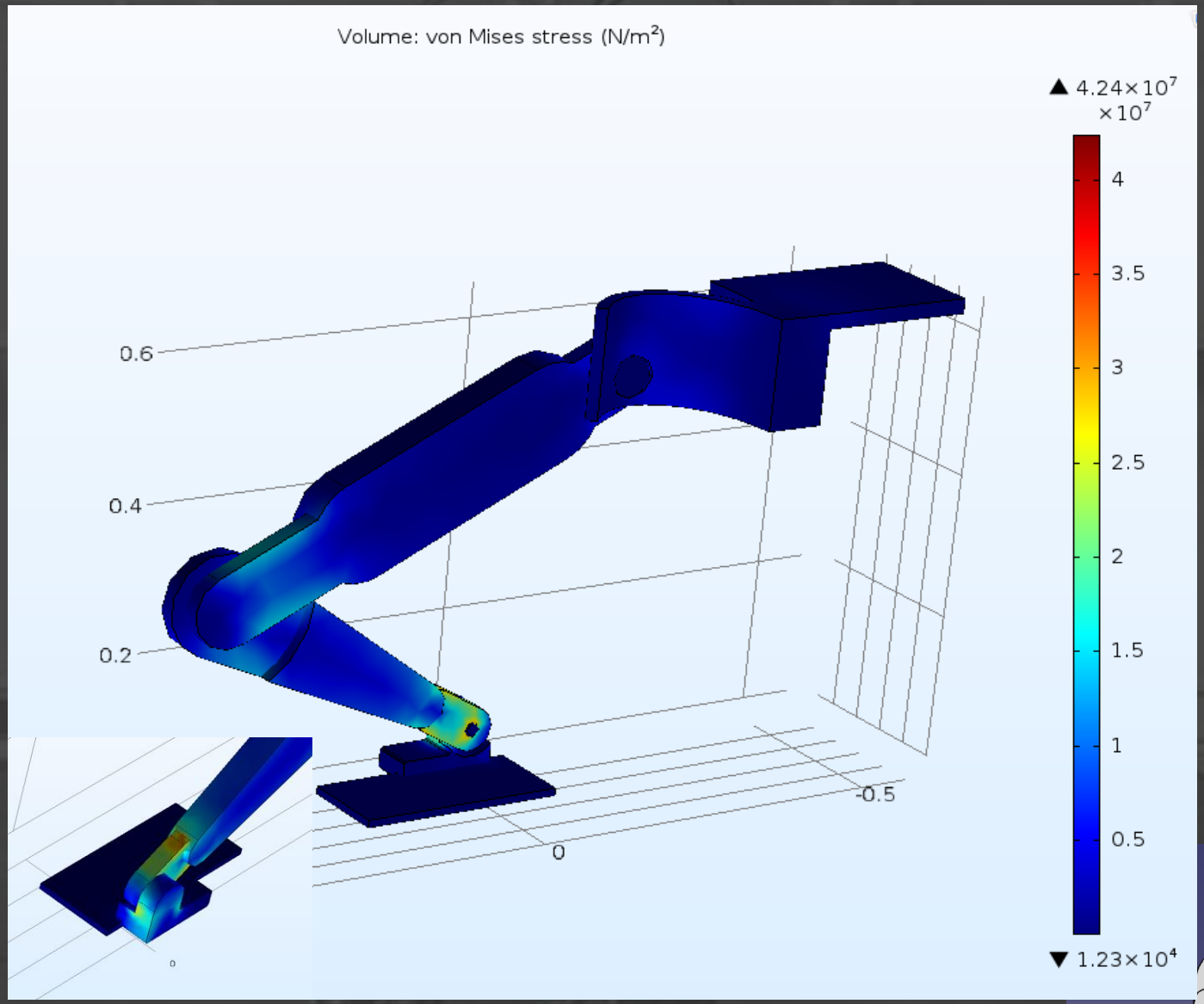

Volume: von Mises stress (N/m²)
▲ 1.92×10⁸
×10⁸
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
▼ 1.69×10³
0.6
0.4
0.2
0
0
-0.1
-0.2


