Cinemática de Robots
Avance 1 Proyecto
Robot Antropomórfico

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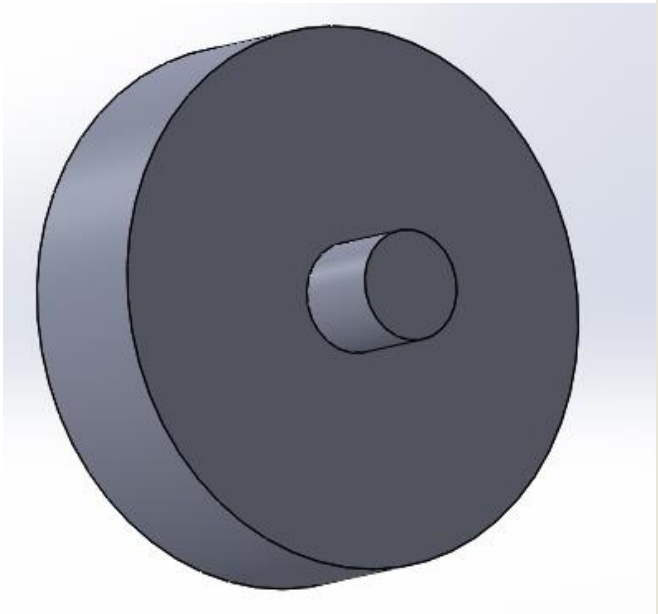
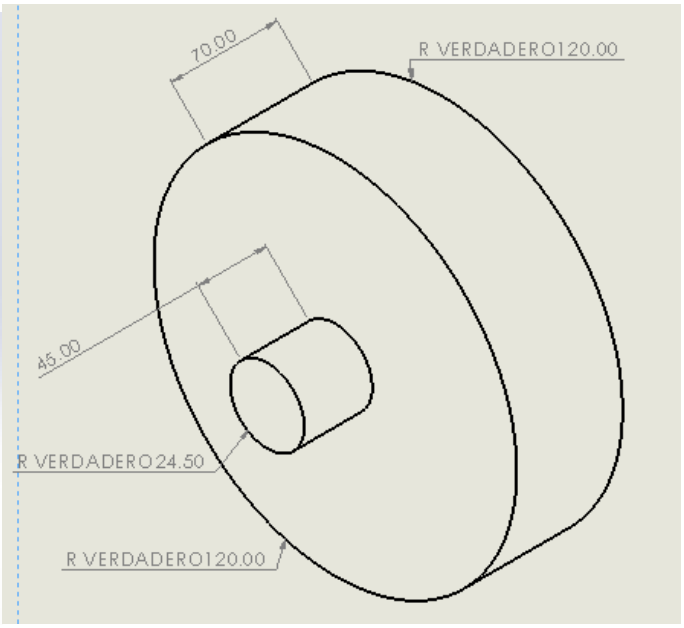
2019

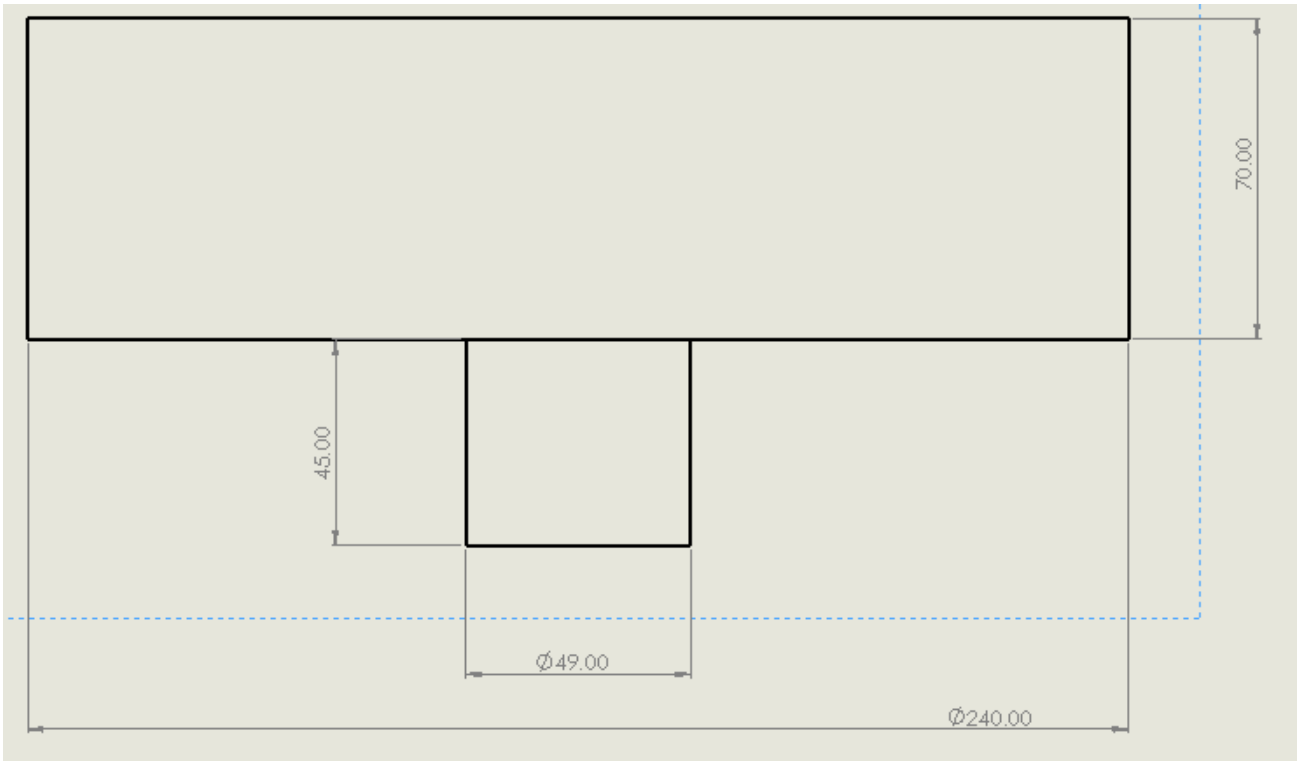
Diseño:

En el diseño del brazo robotico antropomorfico se utilizaron 3 grados de libertad y 3 eslabones, de los cuales una articulacion rotativa y otras dos articulaciones comunes.

El primer eslabon se encuentra seccionado para poder lograr el movimiento rotativo del primer eslabon, el eslabon fijo se diseño de la siguiente forma:

