Ansys Mechanical Getting Started

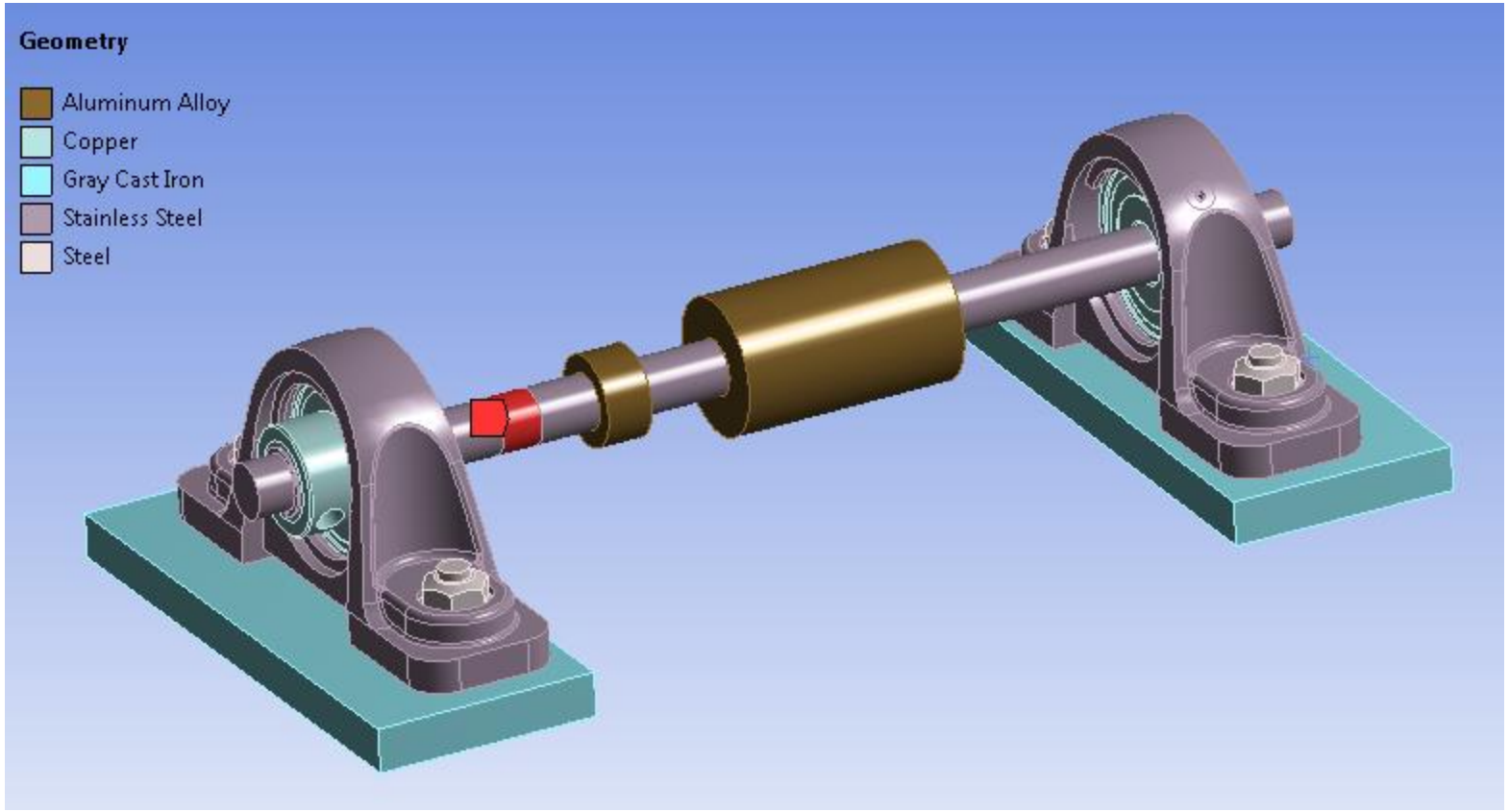
Module 04 Student Workshop: Geometry, Materials, and Coordinate Systems

Please note:

- These training materials were developed and tested in Ansys Release 2023 R1. Although they are expected to behave similarly in later releases, this has not been tested and is not guaranteed.
- The screen images included with these training materials may vary from the visual appearance of a local software session.
- Although some workshop files may open successfully in previous releases, backward compatibility is somewhat unlikely and is not guaranteed.

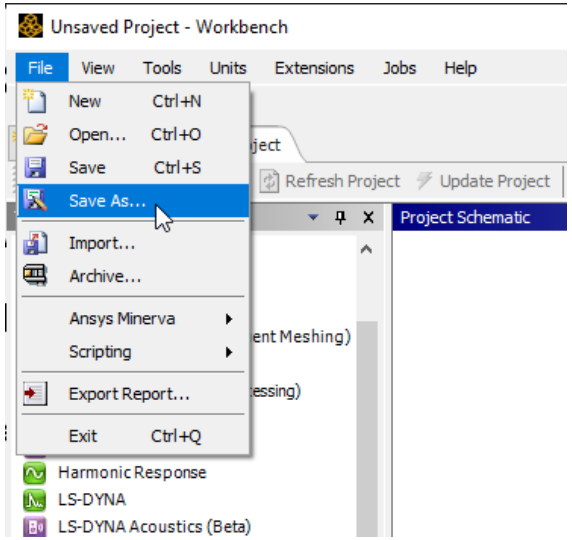
Workshop 04: Geometry, Materials, and Coordinate Systems

- Use this guide to work on the Journal Bearing model.



Workshop 04: Geometry, Materials, and Coordinate Systems

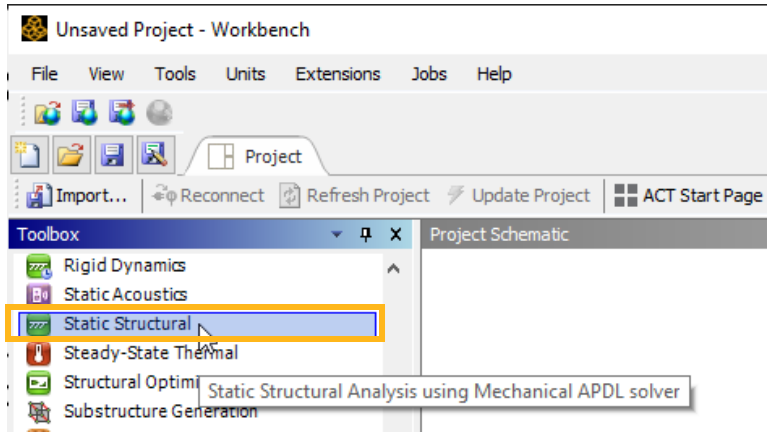
- Open Workbench and save a new project:
  - Start button → Ansys 2023 R1 → Workbench 2023 R1
  - File → Save As …

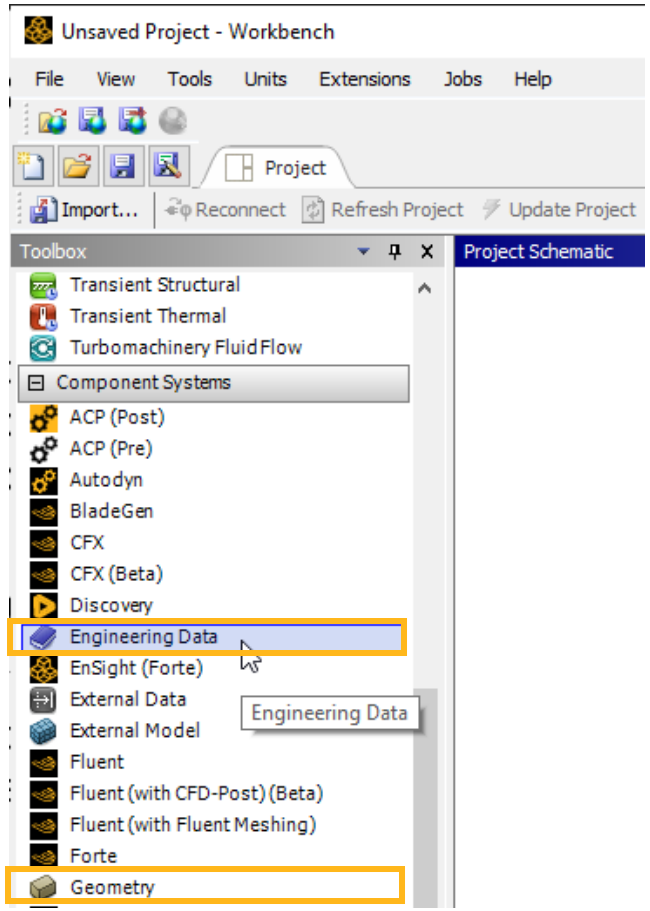


  - Choose an appropriate location on the disk and name this project “WS04.wbpj”

Workshop 04: Geometry, Materials, and Coordinate Systems

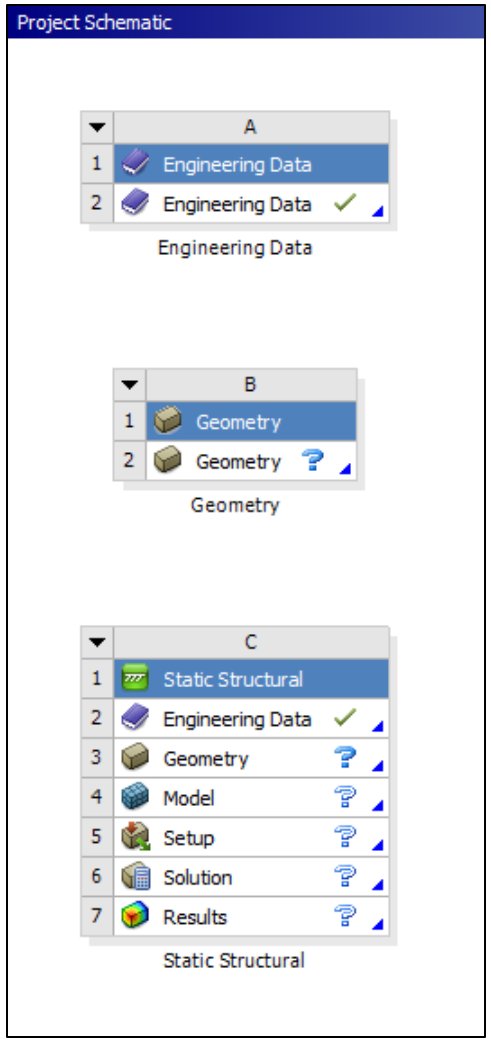
- We will first create the analysis workflow:
  - Insert an Engineering Data component system: Double Click on Engineering Data in the Component Systems toolbox group
  - Similarly, insert a Geometry component system
  - Insert a Static Structural Analysis System: Double-click on Static Structural Analysis Systems toolbox group