Element Size
Calibrate for:
General physics
Predefined
Finer



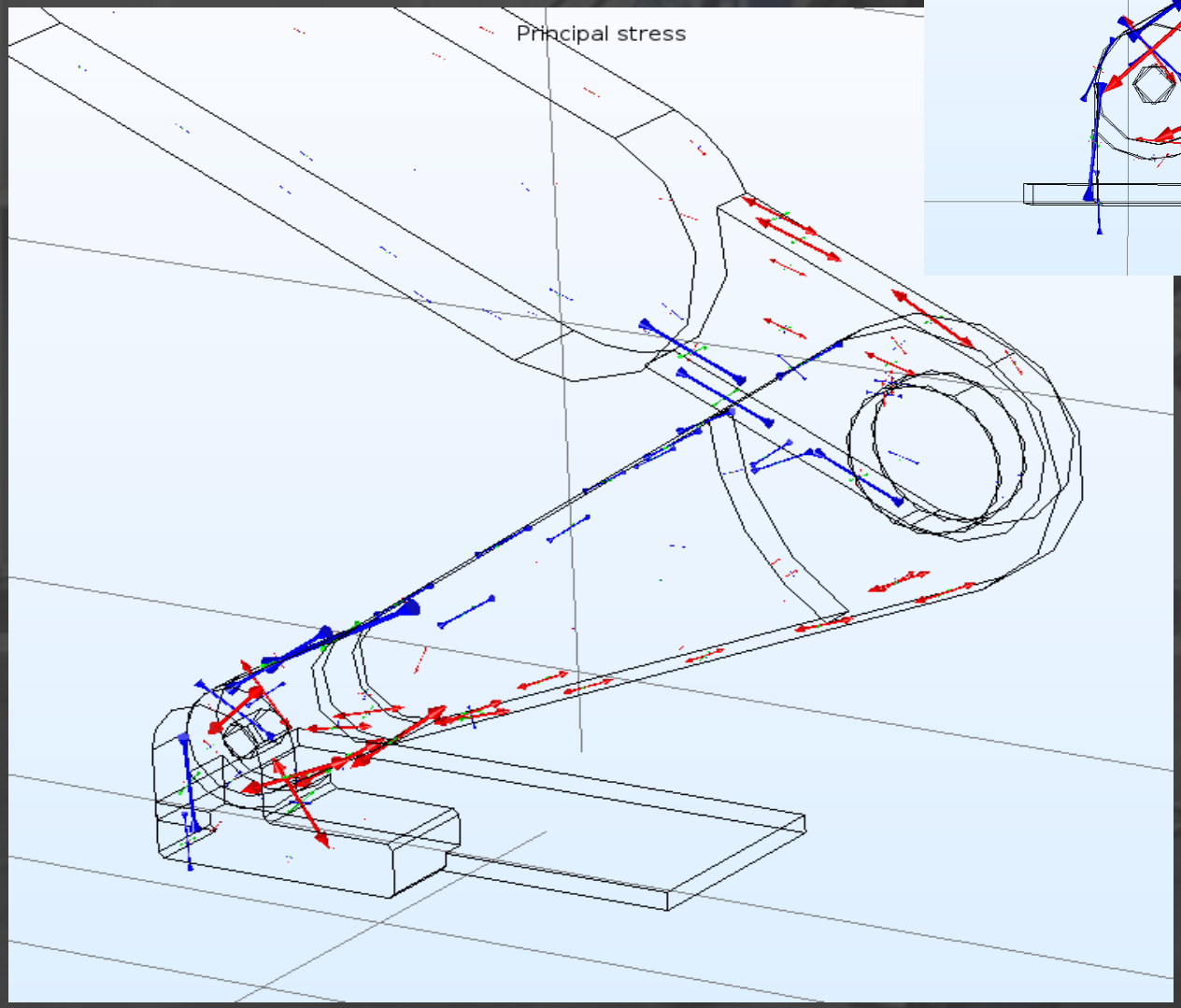
3

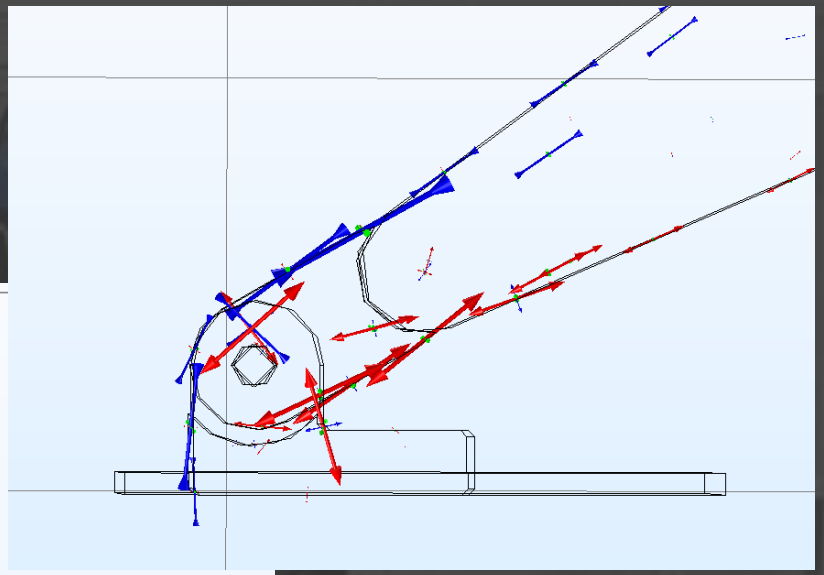
HINGE #2

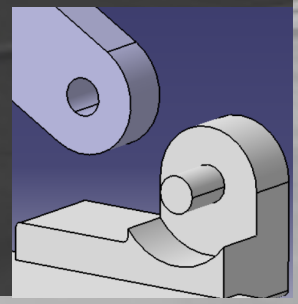

Volume: von Mises stress (N/m²)
▲ 4.24×10⁷
×10⁷
4
3.5
3
2.5
2
1.5
1
0.5
▼ 1.23×10⁴
0.6
0.4
0.2
0
-0.5

3

HINGE #2

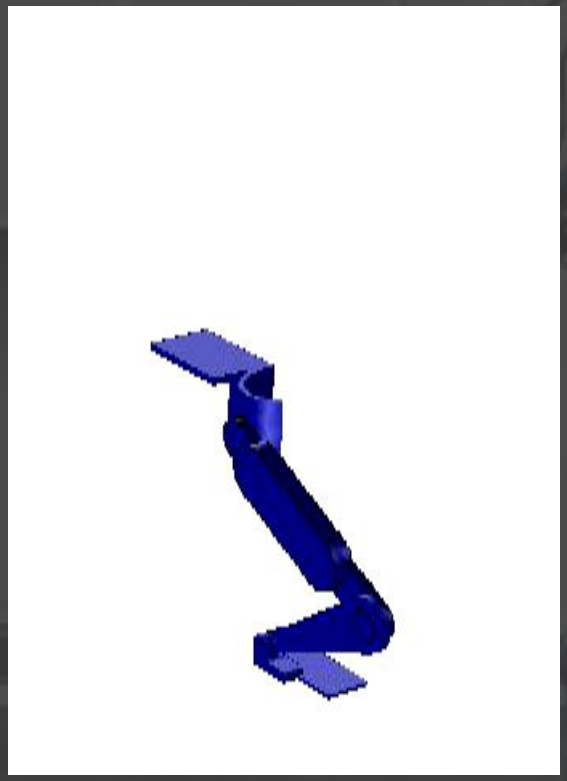






3

HINGE #2



Global Evaluation

Evaluate

Label: Global Evaluation 1

Data

Data set: Study 2/Solution 2 (sol2)

Time selection: All

Expression

Expression:

mbd.hgj1.Mx

Unit:

N*m

Description:

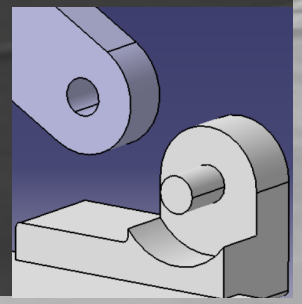
Joint moment, x component

Parameters

Name	Value	Unit	Description
mbd.refpntx	0		Reference point for...
mbd.refpnty	0		Reference point for...
mbd.refpntz	0		Reference point for...