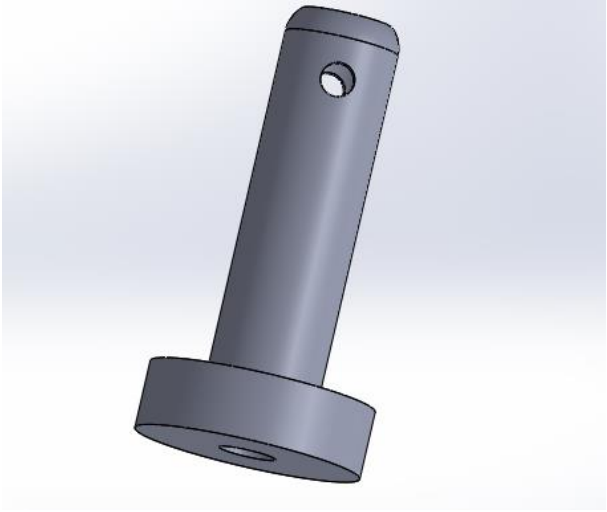


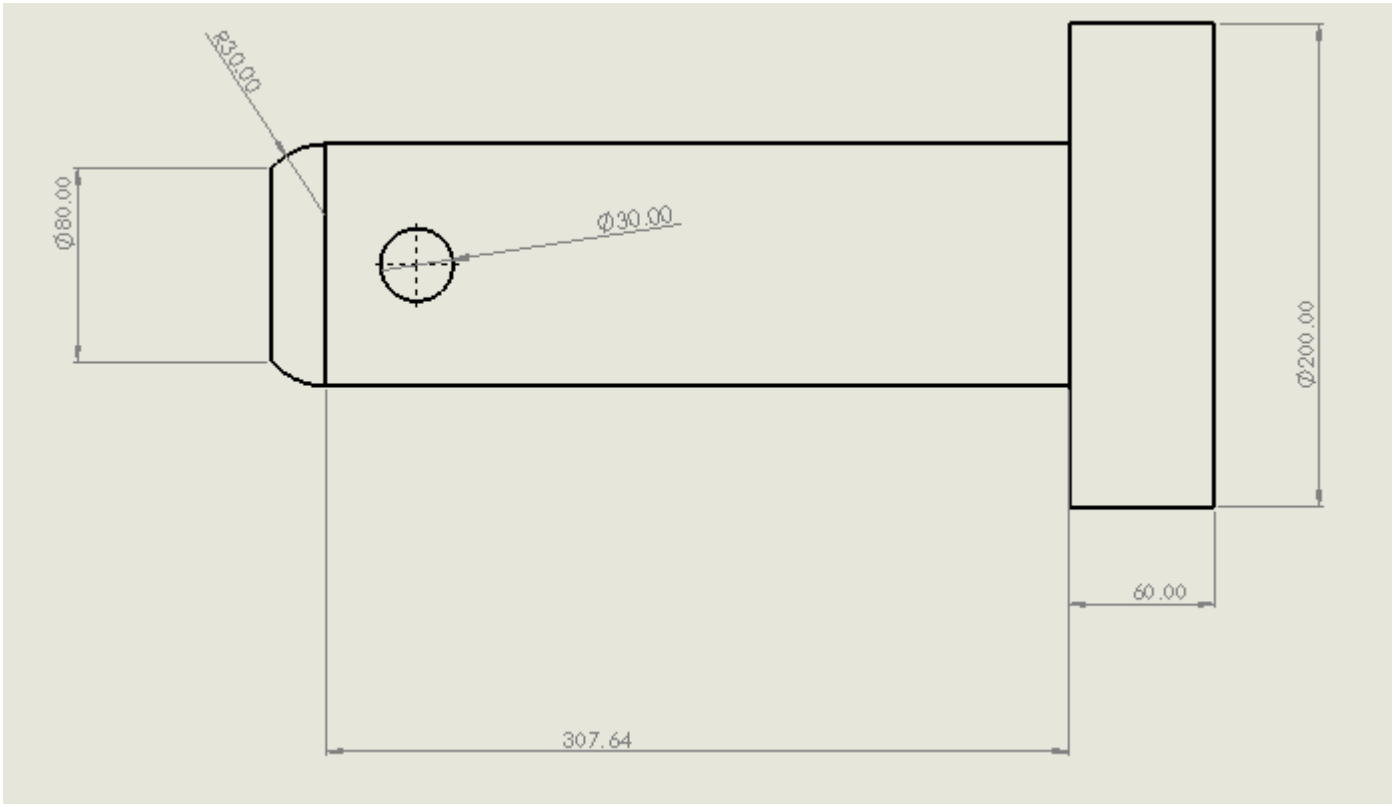


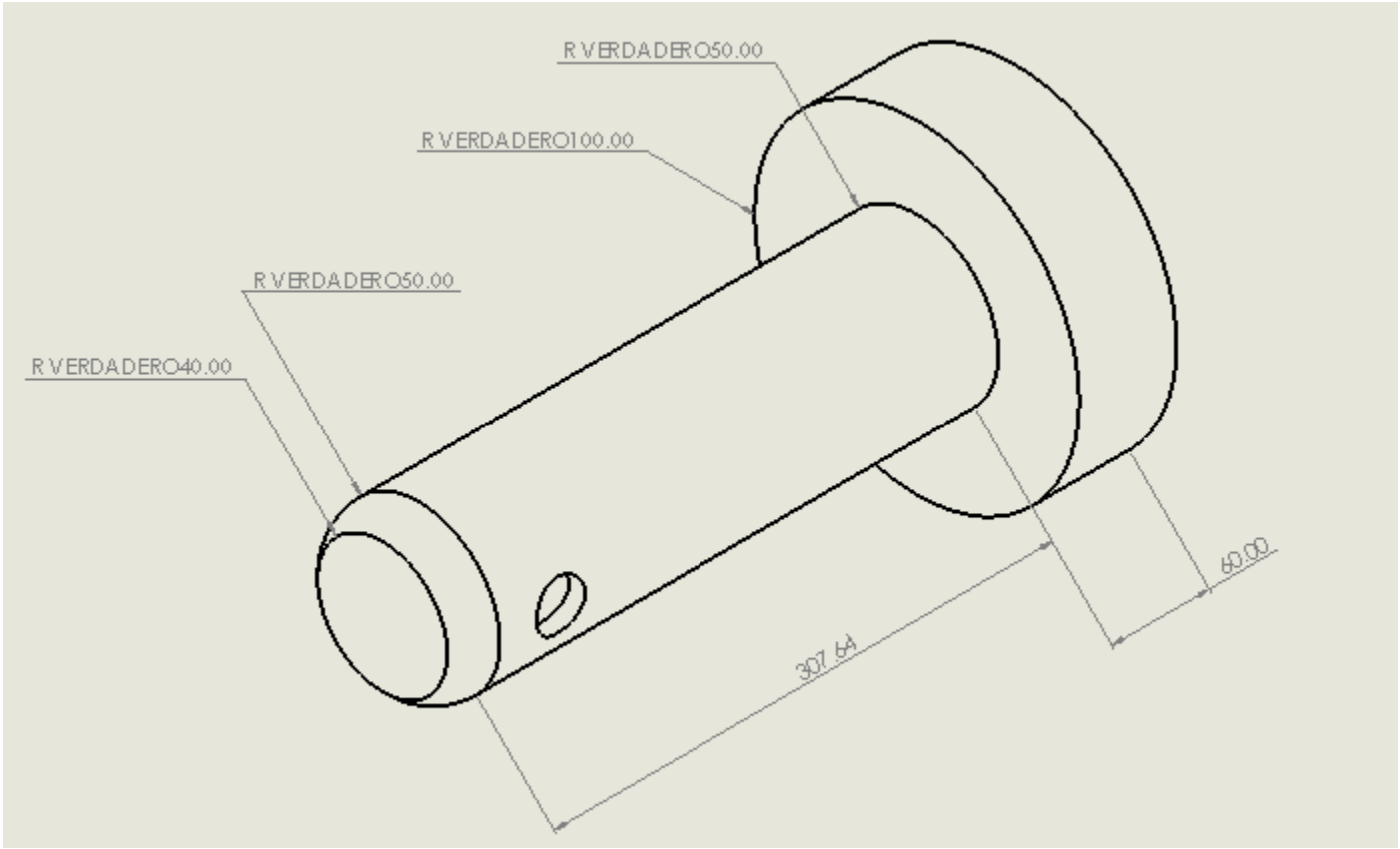


Este eslabon fijo junto al primer eslabon seran los que contengan la articulacion para el movimiento giratorio del brazo robotico.