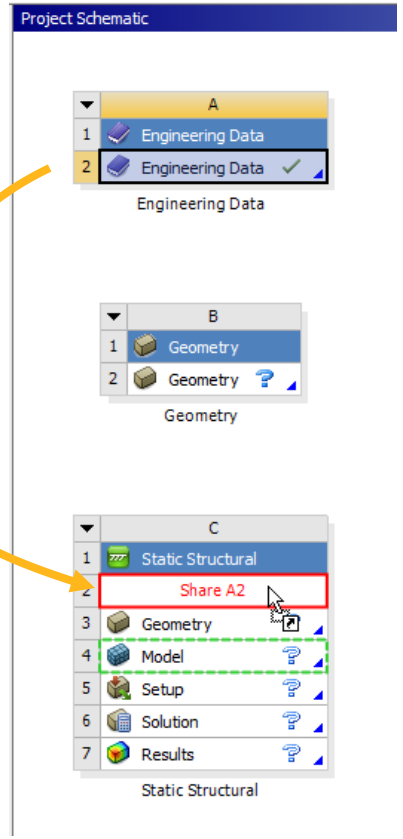
Workshop 04: Geometry, Materials, and Coordinate Systems

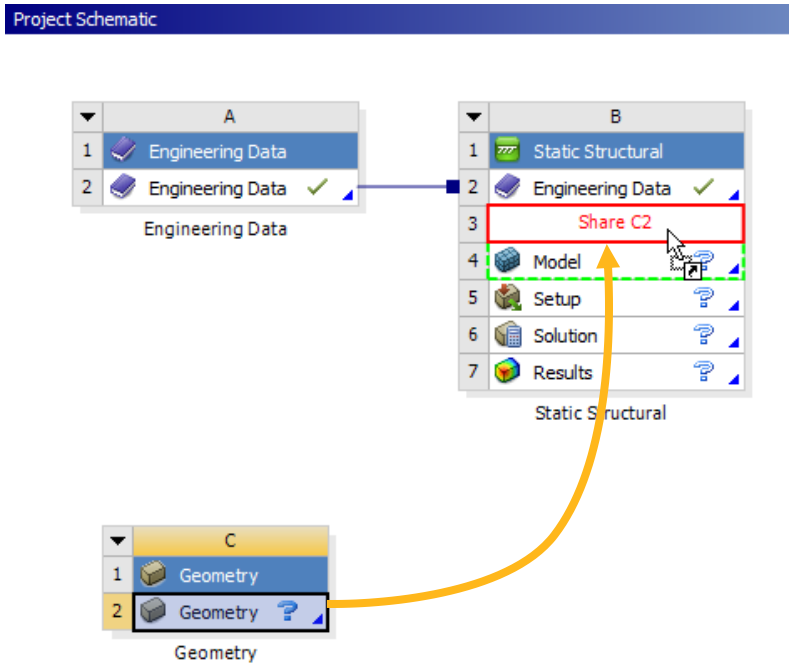
- The project page should now look like this:



Workshop 04: Geometry, Materials, and Coordinate Systems

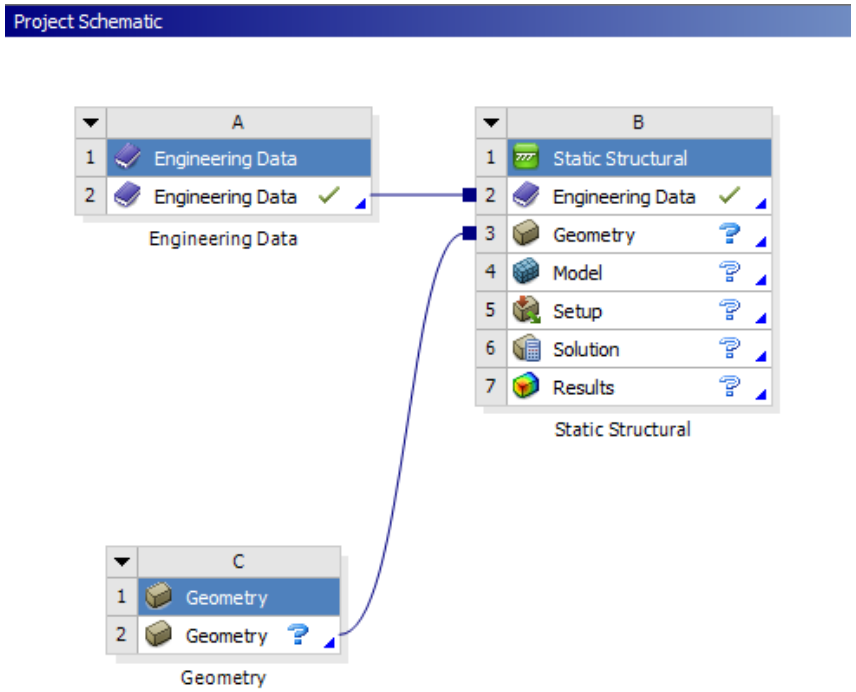
- Define the links between each system:
  - Drag and drop cell A2 in Engineering Data onto cell C2 in Static Structural
  - Drag and drop cell C2 in Geometry onto cell B3 in Static Structural





Workshop 04: Geometry, Materials, and Coordinate Systems

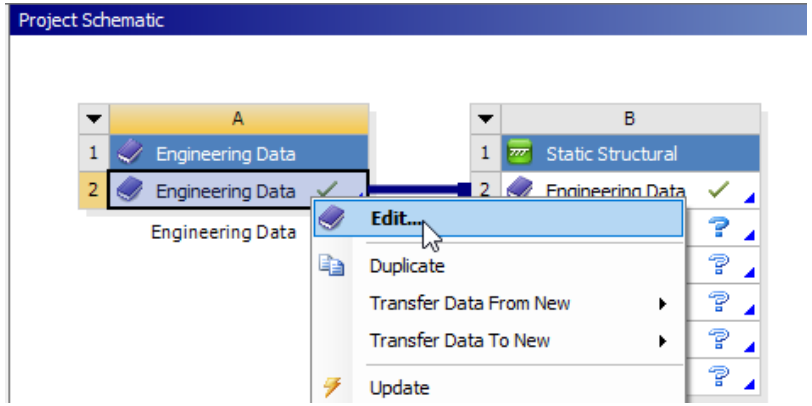
- The Project Schematic should now look like this:

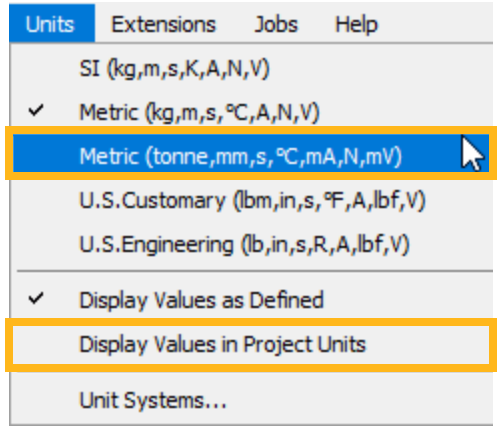


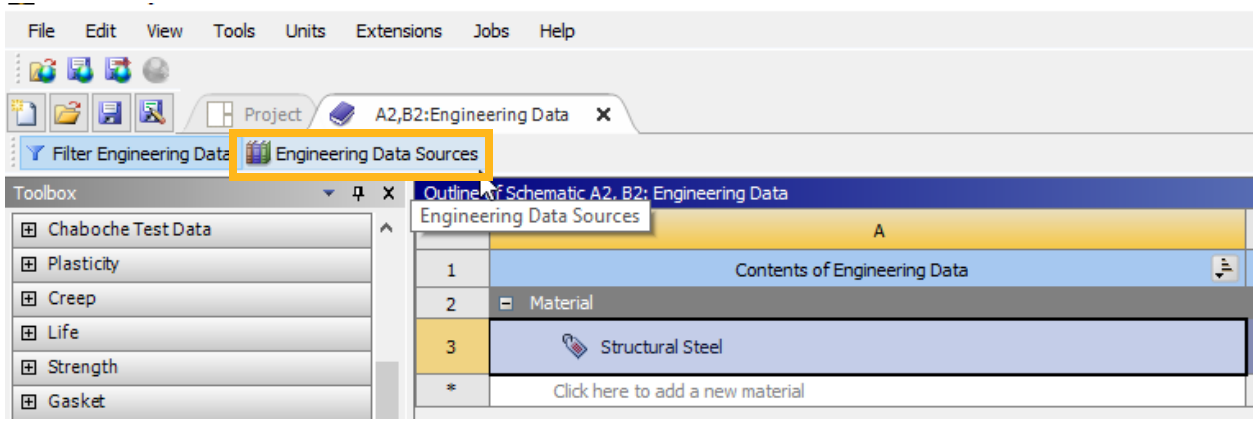
- In this module, it remains to define the materials and geometry used in the simulation.

Workshop 04: Geometry, Materials, and Coordinate Systems

- Double Click on cell A2 to enter the Engineering Data application.
- Verify the Active Units System is Metric (tonne, mm, s, …). If not, change it from the Units menu.
- Select “Display Values in Project Units” so that values are automatically converted from one system to another.
- Click on the Engineering Data Sources button to enter the materials library.

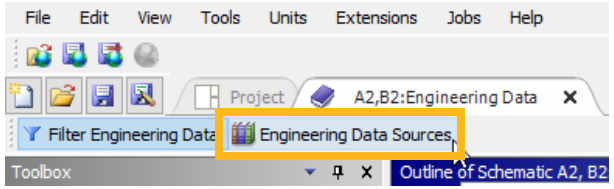






Workshop 04: Geometry, Materials, and Coordinate Systems

- Navigate to the General Materials family.
- Identify the Aluminum Alloy and the Stainless-Steel material models. Click on the '+' button next to each to add them to the materials (Engineering Data) list for the analysis.
- Return to the Engineering Data list by clicking on the Engineering Data Sources button again.