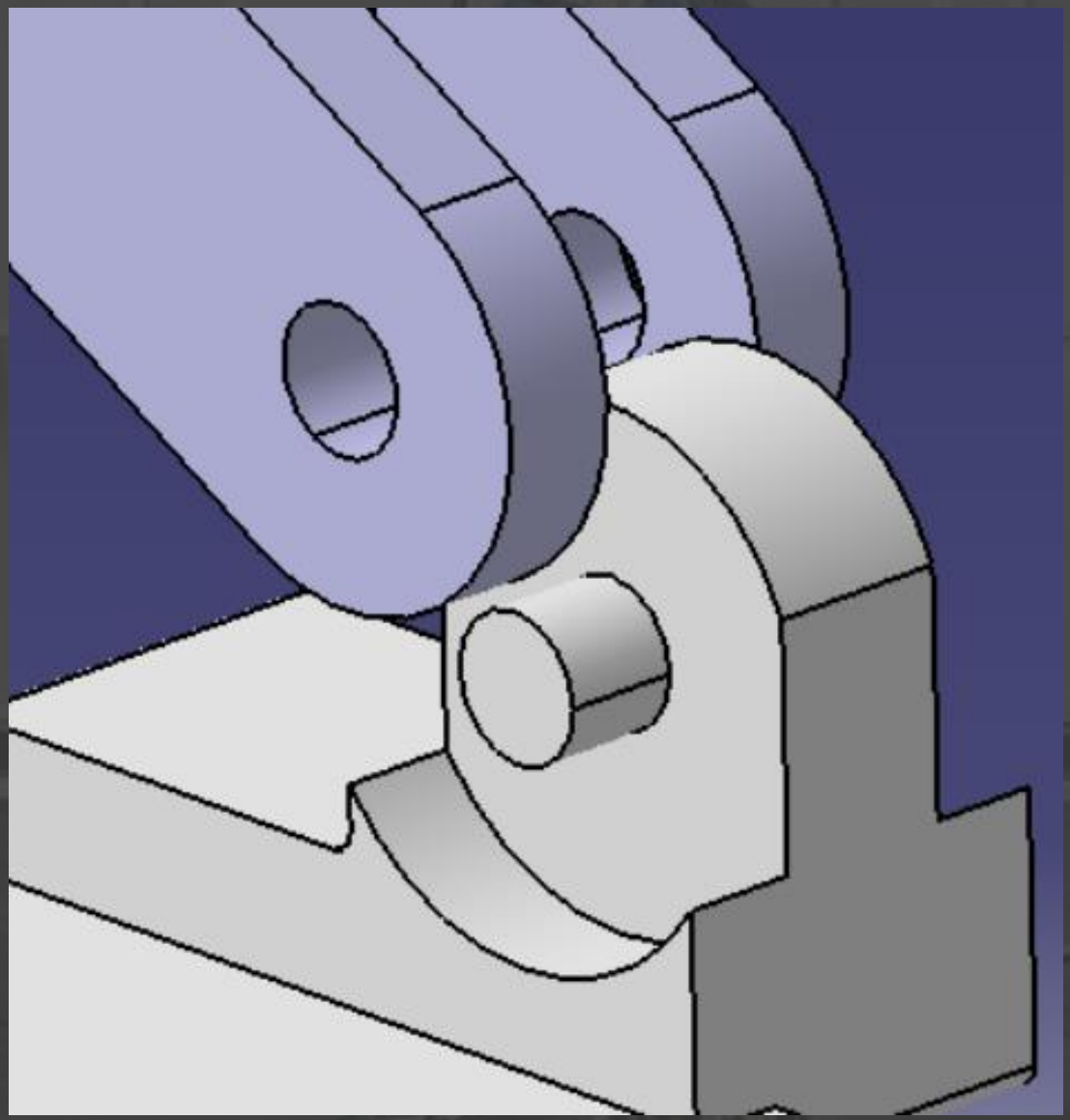
Time (s)	Joint moment, x component (N*m)
0.065000	30.752
0.066000	33.912
0.067000	37.581
0.068000	41.895
0.069000	47.035
0.070000	53.251
0.071000	60.883
0.072000	70.397
0.073000	82.428
0.074000	97.807
0.075000	117.52
0.076000	142.47
0.077000	172.68
0.078000	205.61
0.079000	233.89
0.080000	245.57
0.081000	231.39
0.082000	195.15
0.083000	152.16
0.084000	115.33
0.085000	87.802
0.086000	67.571
0.087000	52.665

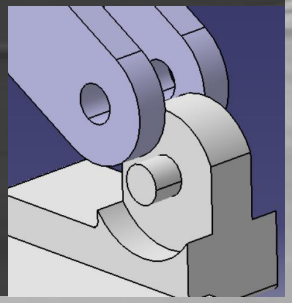
Joint 1에서의 Moment 최대값 확인



3

HINGE #3





3

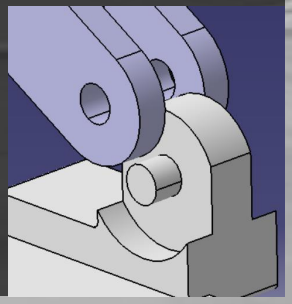
HINGE #3

- Multibody Dynamics *(mbd)*
  - Linear Elastic Material 1
  - Free 1
  - Initial Values 1
  - Gravity 1
  - Fixed Constraint 1
  - Prescribed Displacement 1
  - Attachment 1
  - Attachment 2
  - Attachment 3
  - Attachment 4
  - Attachment 5
  - Attachment 6
  - Boundary Load 1
  - Fixed Joint 1
  - Fixed Joint 2
  - Fixed Joint 3
  - Hinge Joint 1
  - Hinge Joint 2
  - Hinge Joint 3
  - Rotating Frame 1
  - Rotating Frame 2
  - Prescribed Displacement 2
  - Boundary Load 2
  - Equation View