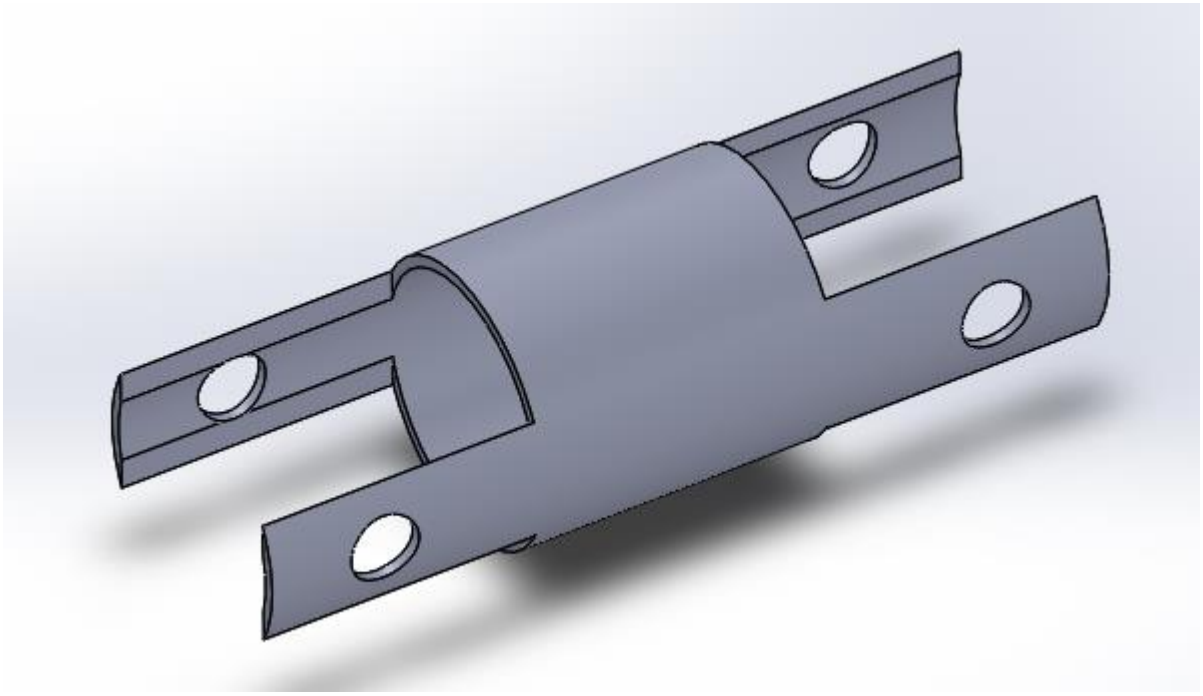
El suiguiente es el eslabon 1 el cual tiene como requisito una altura minima de 33 cm y como se puede observar en el diseño el requisito es cumplido.

