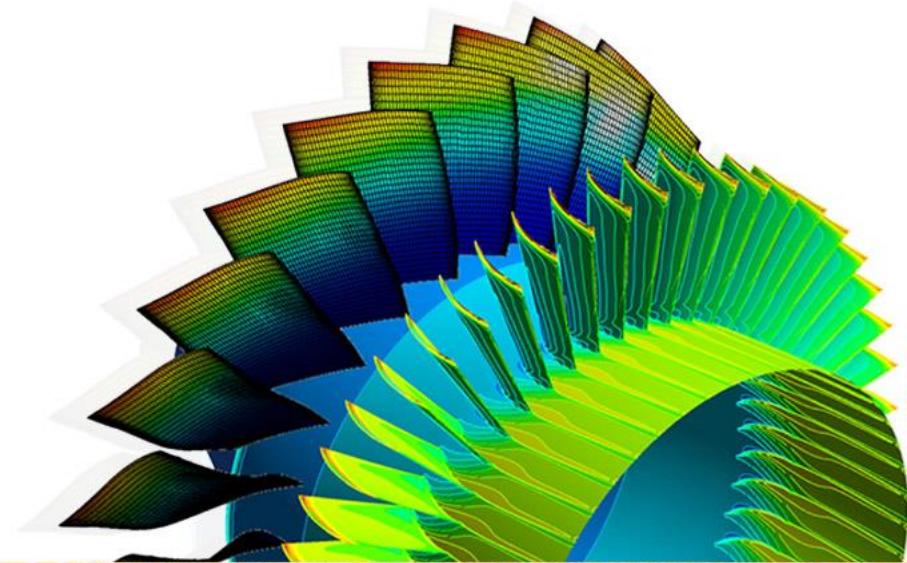




ANSYS Composite PrepPost 19.0

Workshop 10.6 – Rotordynamics

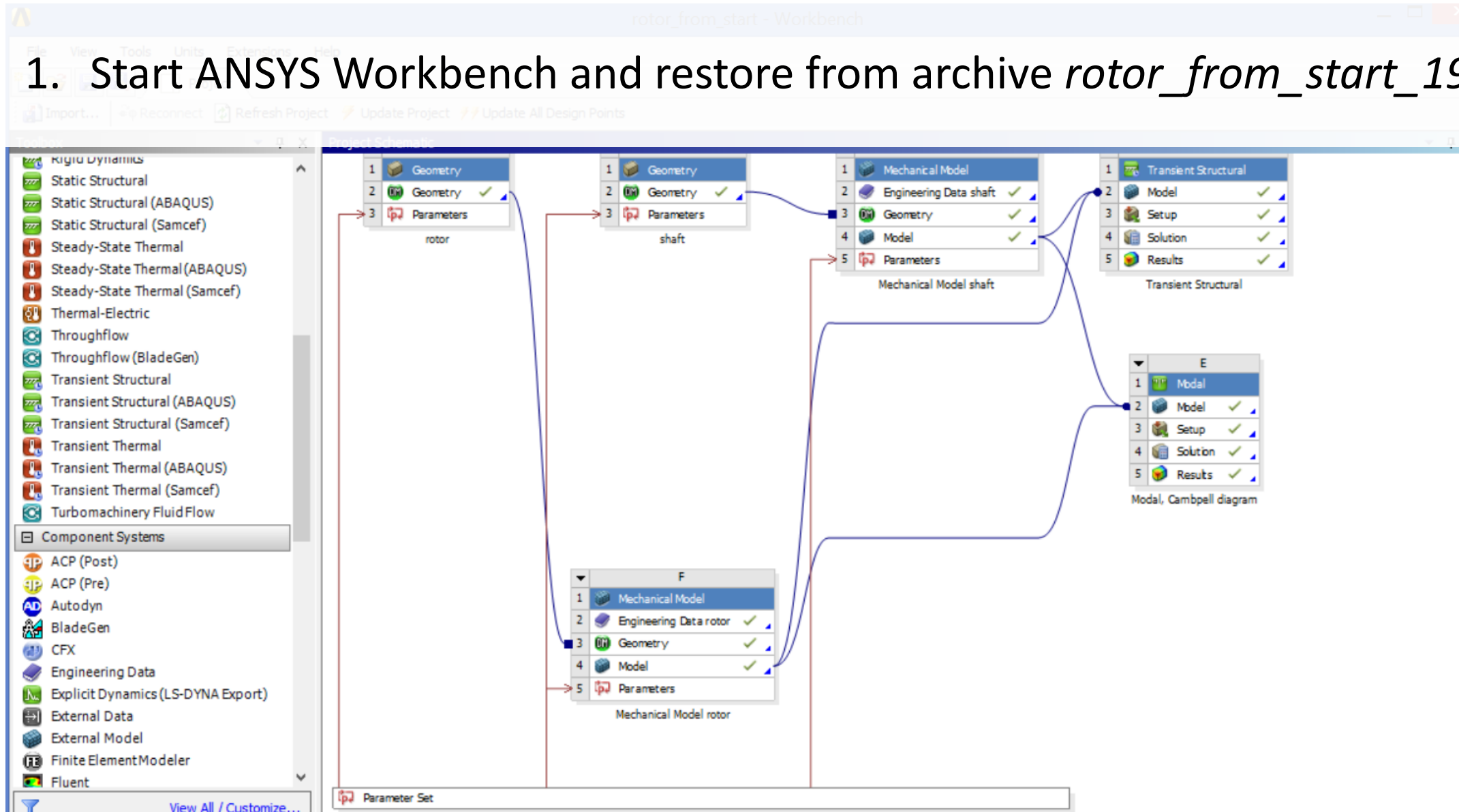


15. Workshop Rotordynamics

- In this workshop we will model a spinning composite disk clamped on a steel shaft by a rigid connection.
- We will go through the complete process of modeling - solving - postprocessing.
- We consider an single ply for the composite disk where the fibers are arranged as 0° , 90° , 45° , -90° , 0° layup with respect to the radial direction of the disk