Engineering Data Sources

	A	B	C	D
1	Data Source		Location	Description
3	ANSYS GRANTA Materials Data for Simulation (Sample)			datasheets. Visit ANSYS GRANTA Materials Data for Simulation to learn about the full product with broader coverage of material data (e.g. linear, non-linear, temperature dependant, fatigue etc.) which includes more than 700 material datasheets.
4	General Materials			General use material samples for use in various analyses.
5	Additive Manufacturing Materials			Additive manufacturing material samples for use in additive manufacturing analyses.

Outline of General Materials

	A	B	C	D	E
1	Contents of General Materials	Add		Source	Description
4	Aluminum Alloy			Ger	General aluminum alloy. Fatigue properties come from MIL-HDBK-5H, page 3-277.
5	Concrete			Ger	
6	Copper Alloy			Ger	
7	FR-4			Ger	Sample FR-4 material, data is averaged from various sources and meant for illustrative purposes. It is assumed that the material x direction is the length -wise (LW), or warp yarn direction, while the material y direction is the cross-wise (CW), or fill yarn direction .
8	Gray Cast Iron			Ger	
9	Magnesium Alloy			Ger	
10	Polyethylene			Ger	
11	Silicon Anisotropic			Ger	
12	Stainless Steel			Ger	
13	Structural Steel			Ger	Fatigue Data at zero mean stress comes from 1998 ASME BPV Code, Section 8, Div 2, Table 5-110.1

Workshop 04: Geometry, Materials, and Coordinate Systems

- Select the Stainless-Steel material model and modify property Young's Modulus to 170,000 MPa.

Outline of Schematic A2, B2: Engineering Data

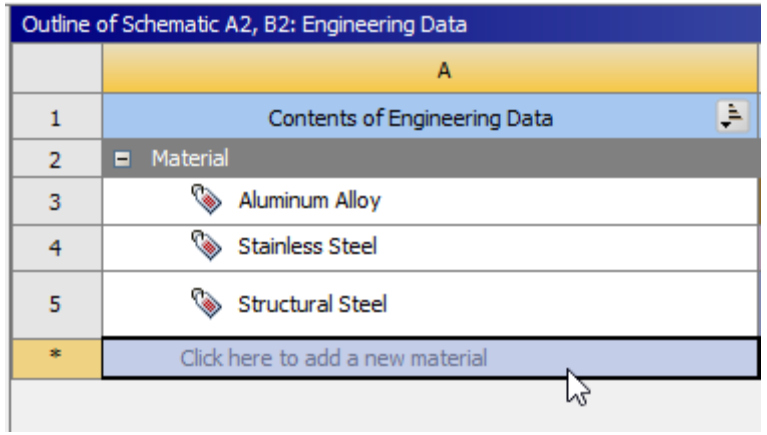
	A	B	C	D
1	Contents of Engineering Data			Source
2	Material			
3	Aluminum Alloy			General_Materials.xml
4	Stainless Steel			General_Materials.xml
5	Structural Steel			General_Materials.xml
*	Click here to add a new material			

Properties of Outline Row 4: Stainless Steel

	A	B	
1	Property	Value	
2	Material Field Variables	Table	
3	Density	7.75E-09	tonne mm^-3
4	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
7	Derive from	Young's Modulus and Poisson's Ratio	
8	Young's Modulus	1.7E+05	MPa
9	Poisson's Ratio	0.31	
10	Bulk Modulus	1.4912E+05	MPa
11	Shear Modulus	64885	MPa

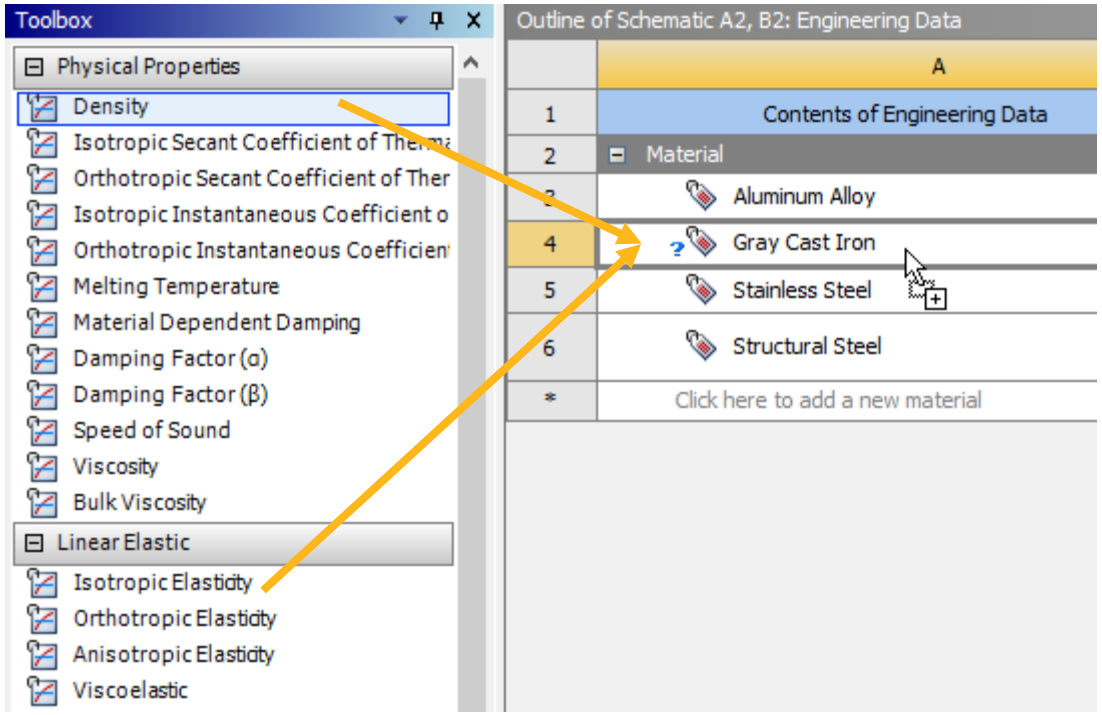
Workshop 04: Geometry, Materials, and Coordinate Systems

- Insert a new Material and name it Gray Cast Iron: type the name on the empty bottom line



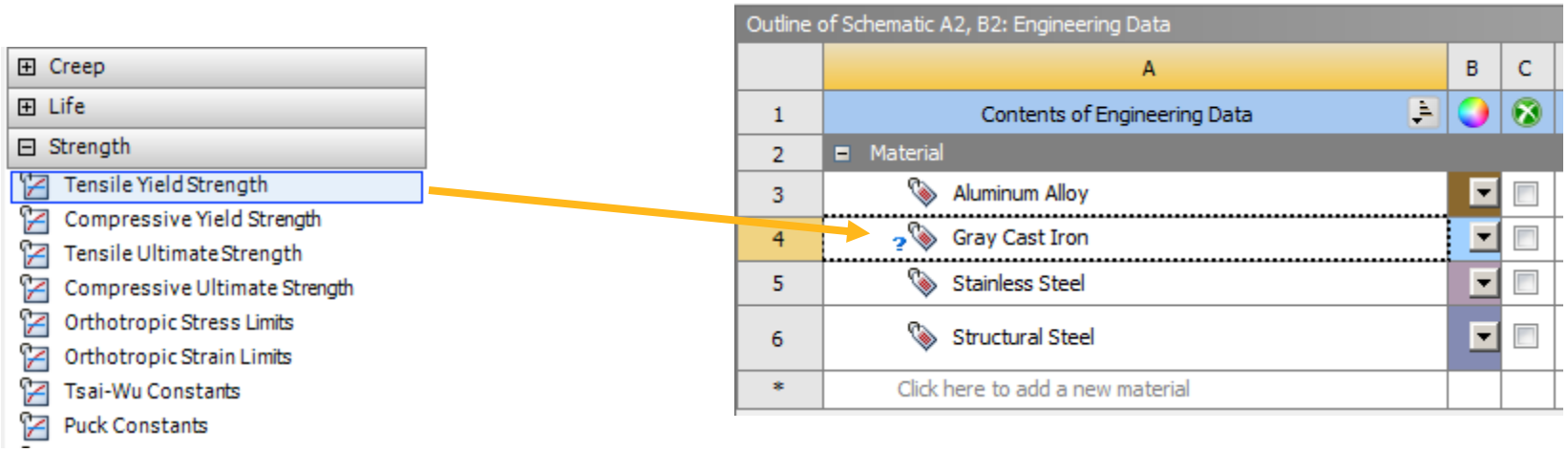
Workshop 04: Geometry, Materials, and Coordinate Systems

- Search for the following properties in the toolbox:
  - Physical Properties: Density
  - Linear Elasticity: Isotropic Elasticity
- Drag and drop each property onto Gray Cast Iron



Workshop 04: Geometry, Materials, and Coordinate Systems

- Also from the toolbox:
  - Drag property Tensile Yield Strength onto Gray Cast Iron



Workshop 04: Geometry, Materials, and Coordinate Systems

- Fill in property Values with the following information:

- Gray Cast Iron:
  - Young’s Modulus E = 1.2 E+05 MPa
  - Poisson's ratio ν = 0.29
  - Density ρ = 7.2E-09 tonne/mm^3
  - Tensile Yield Strength σy = 294 MPa

Outline of Schematic A2, B2: Engineering Data

	A	B	C	D
1	Contents of Engineering Data			Source
2	Material			
3	Aluminum Alloy			General_Materials.xml
4	Gray Cast Iron			
5	Stainless Steel			General_Materials.xml
6	Structural Steel			General_Materials.xml
*	Click here to add a new material			

Properties of Outline Row 4: Gray Cast Iron

	A	B	
1	Property	Value	
2	Material Field Variables	Table	
3	Density	7.2E-09	tonne mm^-3
4	Isotropic Elasticity		
5	Derive from	Young's Modulus and Poisson's Ratio	
6	Young's Modulus	1.2E+05	MPa
7	Poisson's Ratio	0.29	
8	Bulk Modulus	95238	MPa
9	Shear Modulus	46512	MPa
10	Tensile Yield Strength	294	MPa