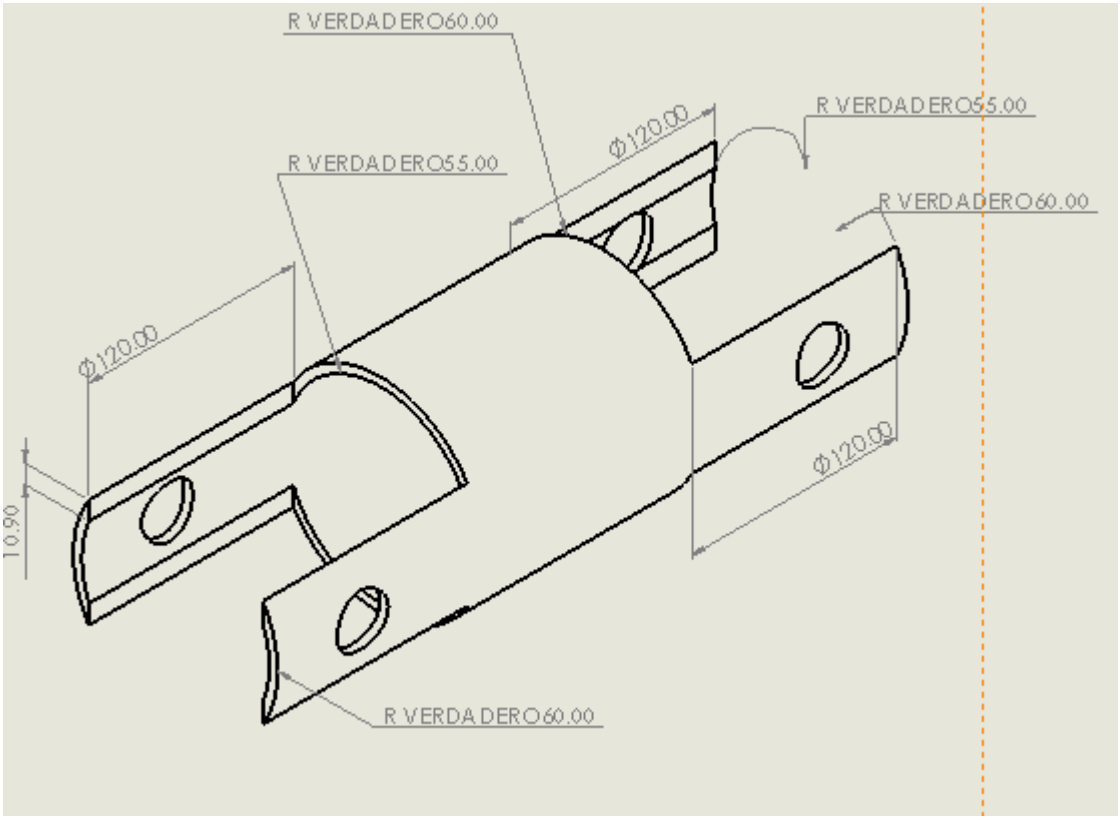


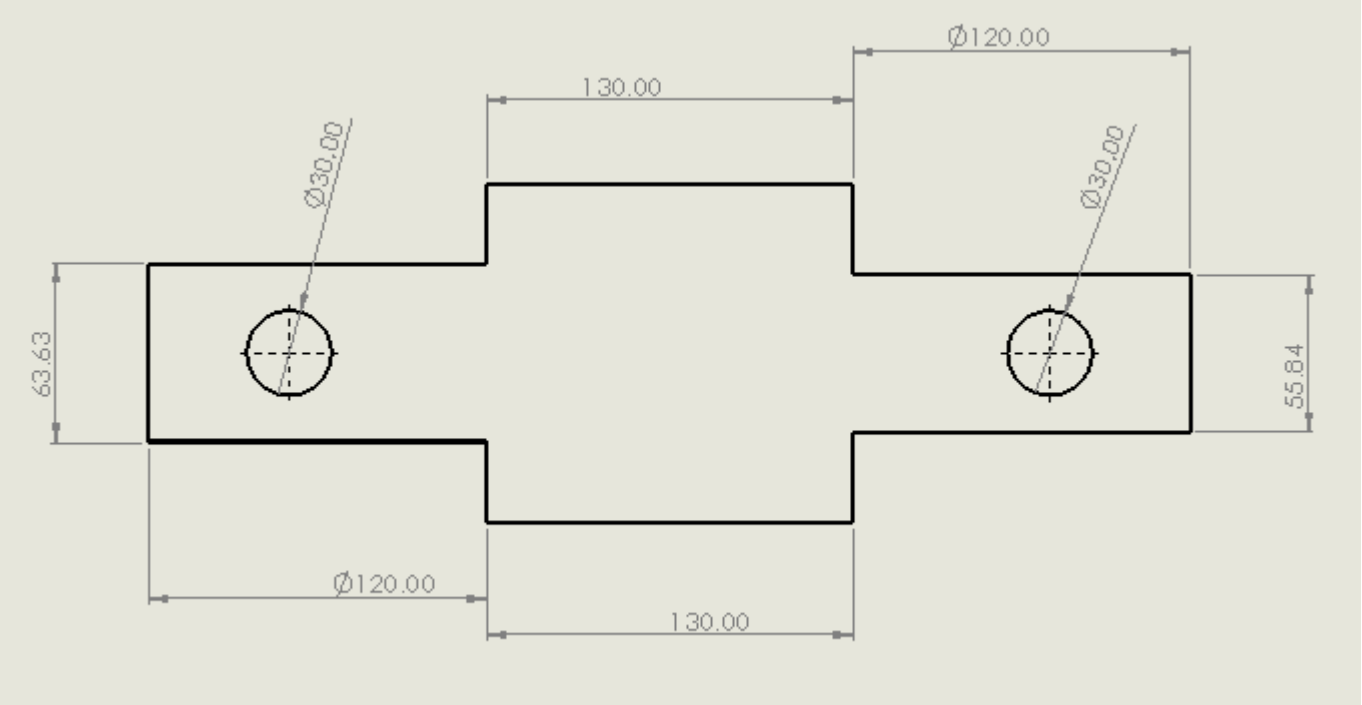

R30.00
Ø80.00
Ø30.00
Ø200.00
60.00
307.64


R VERDADERO50.00
R VERDADERO100.00
R VERDADERO50.00
R VERDADERO40.00
60.00
307.64

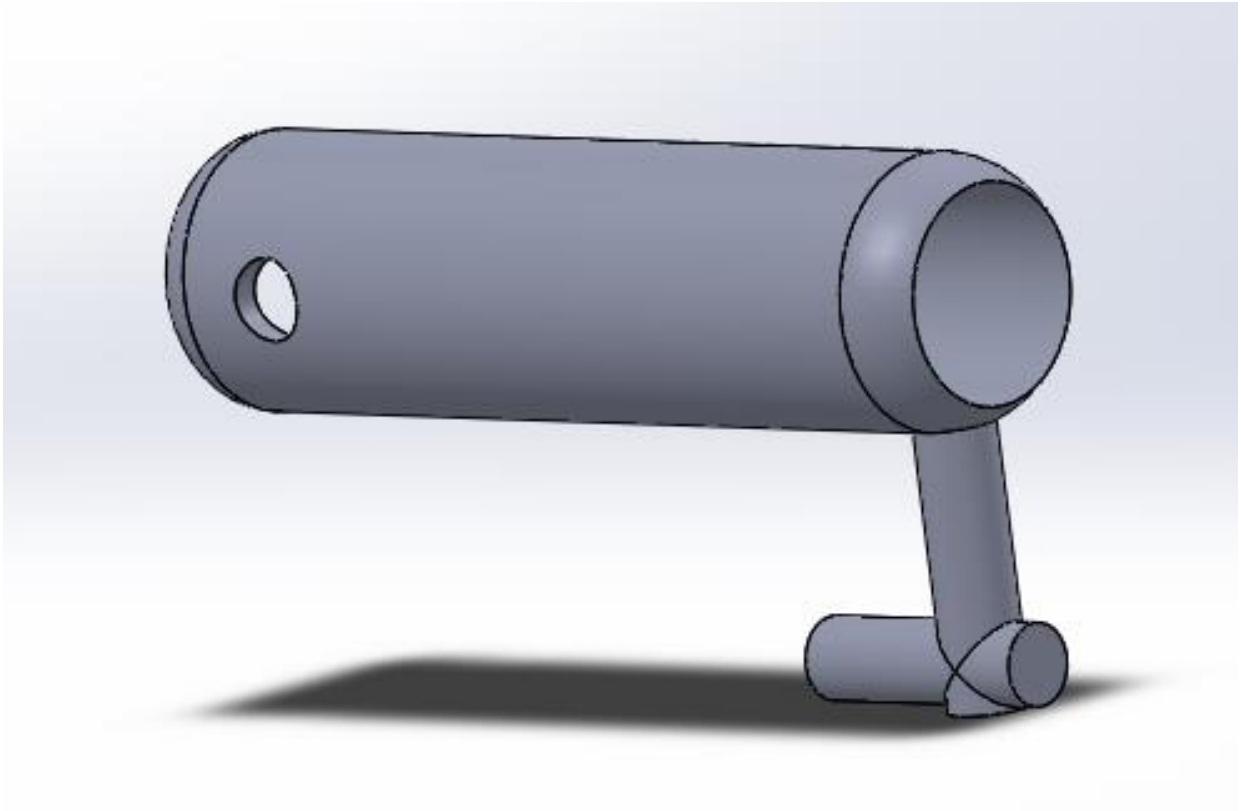
En el eslabón 2 se procuró elaborar una pieza donde la mayor parte del material se concentre en el centro, para que esta pieza sea resistente ya que es lugar en el eslabón 2 donde se encuentran esfuerzos considerables.