초기 조건은 동일

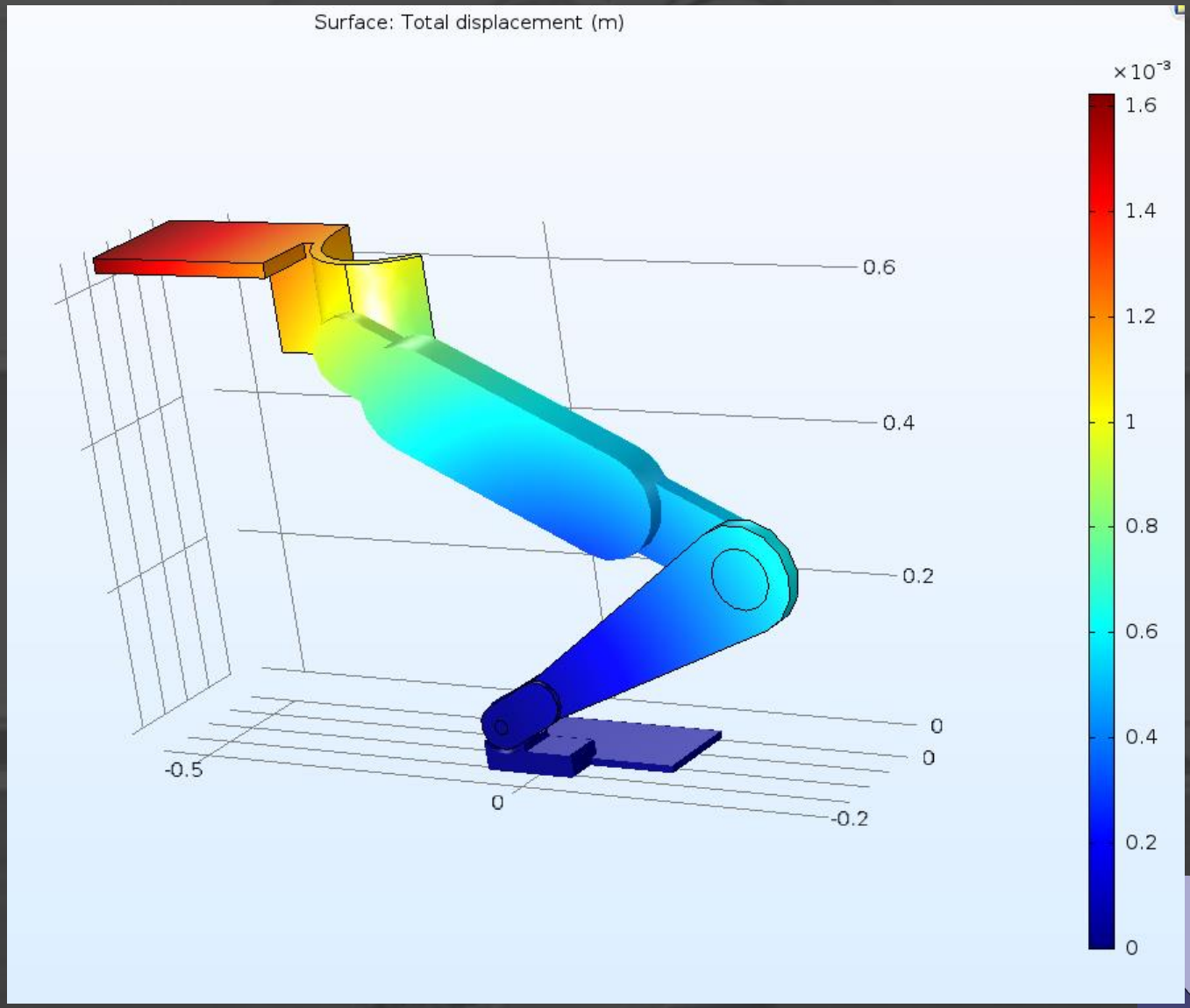
Stationary용 Joint

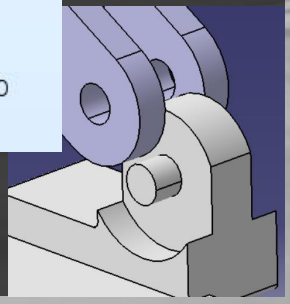
Dynamics용 Joint&제약조건



3

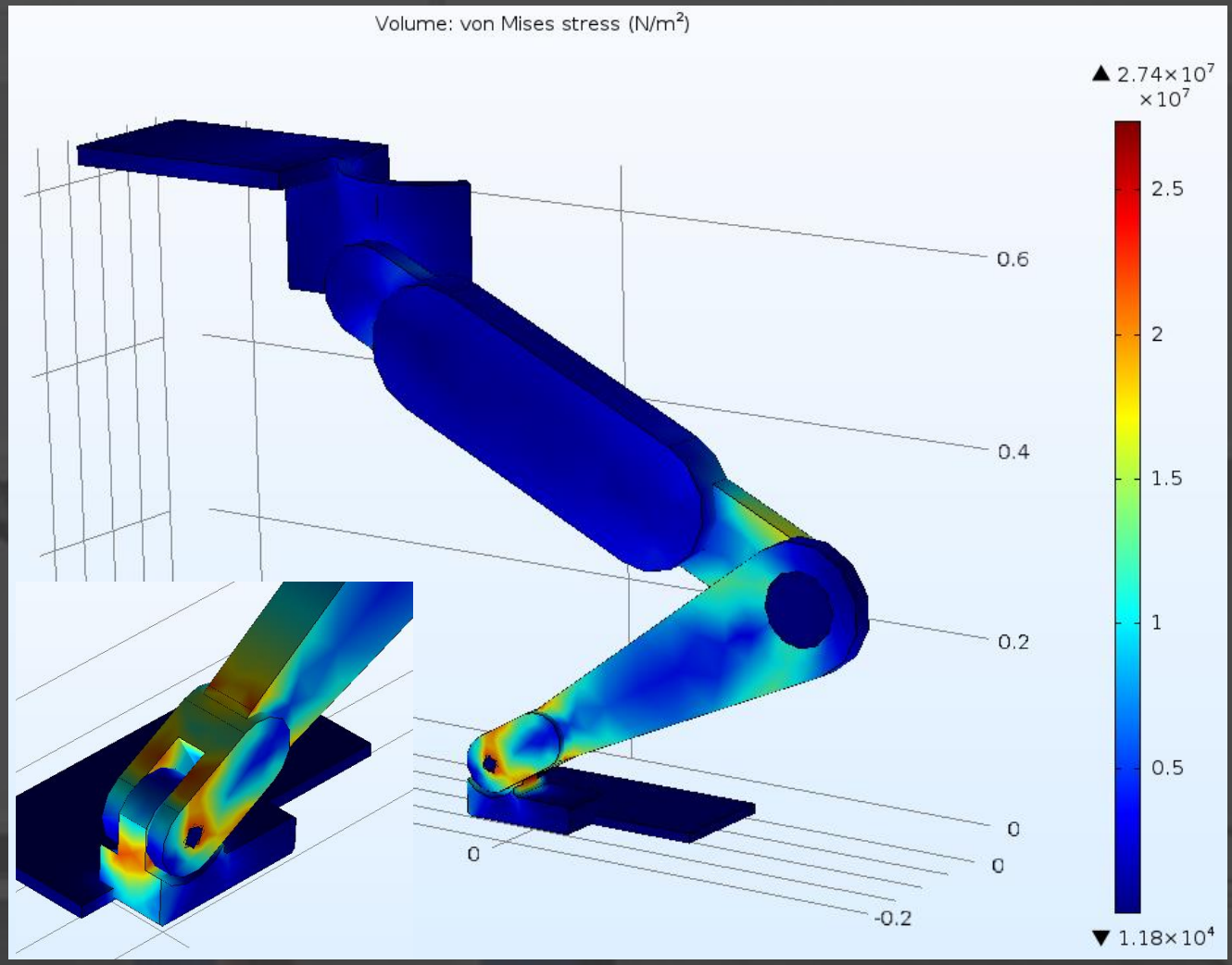
HINGE #3

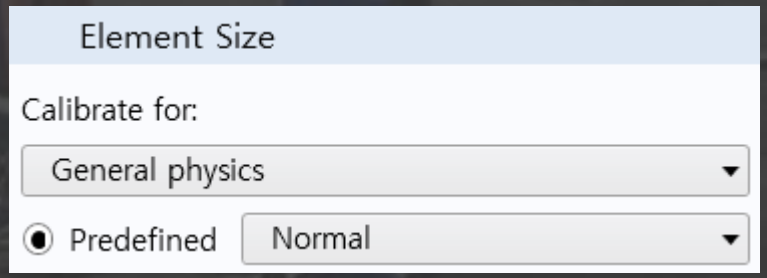

Surface: Total displacement (m)
×10⁻³
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.6
0.4
0.2
0
0
-0.2
-0.5
0