Workshop 04: Geometry, Materials, and Coordinate Systems

- Repeat the above steps to create 3 more materials:
  - Steel:
    - Elastic modulus E = 2.10E+05 MPa
    - Poisson's ratio ν = 0.3
    - Density ρ = 7.15E-09 tonne/mm3
    - Yield strength σy = 260 MPa
  - Unfilled Polycarbonate:
    - Elastic modulus E = 2206.3 Mpa
    - Poisson's ratio ν = 0.35
    - Density ρ = 1.1902E-09 tonne/mm3
    - Yield strength σ y = 65.5 Mpa
  - Copper:
    - Elastic modulus E = 1.05E+05 MPa
    - Poisson's ratio ν = 0.33
    - Density ρ = 8.5E-09 tonne/mm3
    - Yield strength σ y = 200 MPa

Properties of Outline Row 7: Steel

	A	B	
1	Property	Value	
2	Material Field Variables	Table	
3	Density	7.15E-09	tonne mm^-3
4	Isotropic Elasticity		
5	Derive from	Young's Modulus and Poisson...	
6	Young's Modulus	2.1E+05	MPa
7	Poisson's Ratio	0.3	
8	Bulk Modulus	1.75E+05	MPa
9	Shear Modulus	80769	MPa
10	Tensile Yield Strength	260	MPa

Properties of Outline Row 9: Unfilled Polycarbonate

	A	B	
1	Property	Value	
2	Material Field Variables	Table	
3	Density	1.1902E-09	tonne mm^-3
4	Isotropic Elasticity		
5	Derive from	Young's Modulus and Poisson...	
6	Young's Modulus	2206.3	MPa
7	Poisson's Ratio	0.35	
8	Bulk Modulus	2451.4	MPa
9	Shear Modulus	817.15	MPa
10	Tensile Yield Strength	65.5	MPa

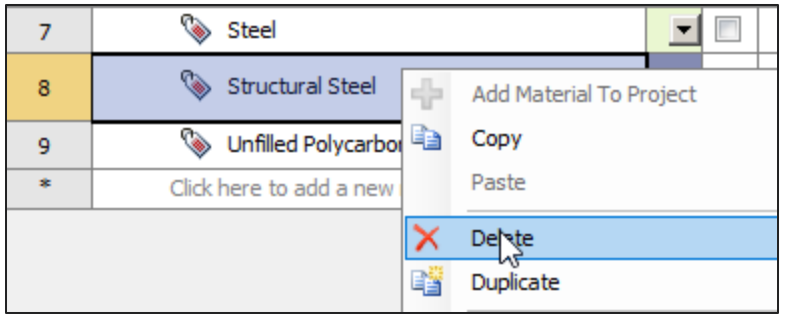
Properties of Outline Row 4: Copper

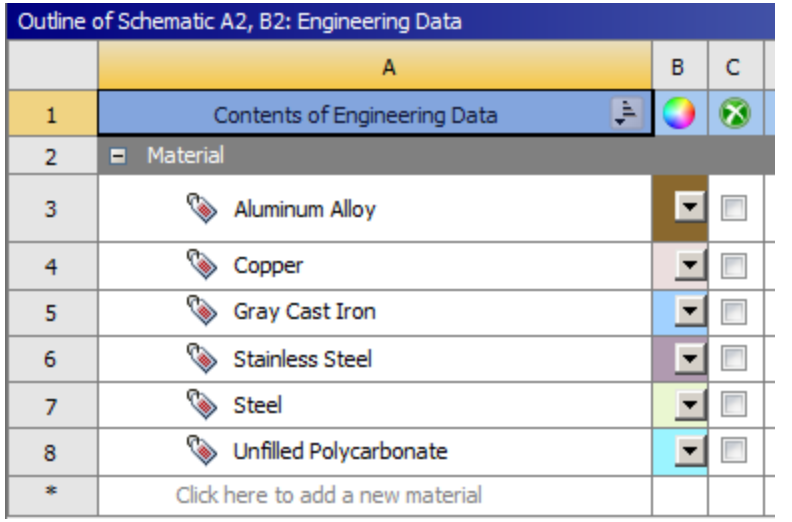
	A	B	
1	Property	Value	
2	Material Field Variables	Table	
3	Density	8.5E-09	tonne mm^-3
4	Isotropic Elasticity		
5	Derive from	Young's Modulus and Poisson...	
6	Young's Modulus	1.05E+05	MPa
7	Poisson's Ratio	0.33	
8	Bulk Modulus	1.0294E+05	MPa
9	Shear Modulus	39474	MPa
10	Tensile Yield Strength	200	MPa

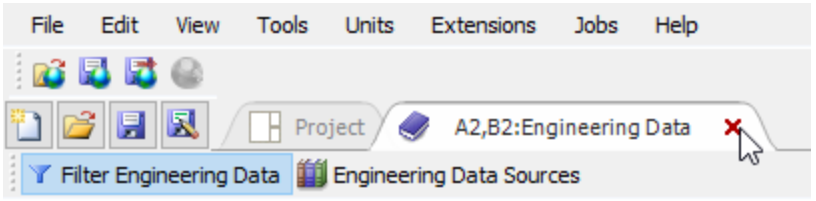
Workshop 04: Geometry, Materials, and Coordinate Systems

- Delete the Structural Steel material from the list: RMB → Delete

- The material list now contains all the materials to be used in the analysis. Return to the project page by closing the Engineering Data tab.







Workshop 04: Geometry, Materials, and Coordinate Systems

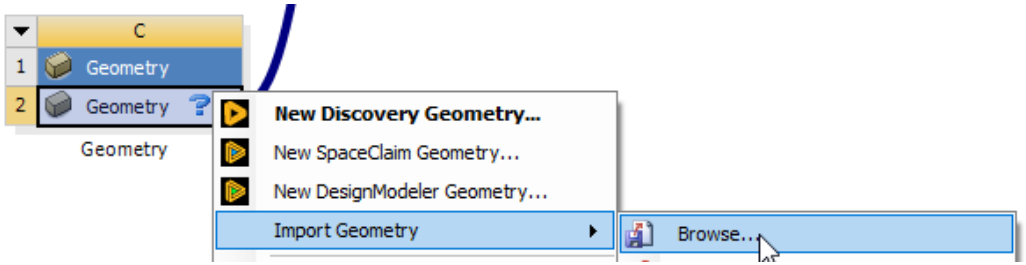
- The next step is geometry import. We'll import the CAD file and then open the geometry editor to create associativity between the geometry and the Mechanical model.

- Display geometry properties (RMB on cell C2 → Properties) and check the Analysis Type is set to 3D.

- Attach the desired geometry: RMB on cell C2 → Import Geometry → Browse

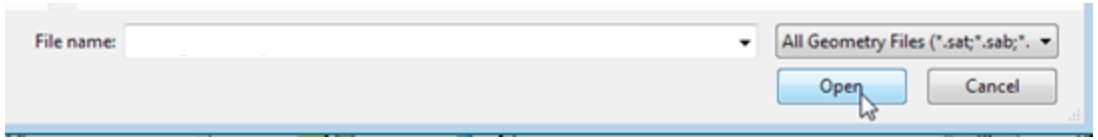
Properties of Schematic B3: Geometry

	A	B
1	Property	Value
2	General	
3	Component ID	Geometry 1
4	Directory Name	Geom
5	Update Condition Parameter (Beta)	None
6	Notes	
7	Notes	
8	Used Licenses	
9	Last Update Used Licenses	
10	Basic Geometry Options	
11	Solid Bodies	☑
12	Surface Bodies	☑
13	Line Bodies	☐
14	Parameters	Independent
15	Parameter Key	ANS;DS
16	Attributes	☐
17	Named Selections	☐
18	Material Properties	☐
19	Advanced Geometry Options	
20	Analysis Type	3D
21	Use Associativity	☑
22	Import Coordinate Systems	☐

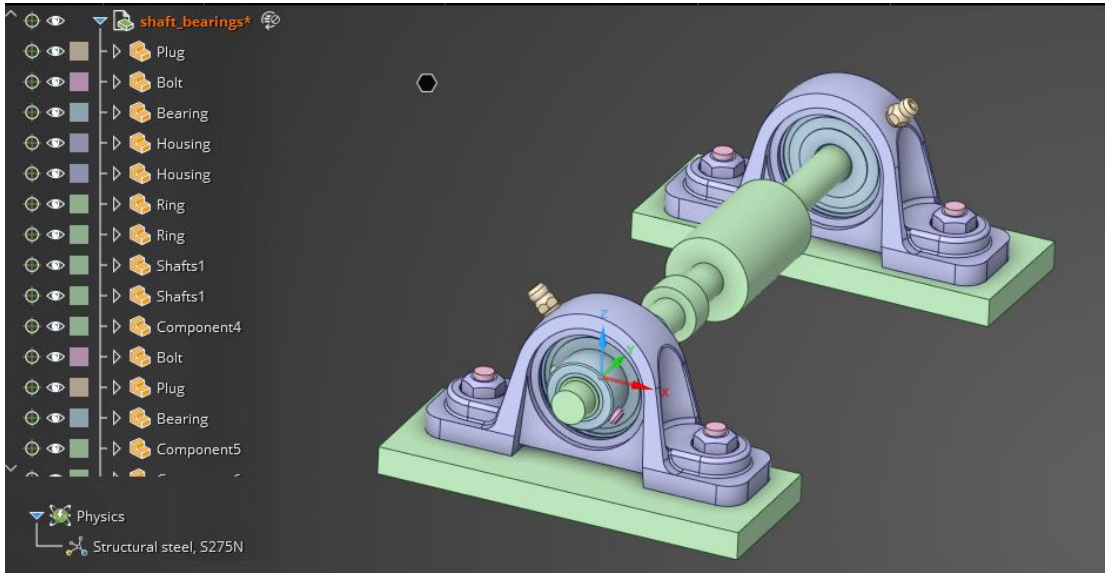


Workshop 04: Geometry, Materials, and Coordinate Systems

- Browse for file shaft_bearings.scdoc and open it.