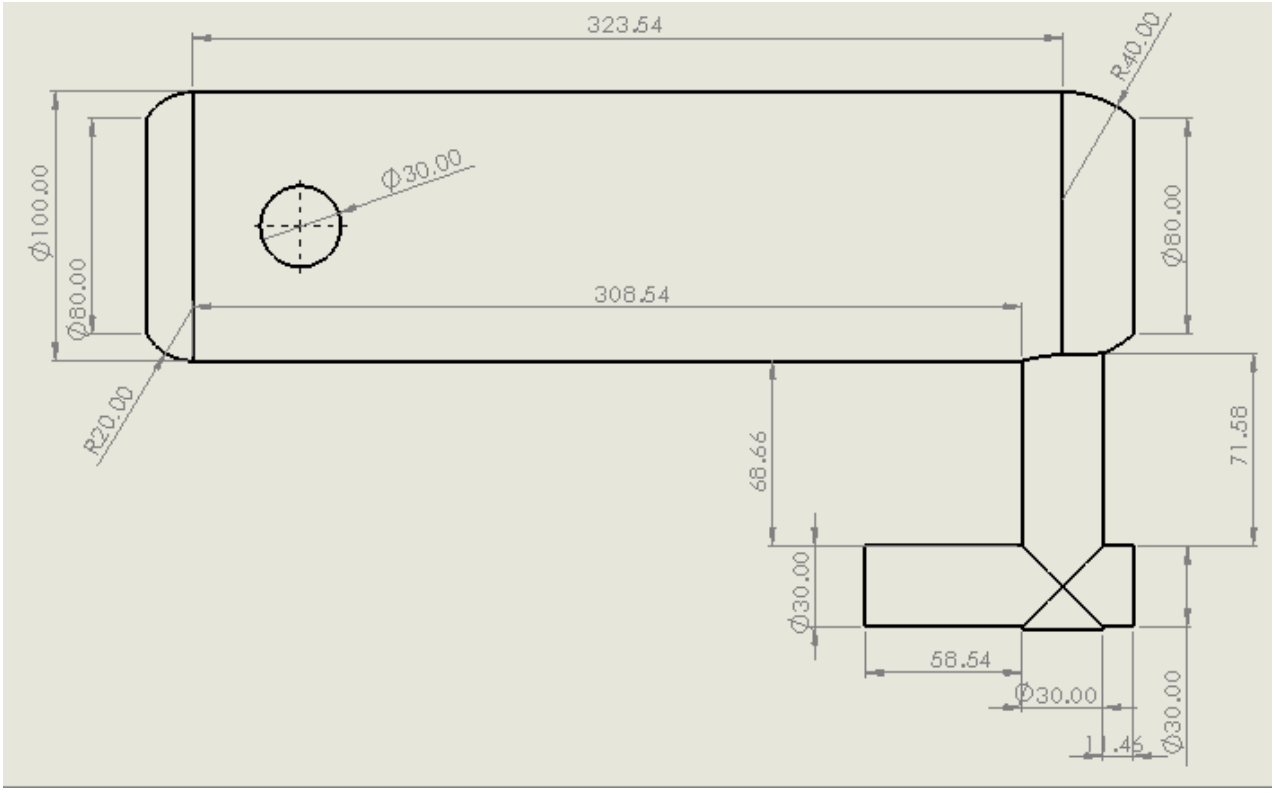




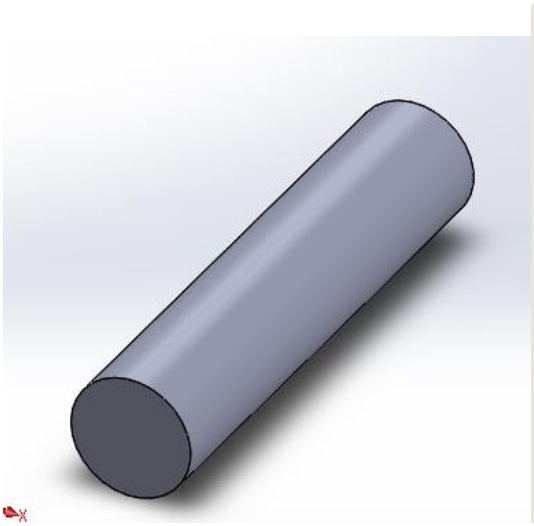

Ø120.00
130.00
Ø30.00
Ø30.00
63.63
55.84
Ø120.00
130.00

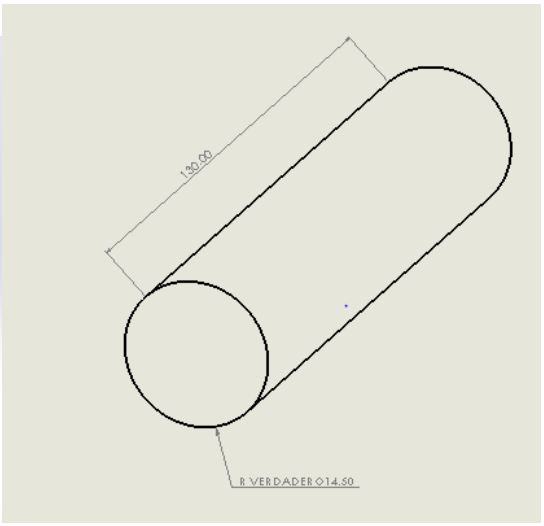
En el eslabón tres se optó por un pequeño gancho donde se colocará el peso de los 250gr.





Para la unión de las piezas se utilizarán ejes de 2.5 cm de diámetro.





Simulación en Ansys:

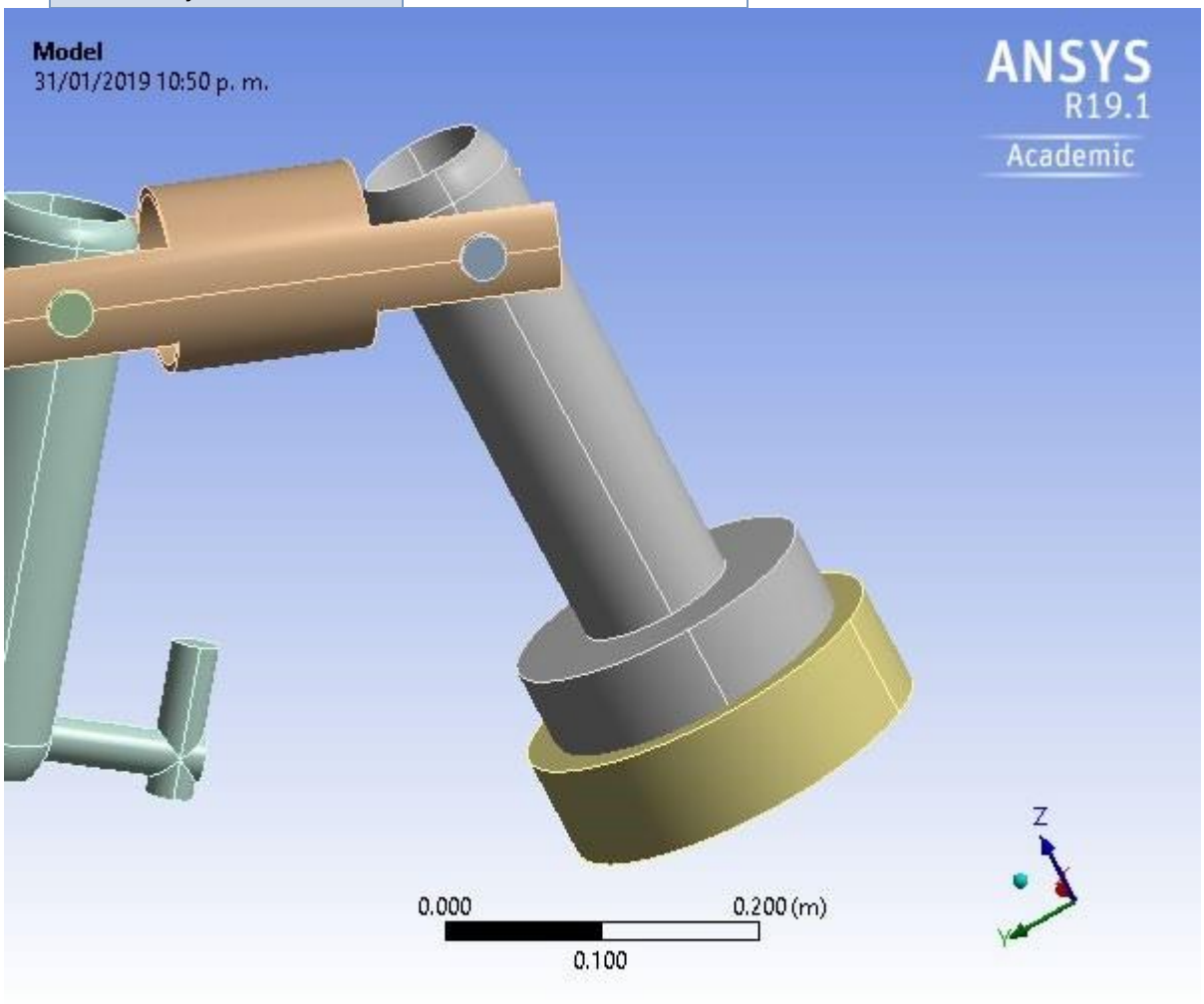
En el Software de Ansys los resultados que se obtuvieron al realizar un análisis estructural arrojaron que el eslabón 3 estará sometido a grandes esfuerzos comparado con los otros eslabones, por lo cual se tendrá especial atención tanto al motor de la articulación entre el eslabón 2-3 así como al espesor y material del ultimo eslabón.

Lo positivo que se encuentra en el análisis en Ansys es que ninguno de los eslabones sufre un esfuerzo tan grande como para deformar o generar un fallo en alguno de los eslabones del robot.

Project

First Saved	Thursday, January 31, 2019
Last Saved	Thursday, January 31, 2019
Product Version	19.1 Release
Save Project Before Solution	No

Save Project After Solution	No



Contents

- **Material Data** ○ PVC Foam (60 kg m^-3)

Units

TABLE 1

Unit System	Metric (m, kg, N, s, V, A) Degrees rad/s Celsius
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Celsius

Model (A4)

Geometry

TABLE 2
Model (A4) > Geometry

Object Name	*Geometry*
State	Fully Defined
Definition	
Source	C:\Users\ricar\Downloads\Ensamblaje1.SAT
Type	ACIS
Length Unit	Millimeters
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	
Length X	0.24 m
Length Y	0.5915 m
Length Z	0.56722 m
Properties	
Volume	7.5148e-003 m³
Mass	0.45089 kg
Scale Factor Value	1.
Statistics	
Bodies	6
Active Bodies	6
Nodes	7449
Elements	3269
Mesh Metric	None
Update Options	
Assign Default Material	No

Basic Geometry Options	
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	No
Parameters	Independent
Parameter Key	ANS;DS
Attributes	No
Named Selections	No
Material Properties	No
Advanced Geometry Options	
Use Associativity	Yes
Coordinate Systems	No
Reader Mode Saves Updated File	No
Use Instances	Yes
Smart CAD Update	Yes
Compare Parts On Update	No
Analysis Type	3-D
Mixed Import Resolution	None
Decompose Disjoint Geometry	Yes
Enclosure and Symmetry Processing	Yes

TABLE 3 Model (A4) > Geometry > Parts

Object Name	*Part 1*	*Part 2*	*Part 3*	*Part 4*	*Part 5*	*Part 6*
State	Meshed					
Graphics Properties						
Visible	Yes					
Transparency	1					
Definition						
Suppressed	No					
Stiffness Behavior	Flexible					
Coordinate System	Default Coordinate Syste ɳ					
Reference Temperature	By Environment					
Behavior	None					