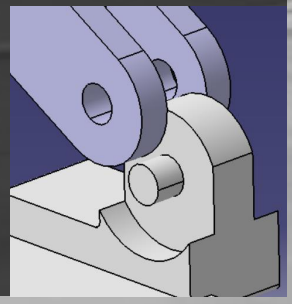


3

HINGE #3

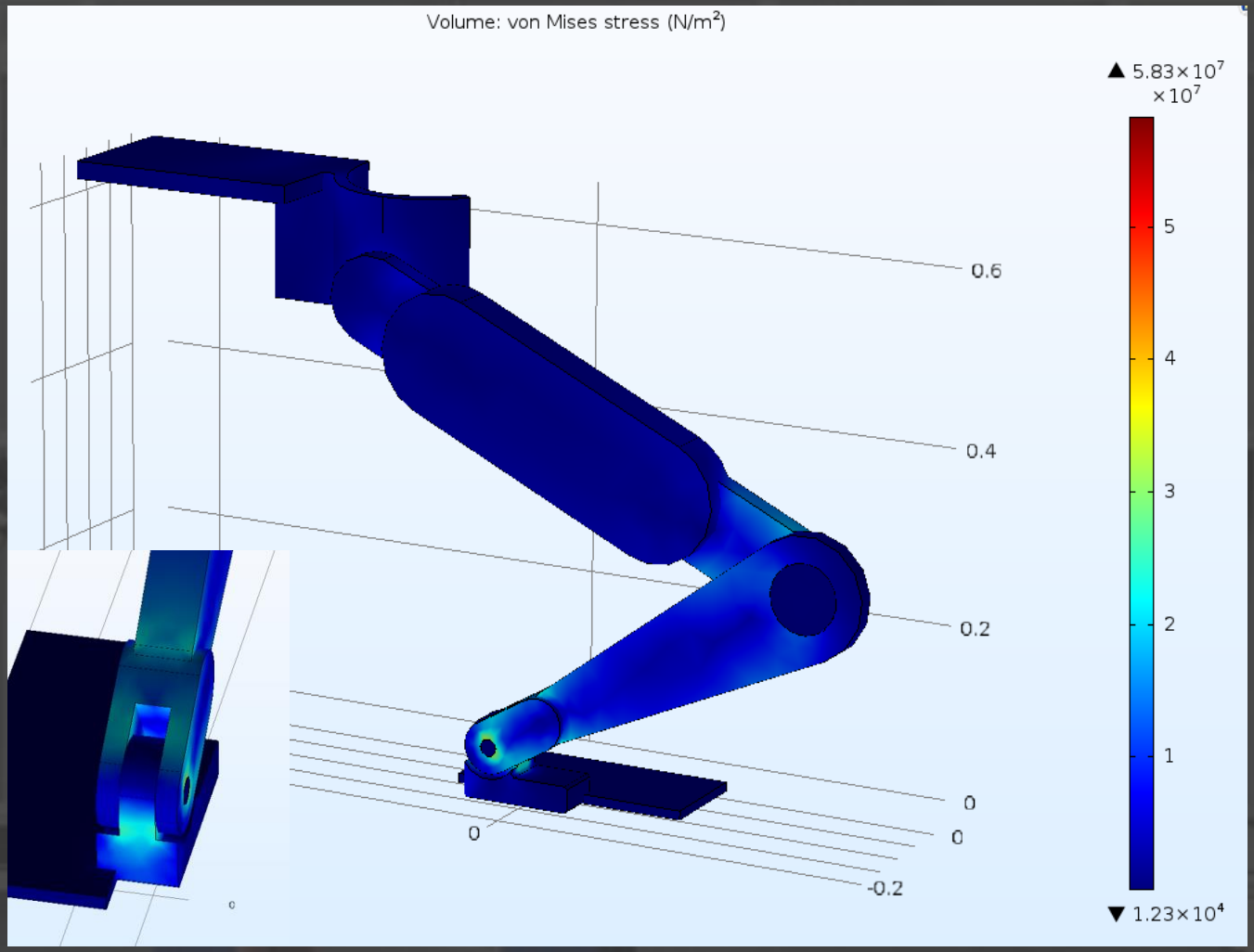

Volume: von Mises stress (N/m²)
▲ 2.74×10⁷
×10⁷
2.5
2
1.5
1
0.5
▼ 1.18×10⁴
0.6
0.4
0.2
0
0
-0.2
0


Element Size
Calibrate for:
General physics
Predefined
Normal



3

HINGE #3

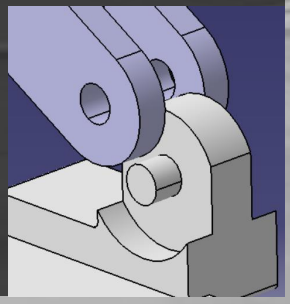


Element Size

Calibrate for:

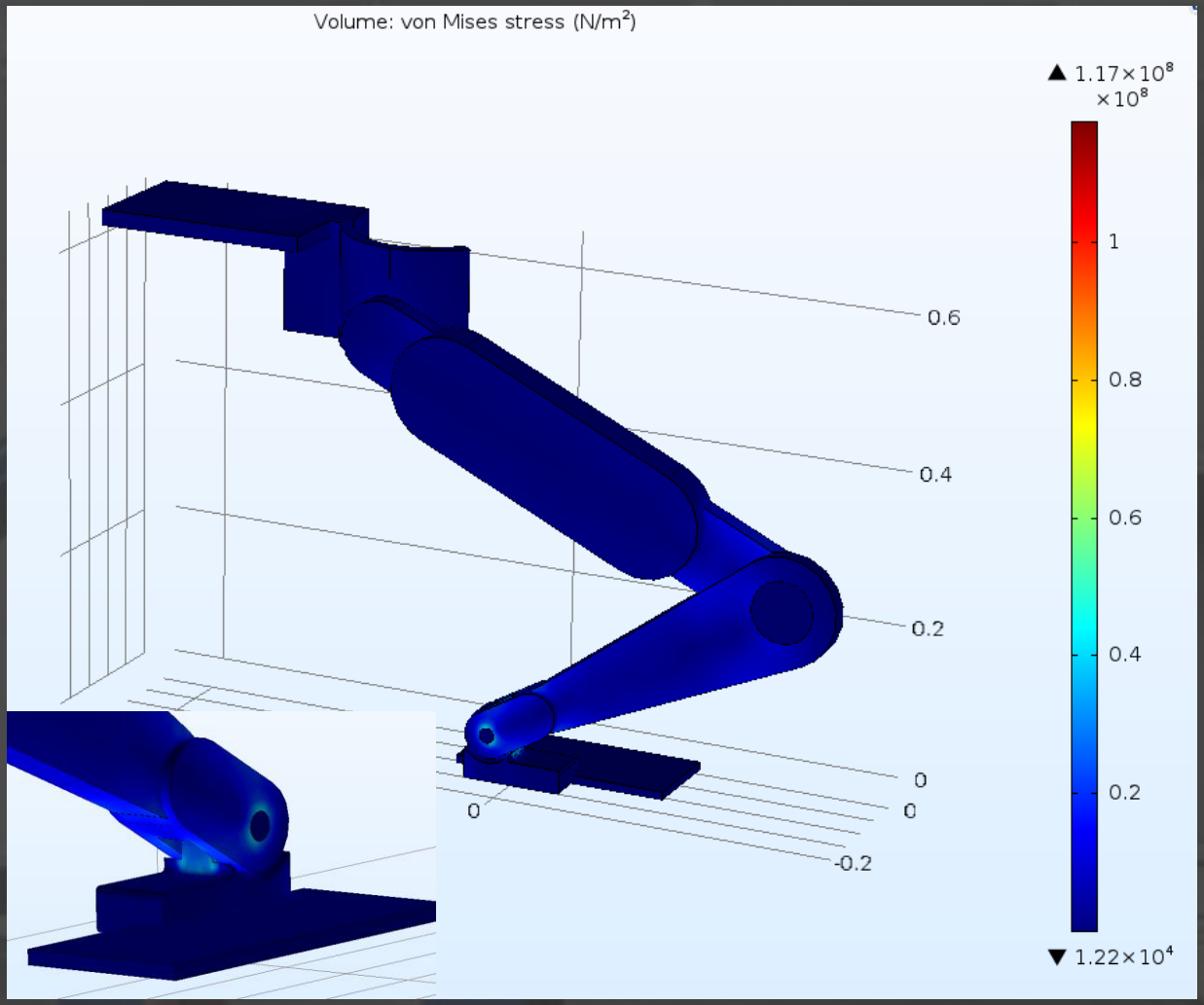
General physics

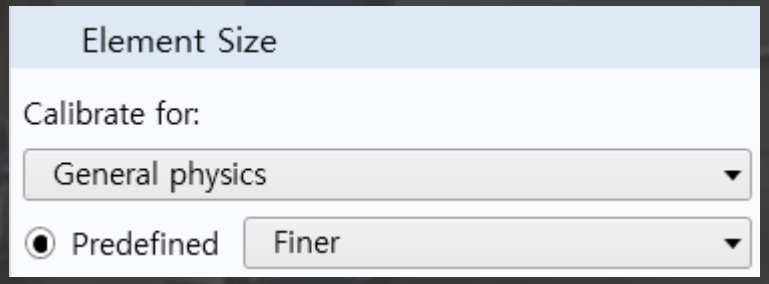
Predefined Fine

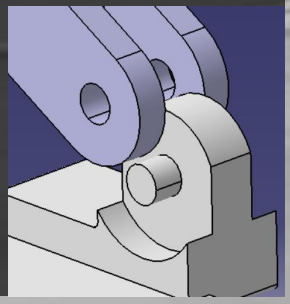


3

HINGE #3

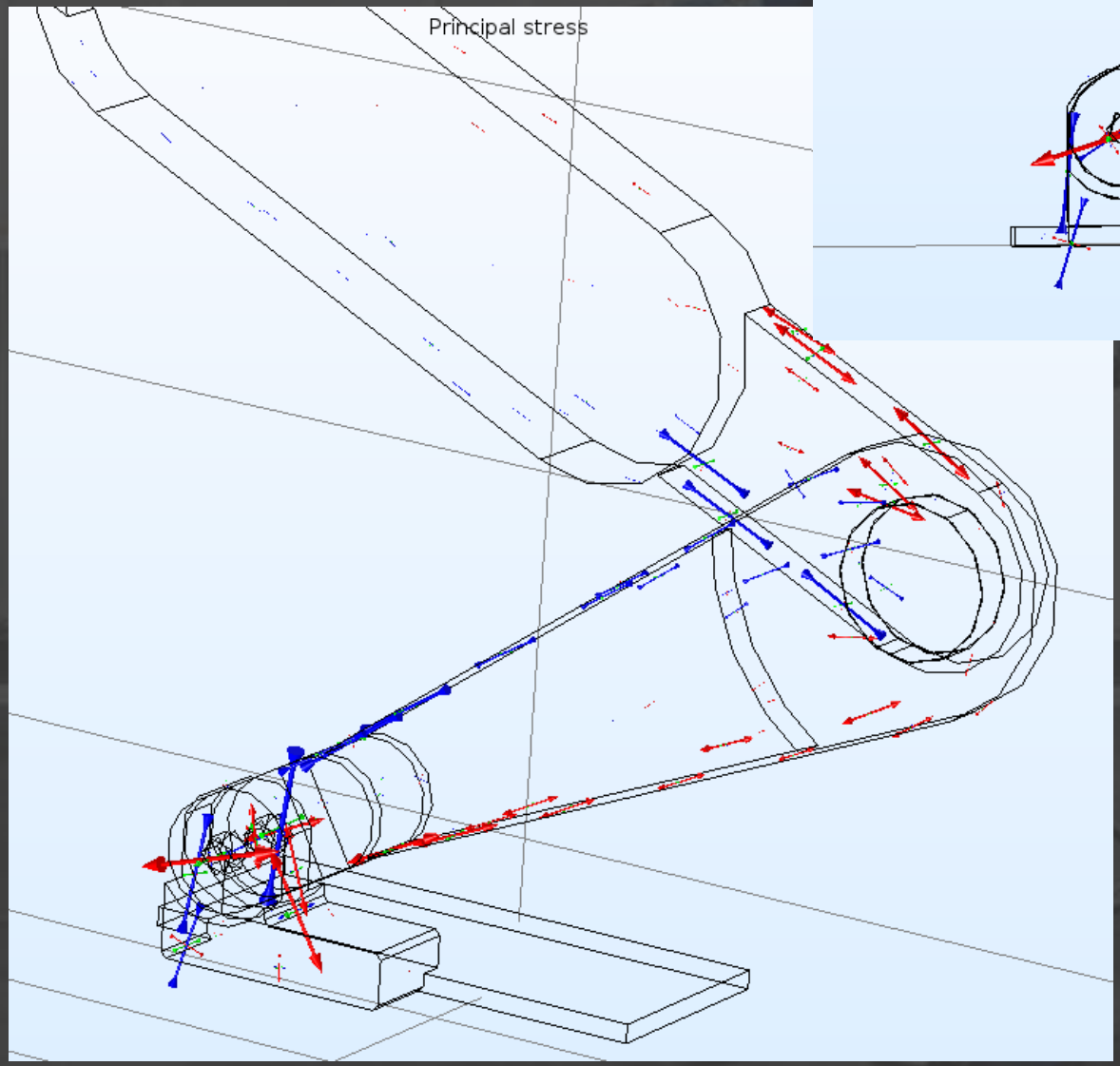

Volume: von Mises stress (N/m²)
▲ 1.17×10⁸
×10⁸
1
0.8
0.6
0.4
0.2
▼ 1.22×10⁴
0.6
0.4
0.2
0
0
-0.2