- Open Discovery: RMB on cell C2 → Edit Geometry in Discovery.
- Review the geometry to make sure it has been imported correctly.



Workshop 04: Geometry, Materials, and Coordinate Systems

- To prevent importing default material from discovery , uncheck the “Material Properties” option from the Geometry cell properties.

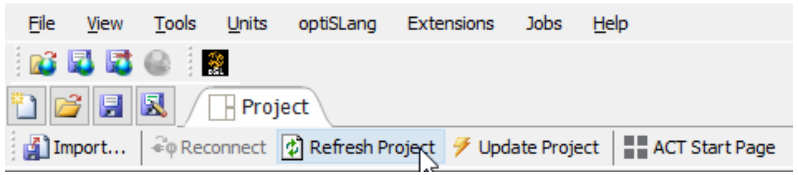
Properties of Schematic B3: Geometry

	A	B
1	Property	Value
2	General	
3	Component ID	Geometry
4	Directory Name	Geom
5	Update Condition Parameter (Beta)	None
6	Notes	
7	Notes	
8	Used Licenses	
9	Last Update Used Licenses	
10	Geometry Source	
11	Geometry File Name	[redacted]
12	Advanced Geometry Options	
13	Analysis Type	3D
14	Compare Parts On Update	No
15	Smart CAD Update	☑
16	Import Using Instances	☑
17	Basic Geometry Options	
18	Material Properties	☐

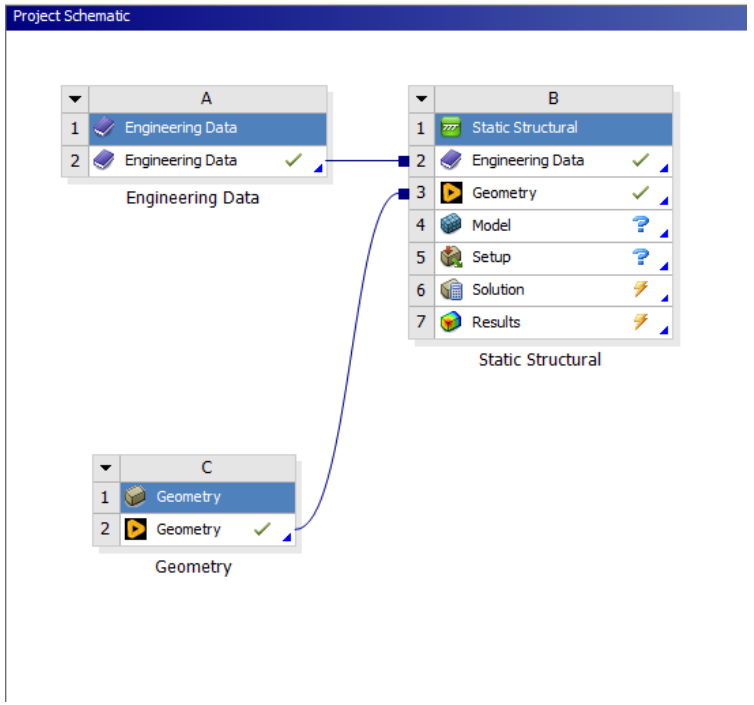
Workshop 04: Geometry, Materials, and Coordinate Systems

- Close Discovery and return to the Workbench project page.
  - At this stage, the C2 geometry cell should contain a green check.

- Refresh the project to transfer geometry and materials into Mechanical.

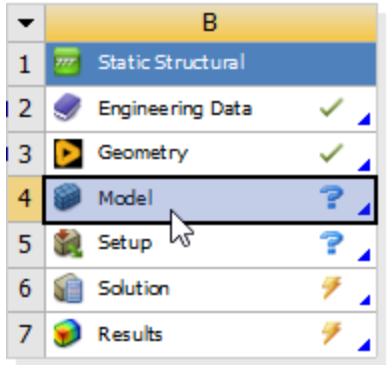


- An intermediate save of the project is recommended.



Workshop 04: Geometry, Materials, and Coordinate Systems

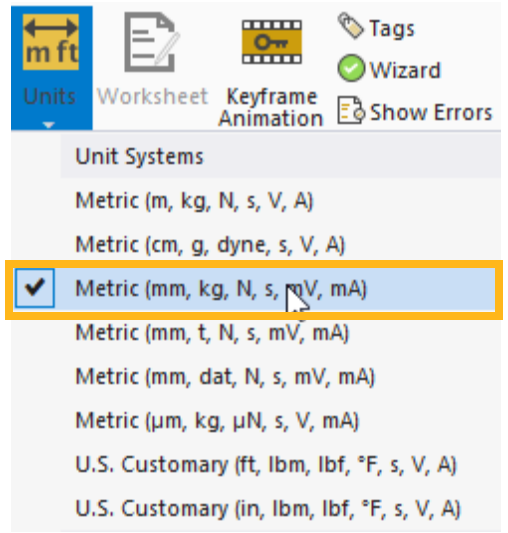
- We will now enter Mechanical and assign materials to each body: Open Mechanical by double-clicking on B4 Model cell.