Material					
Assignment	PVC Foam (60 kg m^-3)				
Nonlinear Effects	Yes				
Thermal Strain Effects	Yes				
Bounding Box					
Length X	0.2 m	0.13 m	0.12 m	0.1 m	0.24 m
Length Y	0.2 m	2.9e-002 m	0.36507 m	0.28982 m	0.24 m
Length Z	0.39 m	2.9e-002 m	0.19537 m	0.40608 m	0.115 m
Properties					
Volume	2.6678e-003 m³	8.489e-005 m³	3.3863e-004 m³	1.0997e-003 m³	3.2388e-003 m³
Mass	0.16007 kg	5.0934e-003 kg	2.0318e-002 kg	6.5985e-002 kg	0.19433 kg
Centroid X	-2.1442e002 m	-2.0376e002 m	-2.0411e002 m	-2.2199e002 m	-2.1205e002 m	-2.1442e002 m
Centroid Y	-1.9941e-002 m	0.22996 m	0.10903 m	0.30709 m	-1.9941e002 m
Centroid Z	0.28845 m	0.525 m	0.62722 m	0.57776 m	0.5068 m	0.16649 m
Moment of Inertia Ip1	2.1001e-003 kg·m²	5.2936e-007 kg·m²	1.4711e-004 kg·m²	8.9273e-004 kg·m²	7.7403e-004 kg·m²
Moment of Inertia Ip2	2.0985e-003 kg·m²	7.4379e-006 kg·m²	6.7182e-005 kg·m²	8.1876e-004 kg·m²	7.7403e-004 kg·m²
Moment of Inertia Ip3	6.6596e-004 kg·m²	7.4379e-006 kg·m²	1.6504e-004 kg·m²	1.9244e-004 kg·m²	1.3593e-003 kg·m²
Statistics					
Nodes	1588	305	2551	1984	716
Elements	775	48	1096	963	339
Mesh Metric	None				

Coordinate Systems

TABLE 4

Model (A4) > Coordinate Systems > Coordinate System

Object Name	*Global Coordinate System*
State	Fully Defined
Definition	
Type	Cartesian
Coordinate System ID	0.
Origin	
Origin X	0. m
Origin Y	0. m

Origin Z	0. m
Directional Vectors	
X Axis Data	[1. 0. 0.]
Y Axis Data	[0. 1. 0.]
Z Axis Data	[0. 0. 1.]

Connections

TABLE 5 Model (A4) > Connections

Object Name	*Connections*
State	Fully Defined
Auto Detection	
Generate Automatic Connection On Refresh	Yes
Transparency	
Enabled	Yes

TABLE 6

Model (A4) > Connections > Contacts

Object Name	*Contacts*
State	Fully Defined
Definition	
Connection Type	Contact
Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Auto Detection	
Tolerance Type	Slider
Tolerance Slider	0.
Tolerance Value	2.1348e-003 m
Use Range	No
Face/Face	Yes
Face Overlap Tolerance	Off
Cylindrical Faces	Include
Face/Edge	No
Edge/Edge	No
Priority	Include All
Group By	Bodies
Search Across	Bodies
Statistics	
Connections	6
Active Connections	6

TABLE 7

Model (A4) > Connections > Contacts > Contact Regions

Object Name	*Contact Region*	*Contact Region 2*	*Contact Region 3*	*Contact Region 4*	*Contact Region 5*	*Contact Region 6*
State	Fully Defined					
Scope						
Scoping Method	Geometry Selection					
Contact	4 Faces	3 Faces	2 Faces			4 Faces
Target	2 Faces	3 Faces	4 Faces			2 Faces
Contact Bodies	Part 1		Part 2	Part 3		Part 4
Target Bodies	Part 2	Part 6	Part 4		Part 5	
Protected	No					
Definition						
Type	Bonded					
Scope Mode	Automatic					
Behavior	Program Controlled					
Trim Contact	Program Controlled					
Trim Tolerance	2.1348e-003 m					
Suppressed	No					
Advanced						
Formulation	Program Controlled					
Small Sliding	Program Controlled					
Detection Method	Program Controlled					
Penetration Tolerance	Program Controlled					
Elastic Slip Tolerance	Program Controlled					
Normal Stiffness	Program Controlled					
Update Stiffness	Program Controlled					
Pinball Region	Program Controlled					
Geometric Modification						
Contact Geometry Correction	None					
Target Geometry Correction	None					

Mesh

TABLE 8
Model (A4) > Mesh

Object Name	*Mesh*
State	Solved
Display	
Display Style	Body Color
Defaults	
Physics Preference	Mechanical
Element Order	Program Controlled
Element Size	Default
Sizing	
Use Adaptive Sizing	Yes
Resolution	Default (2)
Mesh Defeaturing	Yes
Defeature Size	Default
Transition	Fast
Span Angle Center	Coarse
Initial Size Seed	Assembly
Bounding Box Diagonal	0.85394 m
Average Surface Area	9.6923e-003 m²
Minimum Edge Length	1.3427e-003 m
Quality	
Check Mesh Quality	Yes, Errors
Error Limits	Standard Mechanical
Target Quality	Default (0.050000)
Smoothing	Medium
Mesh Metric	None
Inflation	
Use Automatic Inflation	None
Inflation Option	Smooth Transition
Transition Ratio	0.272
Maximum Layers	5
Growth Rate	1.2
Inflation Algorithm	Pre
View Advanced Options	No
Advanced	

Number of CPUs for Parallel Part Meshing	Program Controlled
Straight Sided Elements	No
Number of Retries	Default (4)
Rigid Body Behavior	Dimensionally Reduced
Triangle Surface Mesher	Program Controlled
Topology Checking	Yes
Pinch Tolerance	Please Define
Generate Pinch on Refresh	No
Statistics	
Nodes	7449
Elements	3269

Static Structural (A5)

TABLE 9 Model (A4) > Analysis

Object Name	*Static Structural (A5)*
State	Solved
Definition	
Physics Type	Structural
Analysis Type	Static Structural
Solver Target	Mechanical APDL
Options	
Environment Temperature	22. °C
Generate Input Only	No

TABLE 10
Model (A4) > Static Structural (A5) > Analysis Settings

Object Name	*Analysis Settings*
State	Fully Defined
Step Controls	
Number Of Steps	1.
Current Step Number	1.
Step End Time	1. s
Auto Time Stepping	Program Controlled
Solver Controls	
Solver Type	Program Controlled
Weak Springs	Off
Solver Pivot Checking	Program Controlled
Large Deflection	Off
Inertia Relief	Off
Rotordynamics Controls	

Coriolis Effect	Off
Restart Controls	
Generate Restart Points	Program Controlled
Retain Files After Full Solve	No
Combine Restart Files	Program Controlled
Nonlinear Controls	
Newton-Raphson Option	Program Controlled
Force Convergence	Program Controlled
Moment Convergence	Program Controlled
Displacement Convergence	Program Controlled
Rotation Convergence	Program Controlled
Line Search	Program Controlled
Stabilization	Off
Output Controls	
Stress	Yes
Strain	Yes
Nodal Forces	No
Contact Miscellaneous	No
General Miscellaneous	No
Store Results At	All Time Points
Analysis Data Management	
Solver Files Directory	C:\Users\ricar\Desktop\123_files\dp0\SYS-1\MECH\
Future Analysis	None
Scratch Solver Files Directory	
Save MAPDL db	No
Contact Summary	Program Controlled
Delete Unneeded Files	Yes
Nonlinear Solution	No
Solver Units	Active System
Solver Unit System	mks