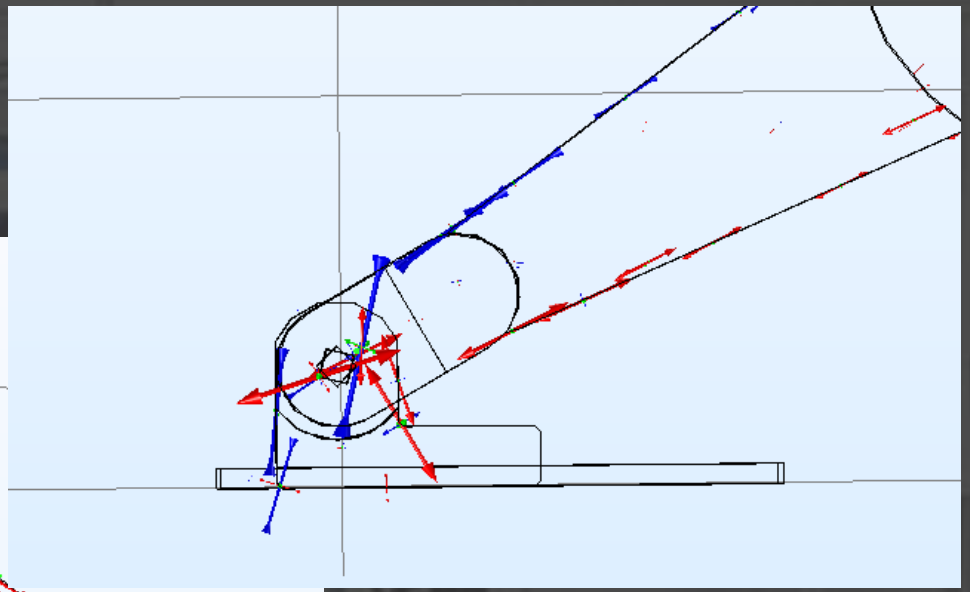

Element Size
Calibrate for:
General physics
Predefined
Finer

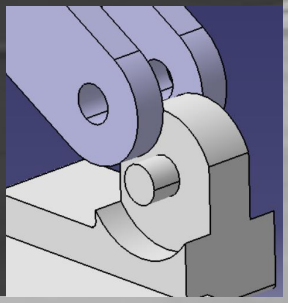


3

HINGE #3

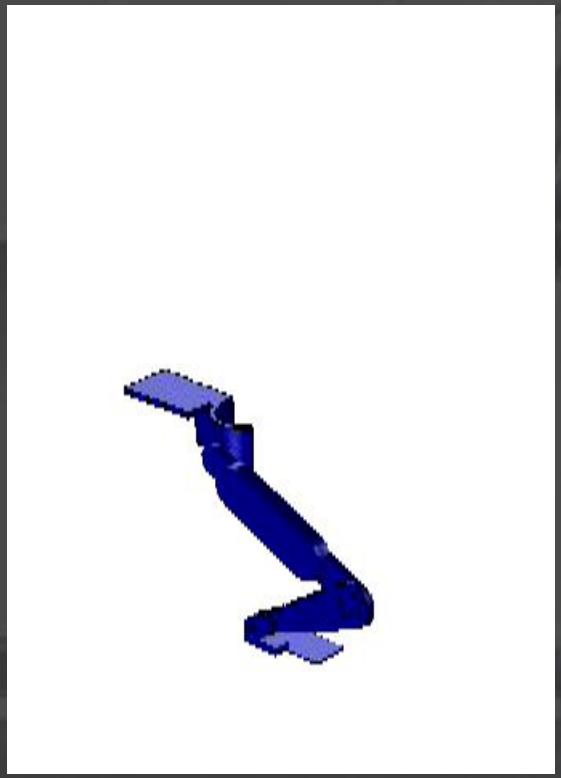






3

HINGE #3



Global Evaluation

Evaluate

Label: Global Evaluation 1

Data

Data set: Study 2/Solution 2 (sol2)

Time selection: All

Expression

Expression:

mbd.hgj1.Mx

Unit:

N*m

Description:

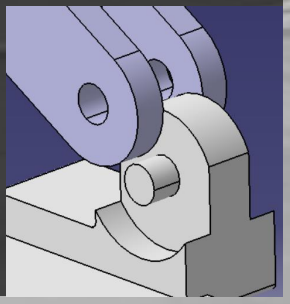
Joint moment, x component

Parameters

Name	Value	Unit	Description
mbd.refpntx	0		Reference point f...
mbd.refpnty	0		Reference point f...
mbd.refpntz	0		Reference point f...

Time (s)	Joint moment, x component (N*m)
0.065000	14.458
0.066000	16.082
0.067000	17.986
0.068000	20.245
0.069000	22.963
0.070000	26.284
0.071000	30.406
0.072000	35.602
0.073000	42.246
0.074000	50.829
0.075000	61.928
0.076000	76.027
0.077000	92.992
0.078000	110.99
0.079000	125.32
0.080000	129.25
0.081000	119.08
0.082000	98.758
0.083000	76.829
0.084000	58.804
0.085000	45.347
0.086000	35.351
0.087000	27.952