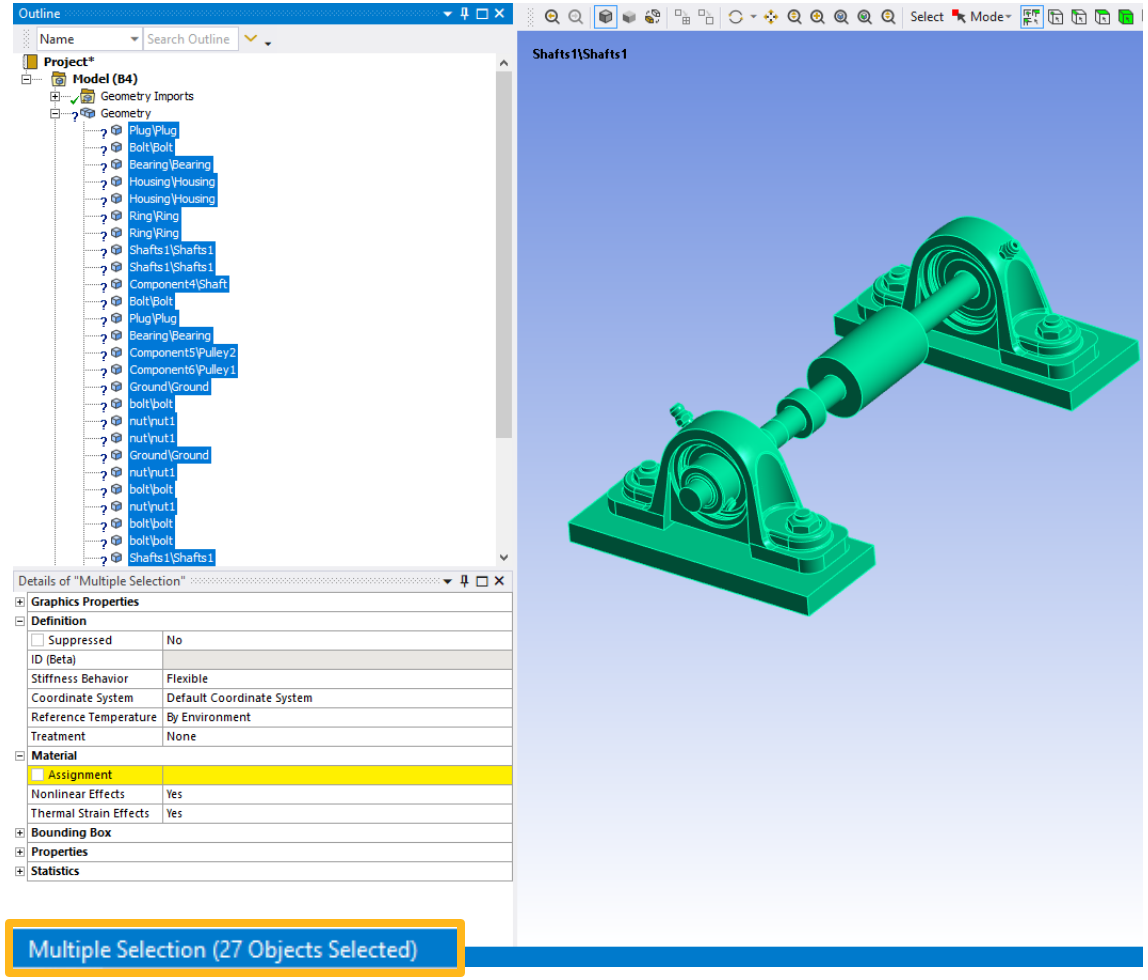


Static Structural

Workshop 04: Geometry, Materials, and Coordinate Systems

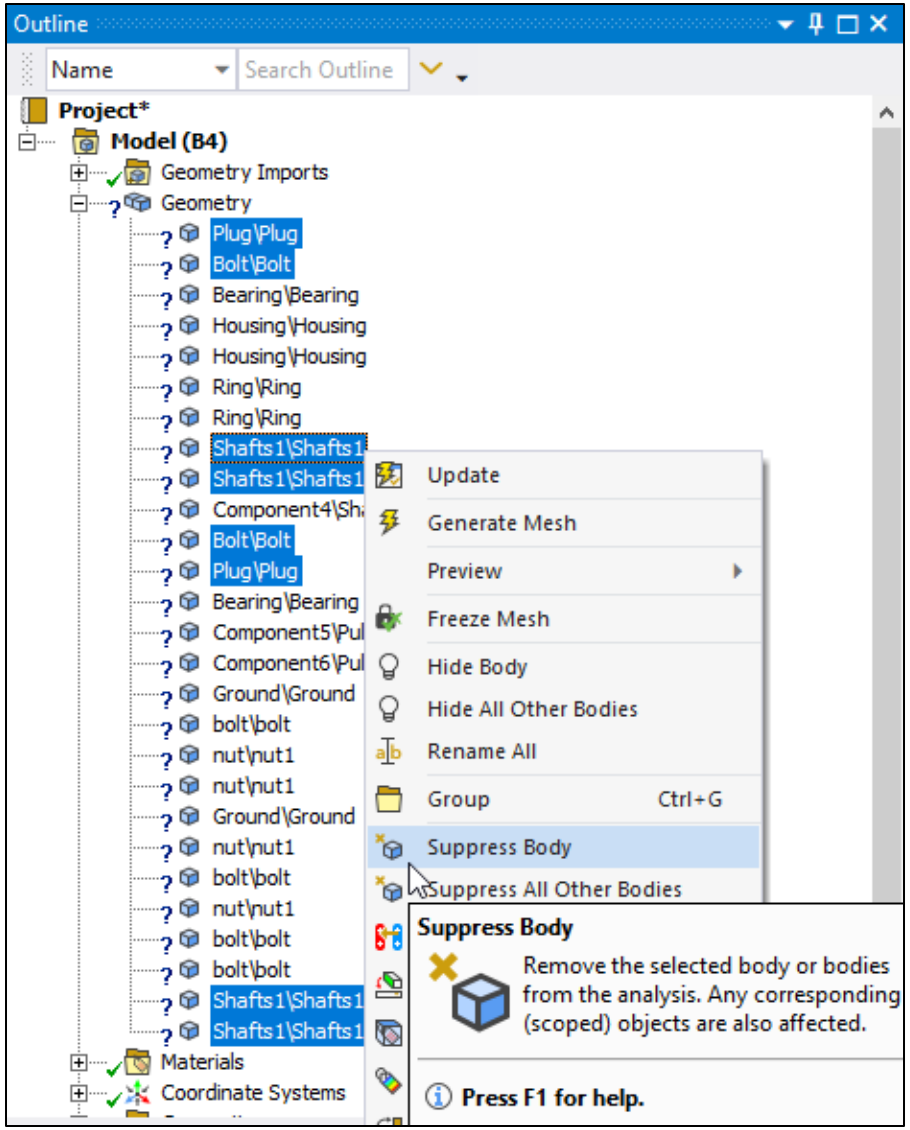
- Once in Mechanical, Select all bodies from the tree (Ctrl or Shift key for multiple selection).
- Check 27 bodies have been selected.
- Check that the Units system is set to Metric (mm, t, N, s, …).





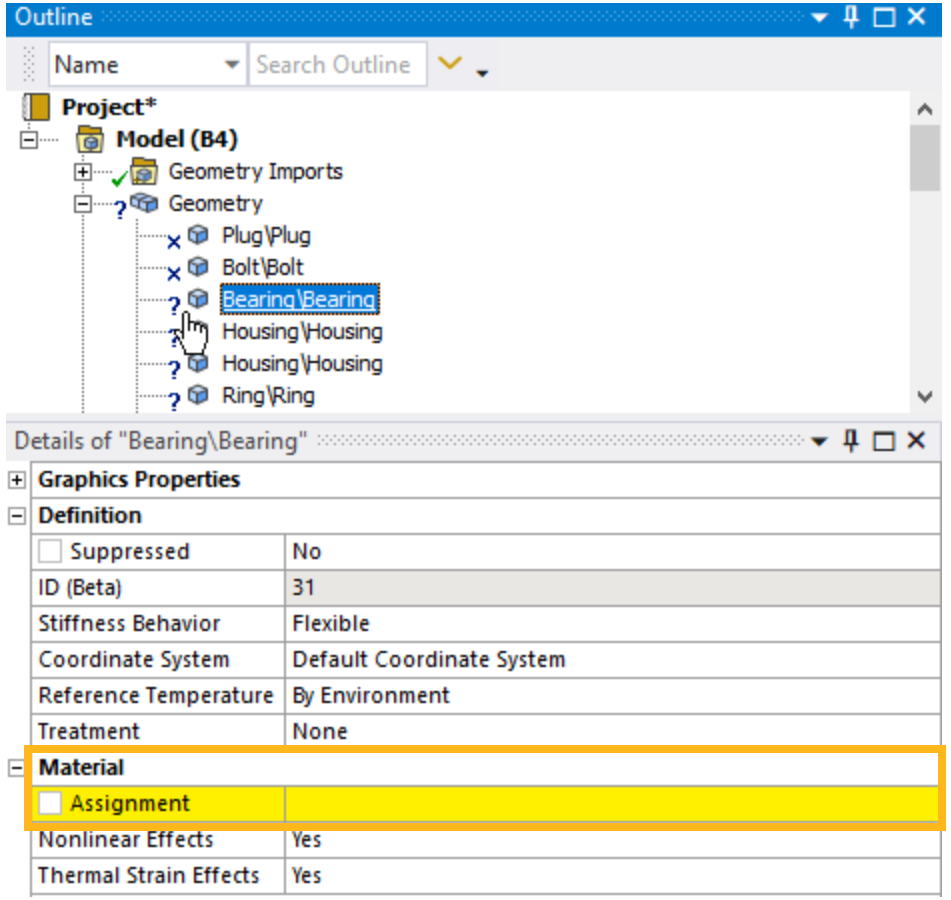
Workshop 04: Geometry, Materials, and Coordinate Systems

- Before starting the model definition, we are going to suppress the bodies which will not be part of the model.
- In the Mechanical tree, select:
  - 2 plug bodies
  - 4 shaft bodies
  - 2 bolt bodies
- RMB → Suppress Body



Workshop 04: Geometry, Materials, and Coordinate Systems

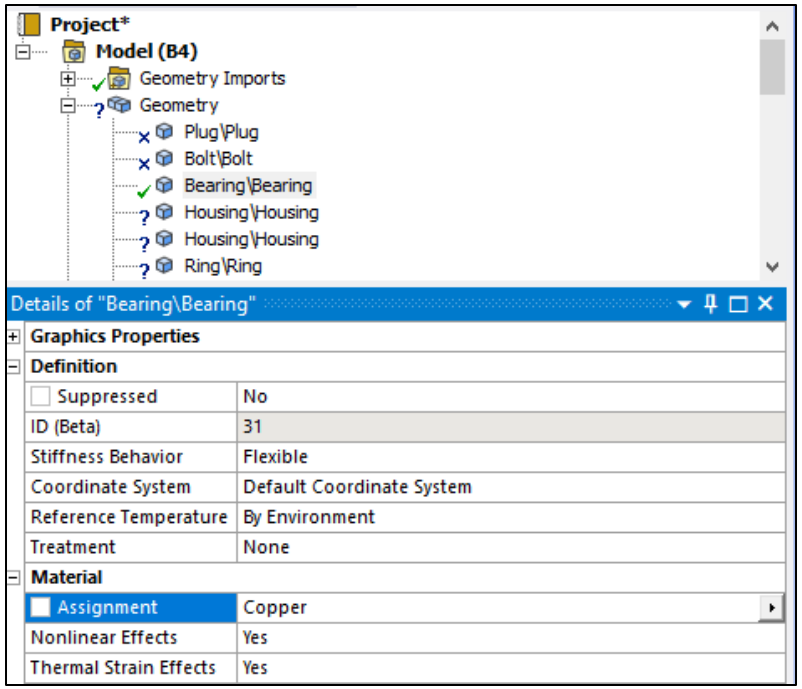
- Note that question marks (?) are present in front of the remaining bodies in the tree.
- If you click on the first unsuppressed body in the Mechanical tree, you'll see a yellow line in the details. This means there is a missing information that needs to be provided. This is because we still need to define the Material assignment for each body.



Note: by default, Structural Steel is automatically assigned to all bodies. Because we have deleted Structural Steel material from the project's material list, material assignment becomes undefined for all bodies.

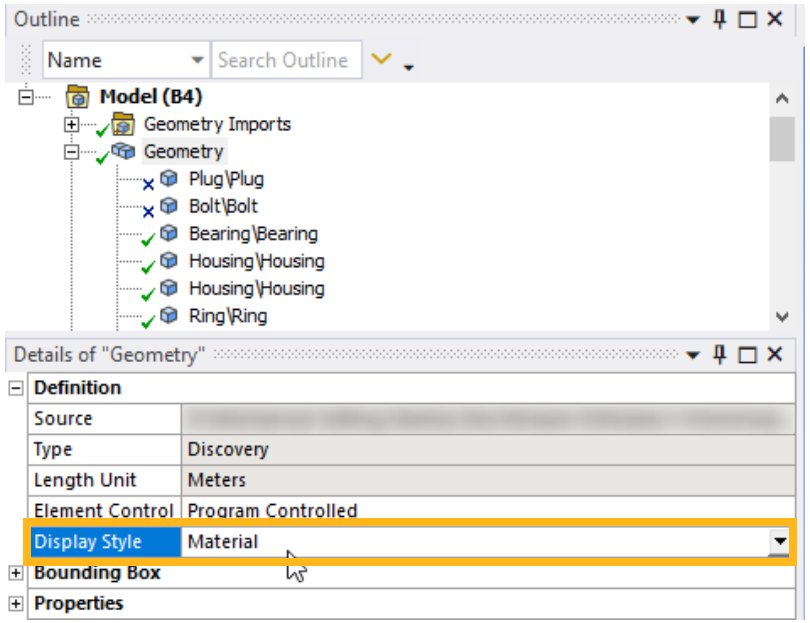
Workshop 04: Geometry, Materials, and Coordinate Systems

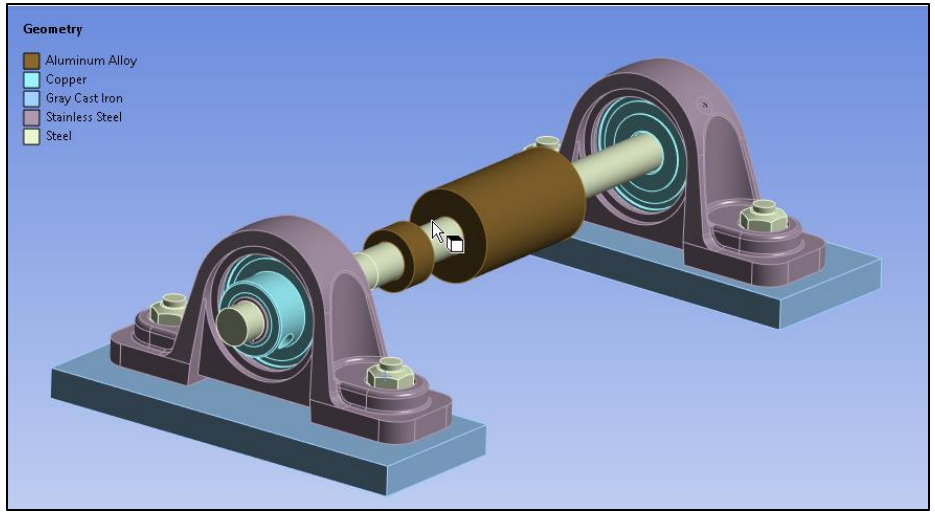
- The Bearing component is in Copper material. To assign this material, select the body named “Bearing\Bearing” and change the Material assignment to Copper in the details window.
- Verify that the green checkmark ( ) is now present in front of the body object in the tree.