TABLE 11
Model (A4) > Static Structural (A5) > Loads

Object Name	*Fixed Support*	*Force*	*Remote Force*
State	Fully Defined		
Scope			
Scoping Method	Geometry Selection		
Geometry	4 Faces	3 Faces	1 Face
Coordinate System			Global Coordinate System
X Coordinate			4.4624e-002 m
Y Coordinate			-1.9941e-002 m
Z Coordinate			0.525 m
Location			Defined
Definition			
Type	Fixed Support	Force	Remote Force

Suppressed	No		
Define By		Vector	
Magnitude		3. N (ramped)	11. N (ramped)
Direction		Defined	
Behavior			Deformable
Advanced			
Pinball Region			All

FIGURE 1
Model (A4) > Static Structural (A5) > Force

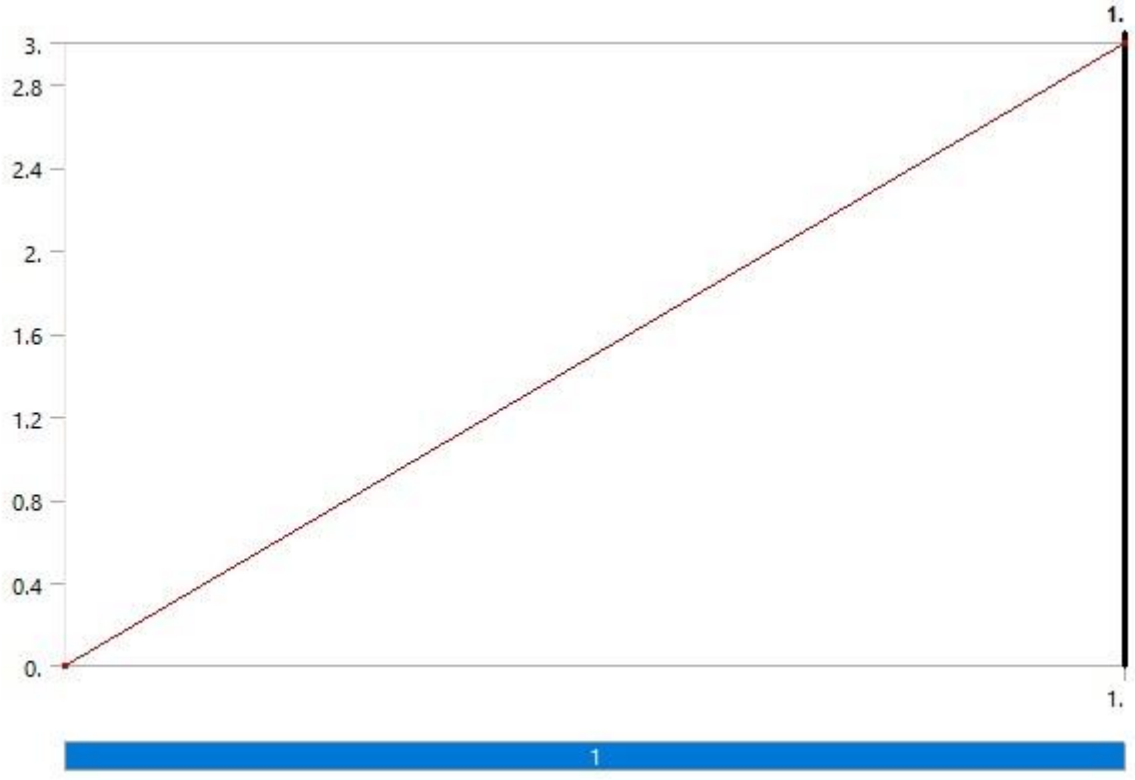
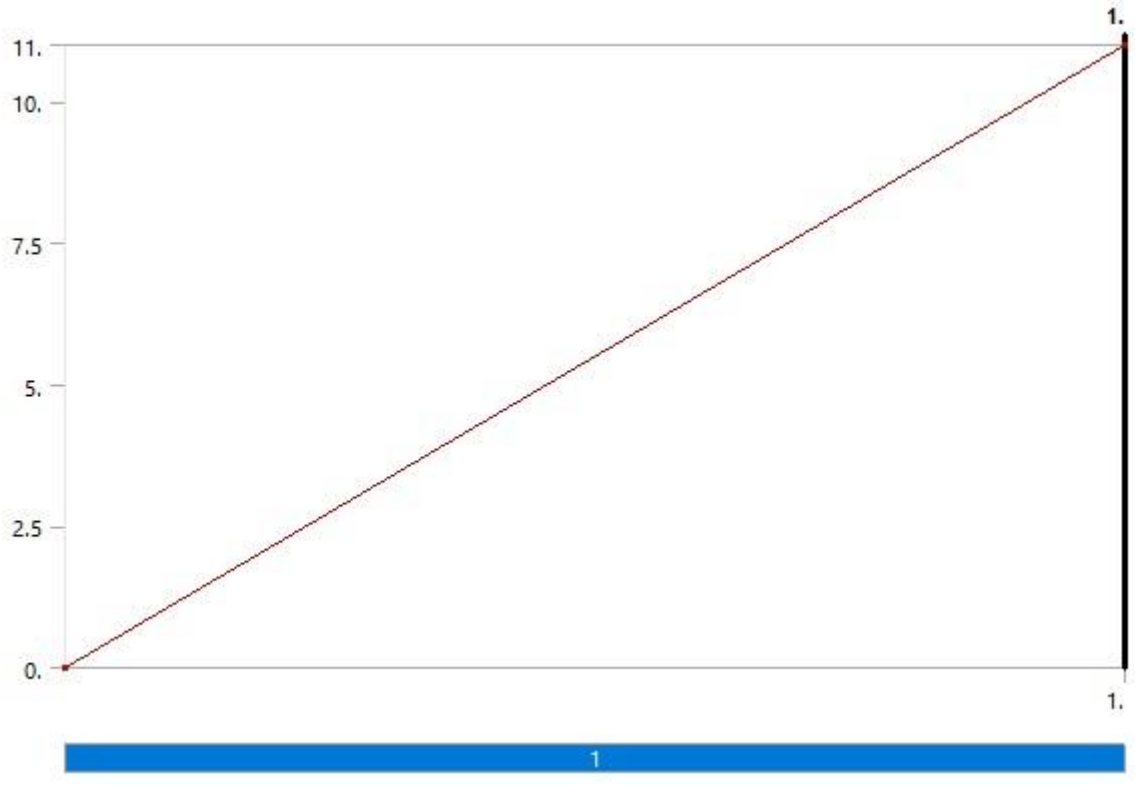


FIGURE 2
Model (A4) > Static Structural (A5) > Remote Force



Solution (A6)

TABLE 12 Model (A4) > Static Structural (A5) > Solution

Object Name	*Solution (A6)*
State	Solved
Adaptive Mesh Refinement	
Max Refinement Loops	1.
Refinement Depth	2.
Information	
Status	Done
MAPDL Elapsed Time	16. s
MAPDL Memory Used	281. MB
MAPDL Result File Size	3.5625 MB
Post Processing	
Beam Section Results	No
On Demand Stress/Strain	No

TABLE 13 Model (A4) > Static Structural (A5) > Solution (A6) > Solution Information

Object Name	*Solution Information*
State	Solved
Solution Information	

Solution Output	Solver Output
Newton-Raphson Residuals	0
Identify Element Violations	0
Update Interval	2.5 s
Display Points	All
FE Connection Visibility	
Activate Visibility	Yes
Display	All FE Connectors
Draw Connections Attached To	All Nodes
Line Color	Connection Type
Visible on Results	No
Line Thickness	Single
Display Type	Lines

TABLE 14 Model (A4) > Static Structural (A5) > Solution (A6) > Results

Object Name	*Total Deformation*
State	Solved
Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Results	
Minimum	0. m
Maximum	2.282e-003 m
Average	1.1903e-003 m
Minimum Occurs On	Part 6
Maximum Occurs On	Part 4
Information	
Time	1. s
Load Step	1
Substep	1
Iteration Number	1