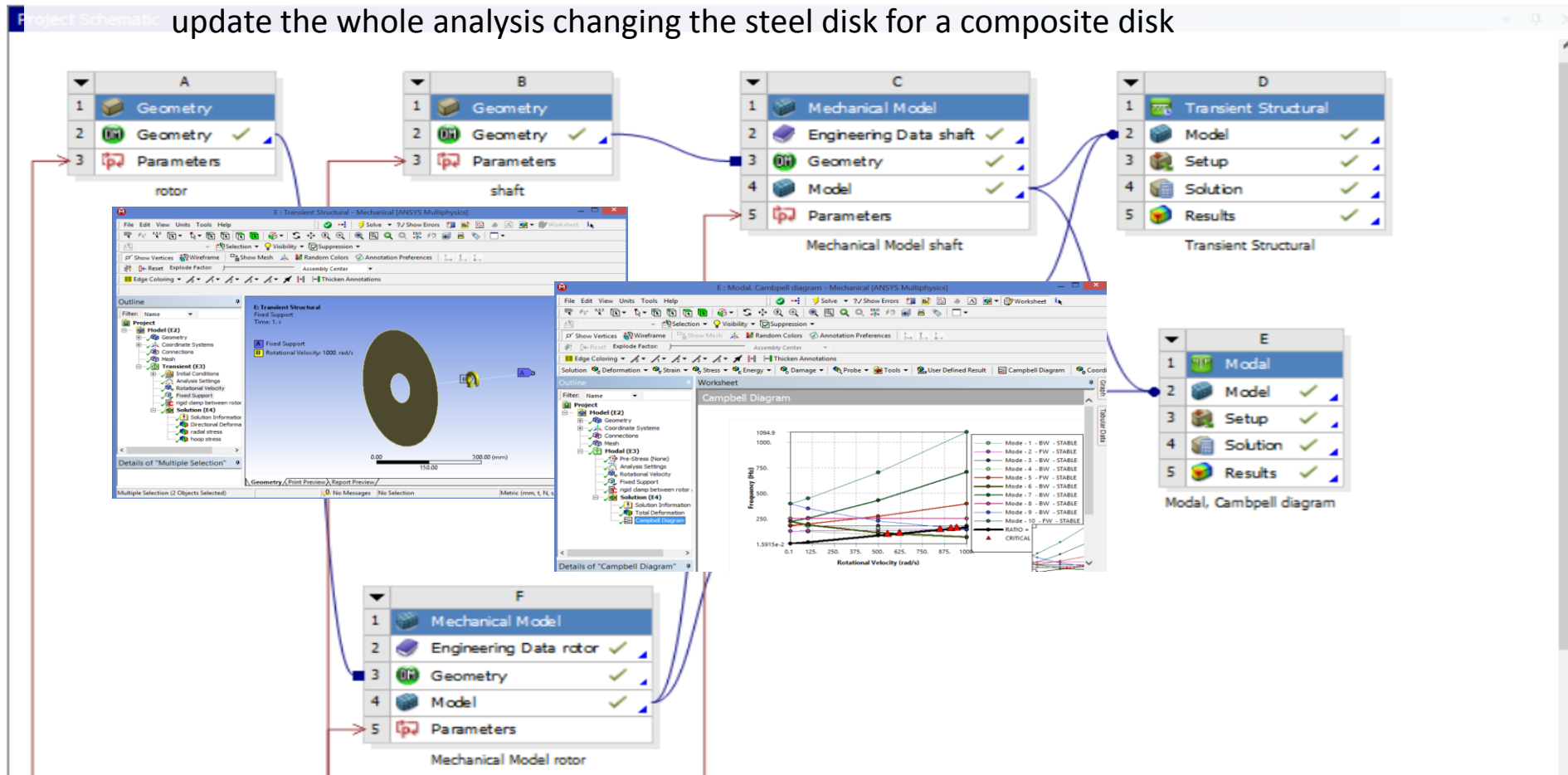
15. Workshop Rotordynamics

1. Start ANSYS Workbench and restore from archive *rotor_from_start_19.0.wbpz*

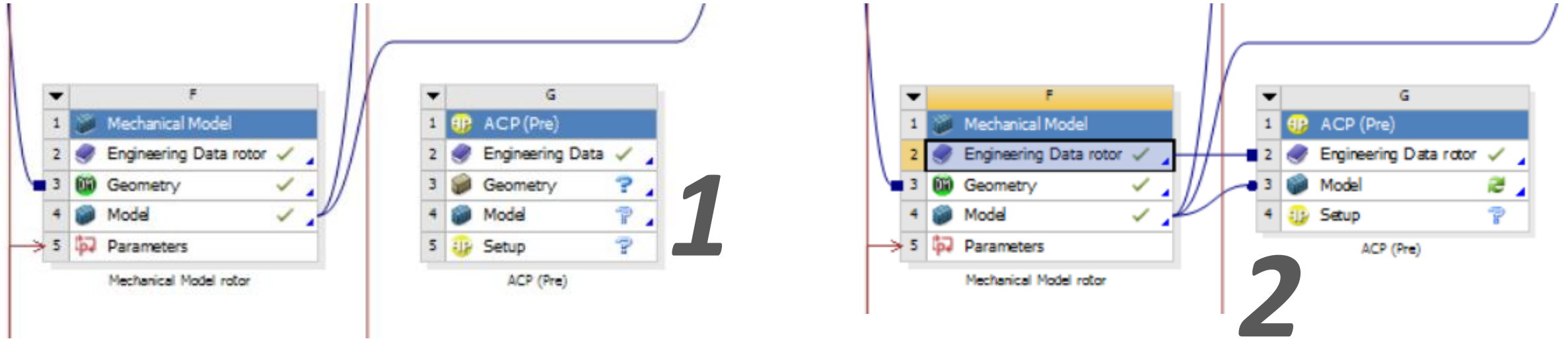


15. Workshop Rotordynamics

1. The preexistent model of the spinning rotor uses a simple steel for both rotor and shaft, we will update the whole analysis changing the steel disk for a composite disk



15. Workshop Rotordynamics



1. Drag and drop ACP (Pre) in the project schematic
2. Connect Model of the Mechanical Model of the rotor to the ACP (Pre) Model
3. Engineering Data rotor of the Mechanical Model of the rotor to the ACP (Pre) Engineering Data