Joint 1에서의 Moment 최대값 확인



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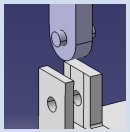
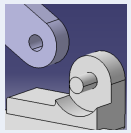
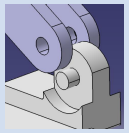
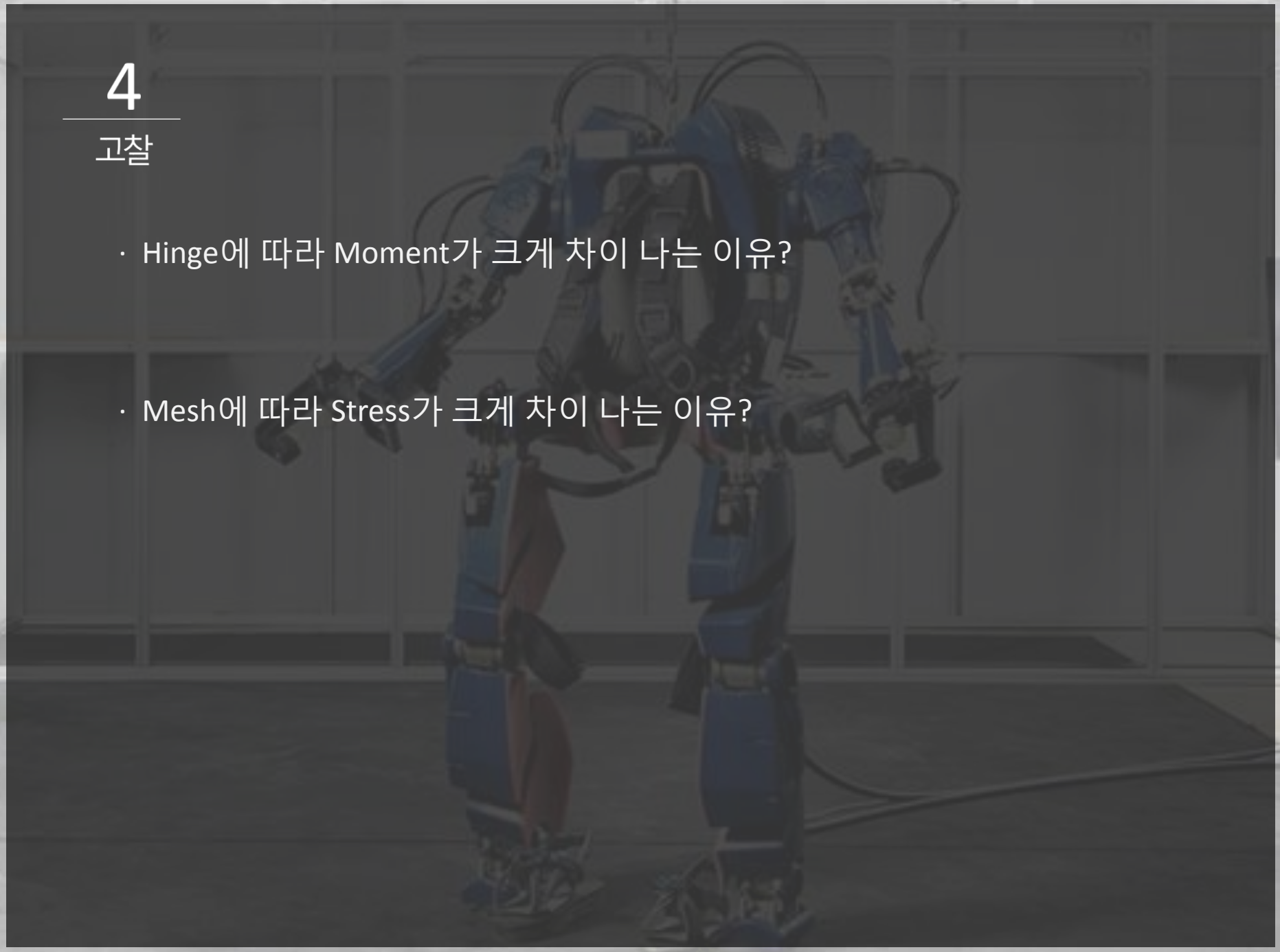
결론

Hinge No.	Joint에서의 Moment	Attachment Force (Z Component)
Hinge 1 	987.79 N·m	Attachment force, z component (N) -1745.5
Hinge 2 	245.57 N·m	Attachment force, z component (N) -1742.8
Hinge 3 	129.25 N·m	Attachment force, z component (N) -1749.0

Attachment에서의 –Z 방향 Force는 거의 차이가 없다.

Hinge 3가 가장 적합한 형상이다.



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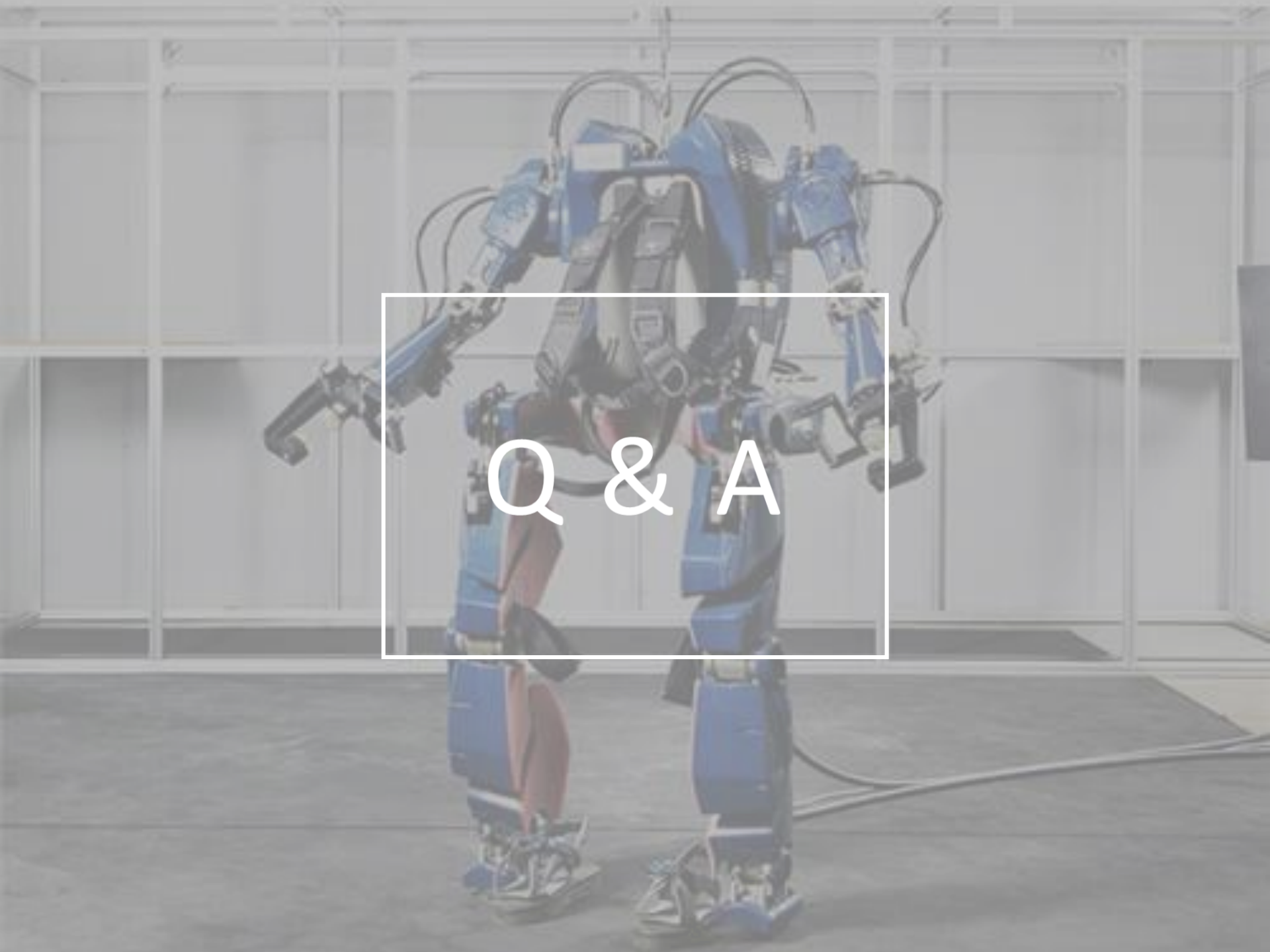
고찰

- Hinge에 따라 Moment가 크게 차이 나는 이유?

- Mesh에 따라 Stress가 크게 차이 나는 이유?


Q & A