Workshop 04: Geometry, Materials, and Coordinate Systems

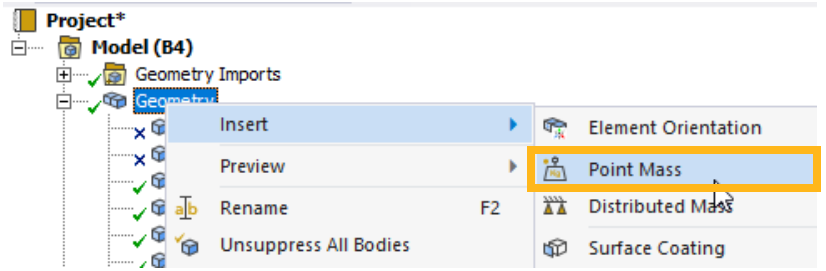
- For the first simulation, we'll review the Housing's behavior as it is currently: made of Stainless Steel. Repeat the steps above to assign the following materials:
  - Housing: Stainless Steel
  - Ring: Stainless Steel
  - Shaft: Steel
  - Bearing: Copper
  - Pulley: Aluminum Alloy
  - Ground: Gray Cast Iron
  - Bolts and nuts: Steel
- You can change the Display Style in the Geometry branch to "Material" to graphically see the material assignment for each body.





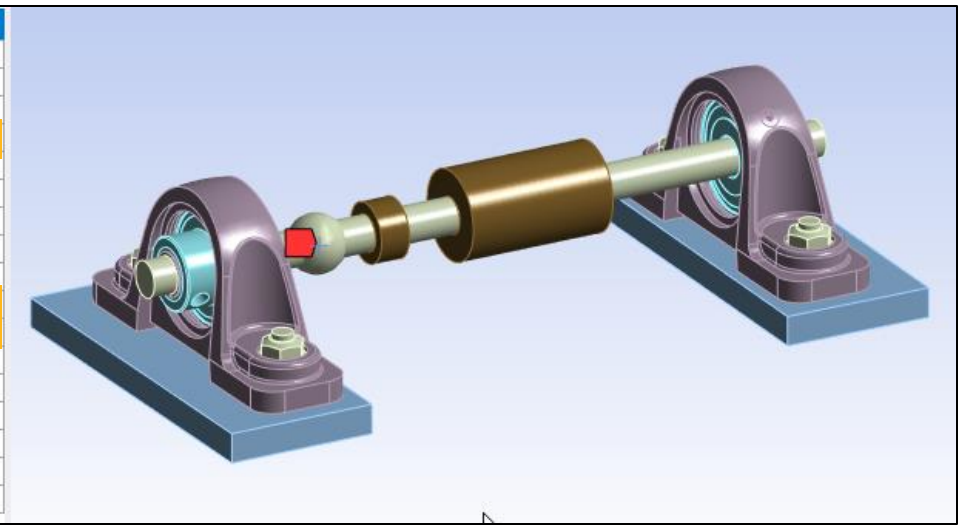
Workshop 04: Geometry, Materials, and Coordinate Systems

- We'll create a point mass, representing the mass fixed near the pulley A to equilibrate the assembly when its rotating. Right Click on Geometry branch → Insert → Point Mass
- Chose the face shown in the image for Geometry scoping and Apply selection.
- Enter 0.001 tonne for the Mass value.



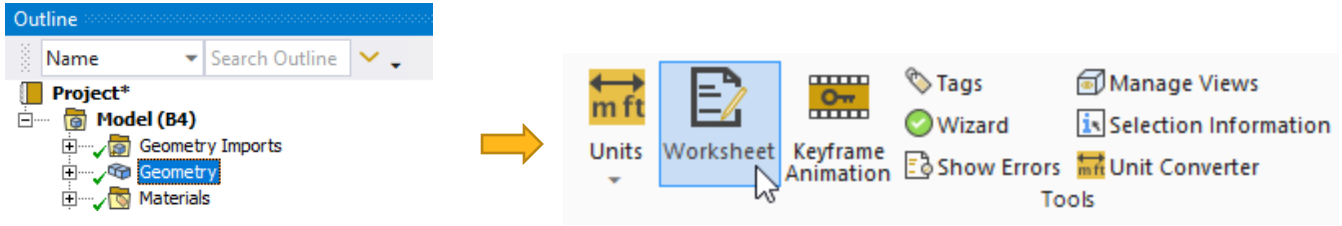
Details of "Point Mass"

Scope	
Scoping Method	Geometry Selection
Applied By	Remote Attachment
Geometry	1 Face
Coordinate System	Global Coordinate System
X Coordinate	7.3226e-003 mm
Y Coordinate	35.319 mm
Z Coordinate	-1.6384e-002 mm
Location	Click to Change
Definition	
Mass	0.001
Mass Moment of Inertia X	0. t·mm²
Mass Moment of Inertia Y	0. t·mm²
Mass Moment of Inertia Z	0. t·mm²
Suppressed	No
Behavior	Deformable
Pinball Region	All



Workshop 04: Geometry, Materials, and Coordinate Systems

- Check all bodies have flexible stiffness behavior. You can use the Worksheet feature: Click on the Geometry branch and then on Worksheet in the toolbar in the Home tab.



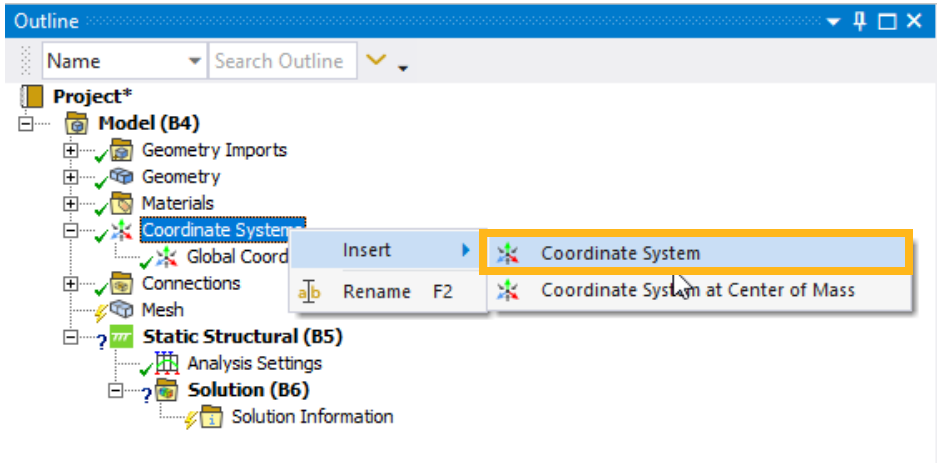
Worksheet

Geometry

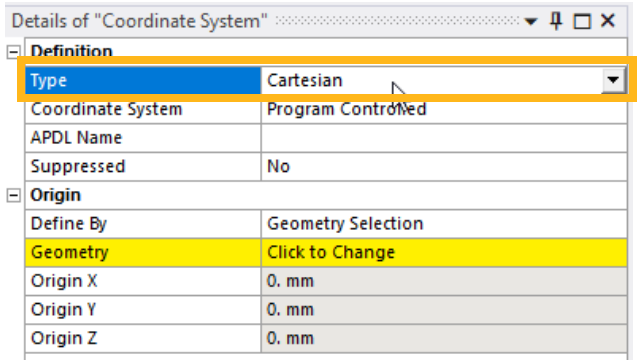
Name	Assignment	Volume (mm³)	Mass (t)	Nodes	Elements	Coordinate System	Location (mm)	Status	Nonlinear Effects	Stiffness Behavior	Mass Moment of Inertia X (t·mm²)	Mass Moment of Inertia Y (t·mm²)	Mass Moment of Inertia Z
Plug\Plug		337.14	0.	0	0			Suppressed	Yes	Flexible	0.	0.	0.
Bolt\Bolt		183.4	0.	0	0			Suppressed	Yes	Flexible	0.	0.	0.
Bearing\Bearing	Copper	16601	1.4111e-004	0	0			Not suppressed	Yes	Flexible	2.9303e-002	1.8957e-002	1.908e-002
Housing\Housing	Stainless Steel	42694	3.3088e-004	0	0			Not suppressed	Yes	Flexible	0.10021	0.33205	0.38925
Housing\Housing	Stainless Steel	42694	3.3088e-004	0	0			Not suppressed	Yes	Flexible	0.10021	0.38925	0.33204
Ring\Ring	Stainless Steel	37.06	2.8721e-007	0	0			Not suppressed	Yes	Flexible	5.5834e-006	1.1831e-005	6.2626e-006
Ring\Ring	Stainless Steel	37.06	2.8721e-007	0	0			Not suppressed	Yes	Flexible	5.5834e-006	1.1831e-005	6.2626e-006
Shafts1\Shafts1		45.679	0.	0	0			Suppressed	Yes	Flexible	0.	0.	0.
Shafts1\Shafts1		45.679	0.	0	0			Suppressed	Yes	Flexible	0.	0.	0.
Component4\Sha	Steel	28025	2.0038e-004	0	0			Not suppressed	Yes	Flexible	0.95709	3.687e-003	0.95709
Bolt\Bolt		183.4	0.	0	0			Suppressed	Yes	Flexible	0.	0.	0.
Plug\Plug		337.14	0.	0	0			Suppressed	Yes	Flexible	0.	0.	0.
Bearing\Bearing	Copper	16600	1.411e-004	0	0			Not suppressed	Yes	Flexible	1.908e-002	2.9303e-002	1.8957e-002
Component5\Pull	Aluminum Alloy	29392	8.1415e-005	0	0			Not suppressed	Yes	Flexible	2.2161e-002	1.0659e-002	2.2161e-002
Component6\Pull	Aluminum Alloy	1972.6	5.4641e-006	0	0			Not suppressed	Yes	Flexible	2.3279e-004	3.7453e-004	2.3279e-004
Ground\Ground	Gray Cast Iron	62503	4.5002e-004	0	0			Not suppressed	Yes	Flexible	0.10034	0.63598	0.72896
bolt\bolt	Steel	1969.4	1.4081e-005	0	0			Not suppressed	Yes	Flexible	1.8168e-003	1.8168e-003	1.8943e-004
nut\nut1	Steel	621.32	4.4424e-006	0	0			Not suppressed	Yes	Flexible	7.6757e-005	7.6754e-005	1.263e-004
nut\nut1	Steel	621.32	4.4424e-006	0	0			Not suppressed	Yes	Flexible	7.6757e-005	7.6754e-005	1.263e-004
Ground\Ground	Gray Cast Iron	62503	4.5002e-004	0	0			Not suppressed	Yes	Flexible	0.10034	0.63597	0.72895
nut\nut1	Steel	621.32	4.4424e-006	0	0			Not suppressed	Yes	Flexible	7.6757e-005	7.6754e-005	1.263e-004
bolt\bolt	Steel	1969.4	1.4081e-005	0	0			Not suppressed	Yes	Flexible	1.8168e-003	1.8168e-003	1.8943e-004
nut\nut1	Steel	621.32	4.4424e-006	0	0			Not suppressed	Yes	Flexible	7.6757e-005	7.6754e-005	1.263e-004
bolt\bolt	Steel	1969.4	1.4081e-005	0	0			Not suppressed	Yes	Flexible	1.8167e-003	1.8166e-003	1.8941e-004
bolt\bolt	Steel	1969.4	1.4081e-005	0	0			Not suppressed	Yes	Flexible	1.8168e-003	1.8168e-003	1.8943e-004
Shafts1\Shafts1		47.259	0.	0	0			Suppressed	Yes	Flexible	0.	0.	0.
Shafts1\Shafts1		47.259	0.	0	0			Suppressed	Yes	Flexible	0.	0.	0.