FIGURE 3

Model (A4) > Static Structural (A5) > Solution (A6) > Total Deformation

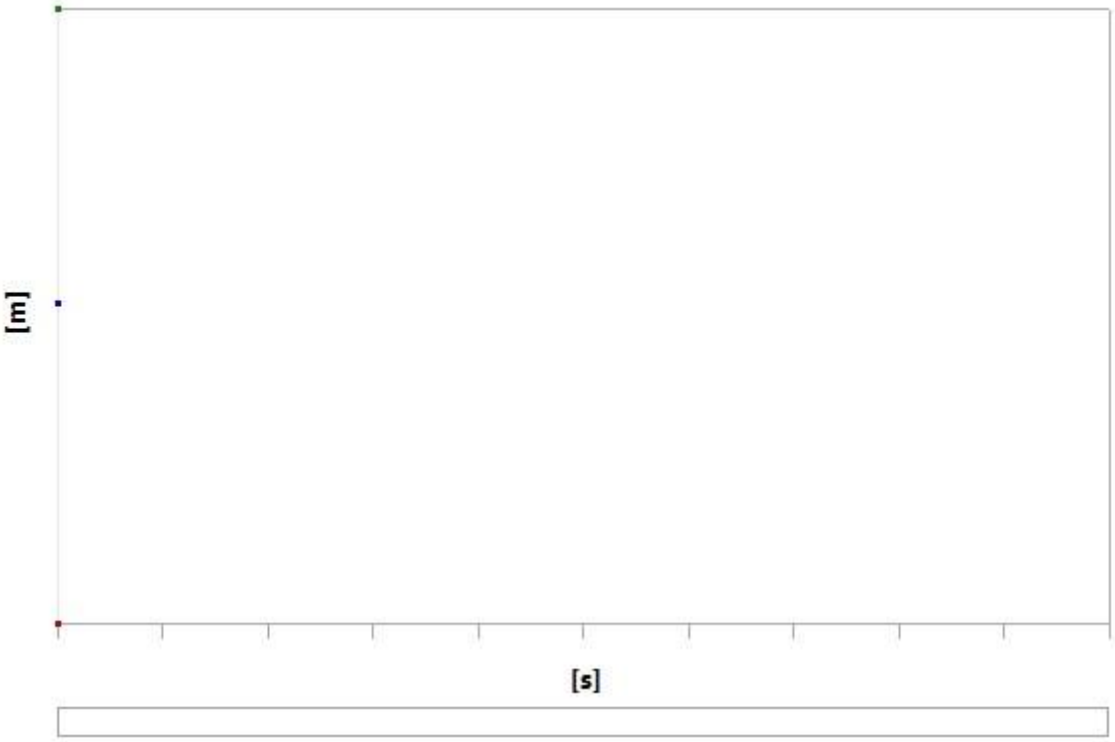


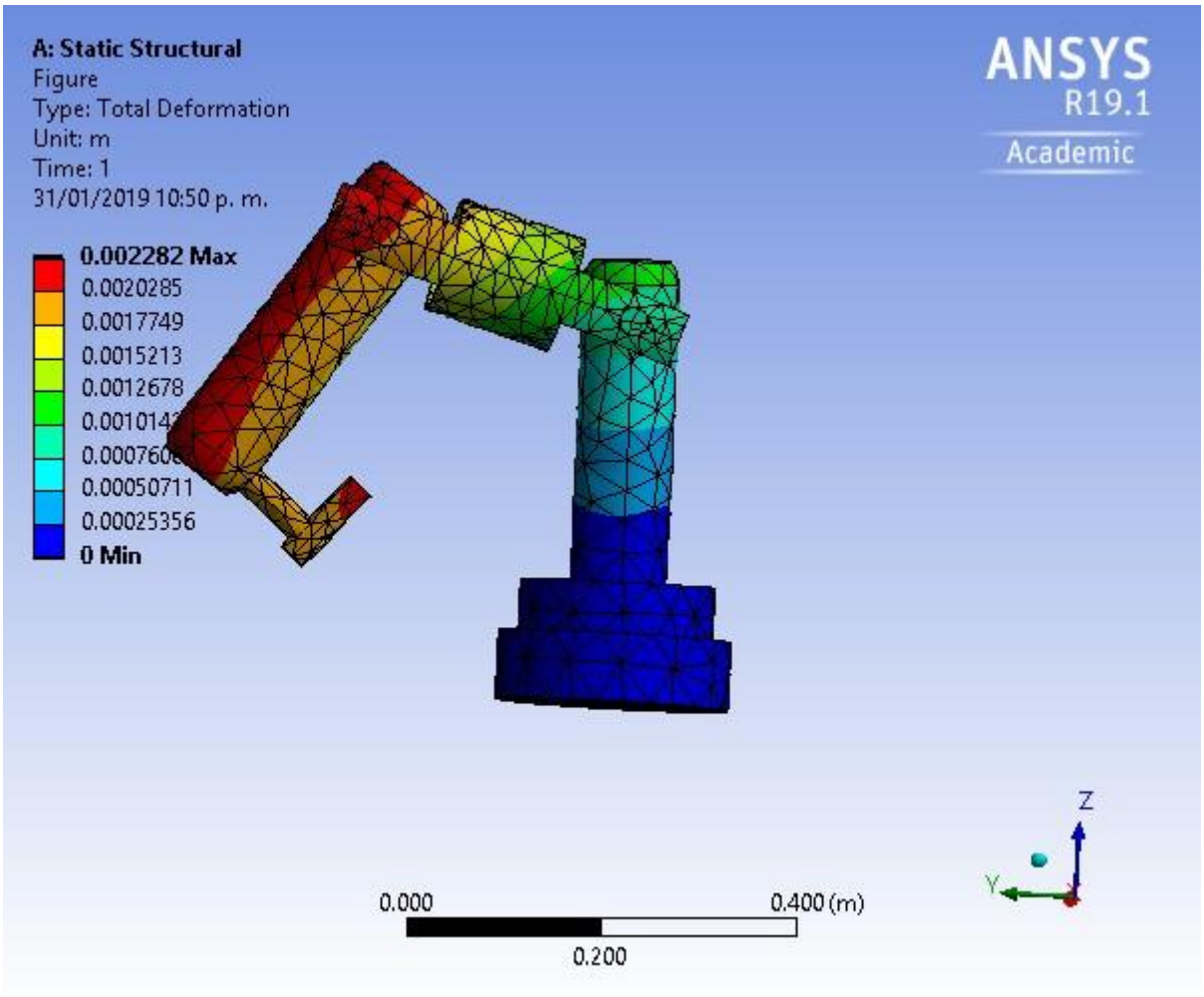
TABLE 15

Model (A4) > Static Structural (A5) > Solution (A6) > Total Deformation

Time [s]	Minimum [m]	Maximum [m]	Average [m]
1.	0.	2.282e-003	1.1903e-003

FIGURE 4

Model (A4) > Static Structural (A5) > Solution (A6) > Total Deformation > Figure



Material Data

PVC Foam (60 kg m^-3)

TABLE 16 PVC Foam (60 kg m^-3) > Density

Density kg m^-3
60

TABLE 17 PVC Foam (60 kg m^-3) > Isotropic Elasticity

Tensile X direction Pa	Tensile Y direction Pa	Tensile Z direction Pa	Compressive direction Pa	Compressive Y direction Pa	Compressive Z direction Pa	Shear XY Pa	Shear YZ Pa	Shear XZ Pa

Young's Modulus Pa	Poisson's Ratio	Bulk Modulus Pa	Shear Modulus Pa
7.e+007	0.3	5.8333e+007	2.6923e+007

TABLE 18 PVC Foam (60 kg m^-3) > Orthotropic Stress Limits

1.5e+006	1.5e+006	9.5e+005	-1.5e+006	-1.5e+006	-9.5e+005	9.3e+005	9.3e+005	9.3e+005

TABLE 19

PVC Foam (60 kg m^-3) > Color

Red	Green	Blue
155	244	255