Workshop 04: Geometry, Materials, and Coordinate Systems

- We are now going to create a new coordinate system to be used for further force definition. RMB on Coordinate System branch → Insert → Coordinate System



- Select Type Cartesian

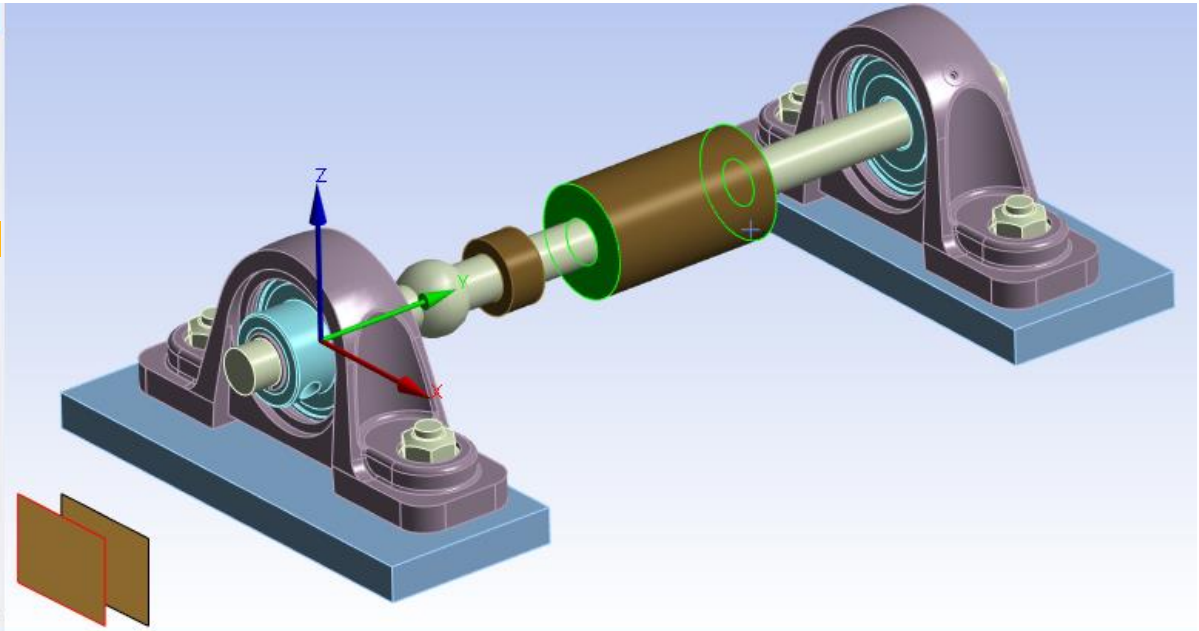


Workshop 04: Geometry, Materials, and Coordinate Systems

- Chose a geometry object for the origin definition: Select the faces as shown on the image (side faces of pulley B), and apply the selection:

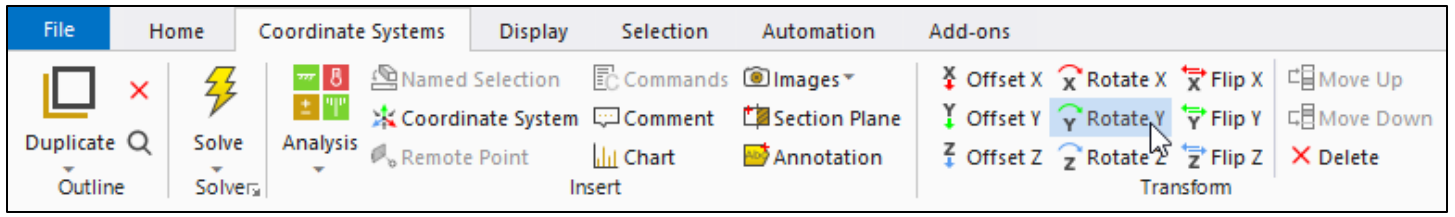
Details of "Coordinate System"

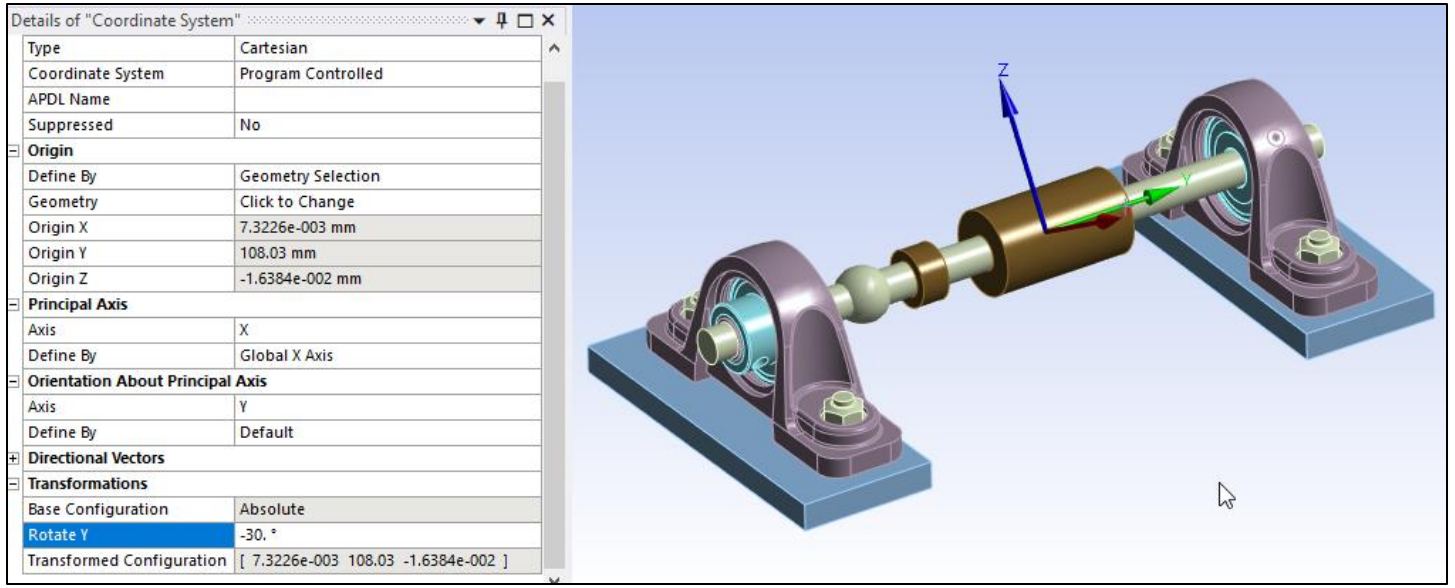
Definition	
Type	Cartesian
Coordinate System	Program Controlled
APDL Name	
Suppressed	No
Origin	
Define By	Geometry Selection
Geometry	Apply Cancel
Origin X	0. mm
Origin Y	0. mm
Origin Z	0. mm
Principal Axis	
Axis	X
Define By	Global X Axis
Orientation About Principal Axis	
Axis	Y
Define By	Default
Directional Vectors	
Transformations	
Base Configuration	Absolute
Transformed Configuration	[0. 0. 0.]



Workshop 04: Geometry, Materials, and Coordinate Systems

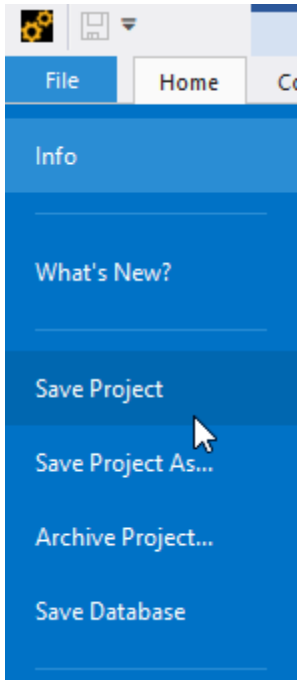
- Rotate the coordinate system around the local Y axis by 30°:
  - Add a rotation around Y
  - Set the Rotate Y detail to -30° (this corresponds to a counterclockwise rotation)





Workshop 04: Geometry, Materials, and Coordinate Systems

- Save the project for future use.



End of presentation