15. Workshop Rotordynamics

1

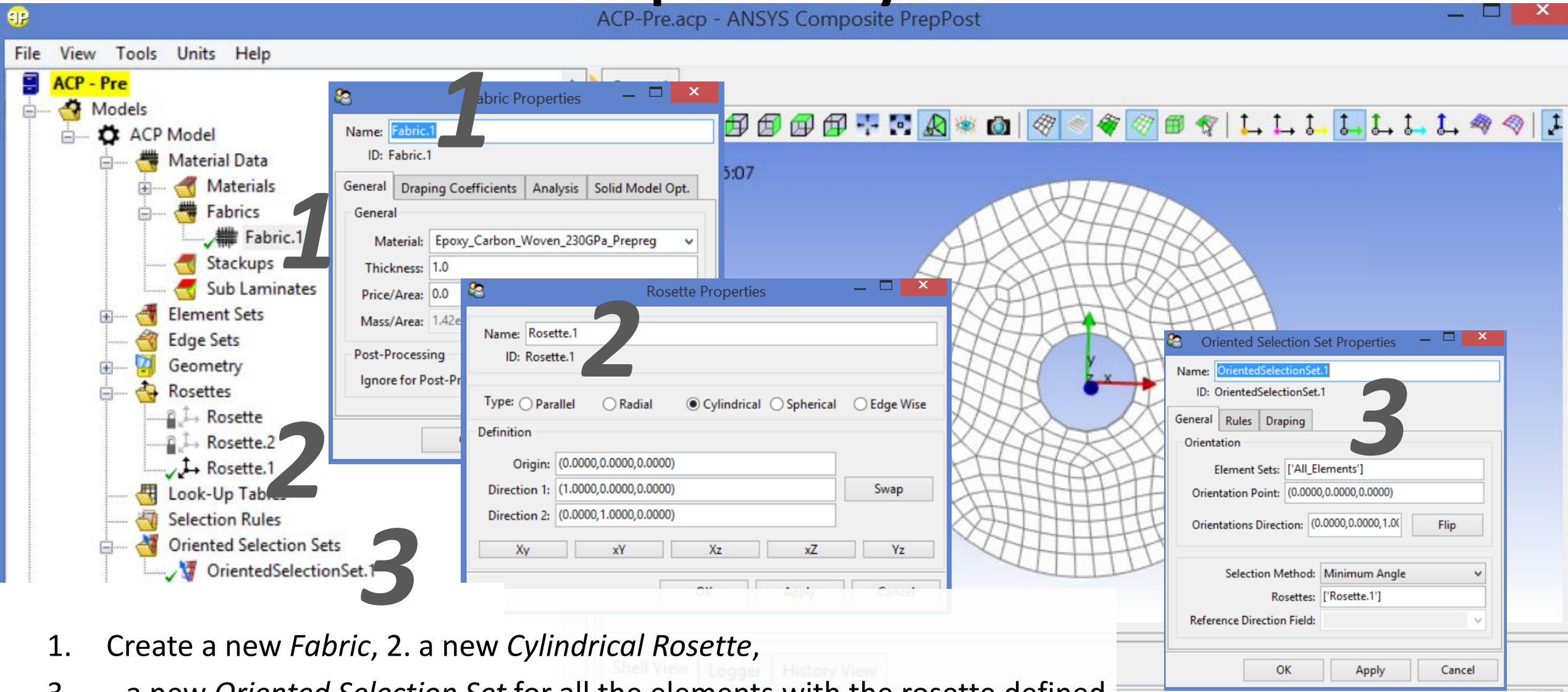
2

1

	A	B	D
1	Contents of Engineering Data rotor		Description
2	Material		
3	Epoxy_Carbon_Woven_230GPa_Prepreg	<input type="checkbox"/>	
4	Resin_Epoxy	<input type="checkbox"/>	
5	Structural Steel	<input type="checkbox"/>	Fatigue Data at zero mean stress comes from 1998 ASME BPV Code, Section 8, Div 2, Table 5-110.1
*	Click here to add a new material		

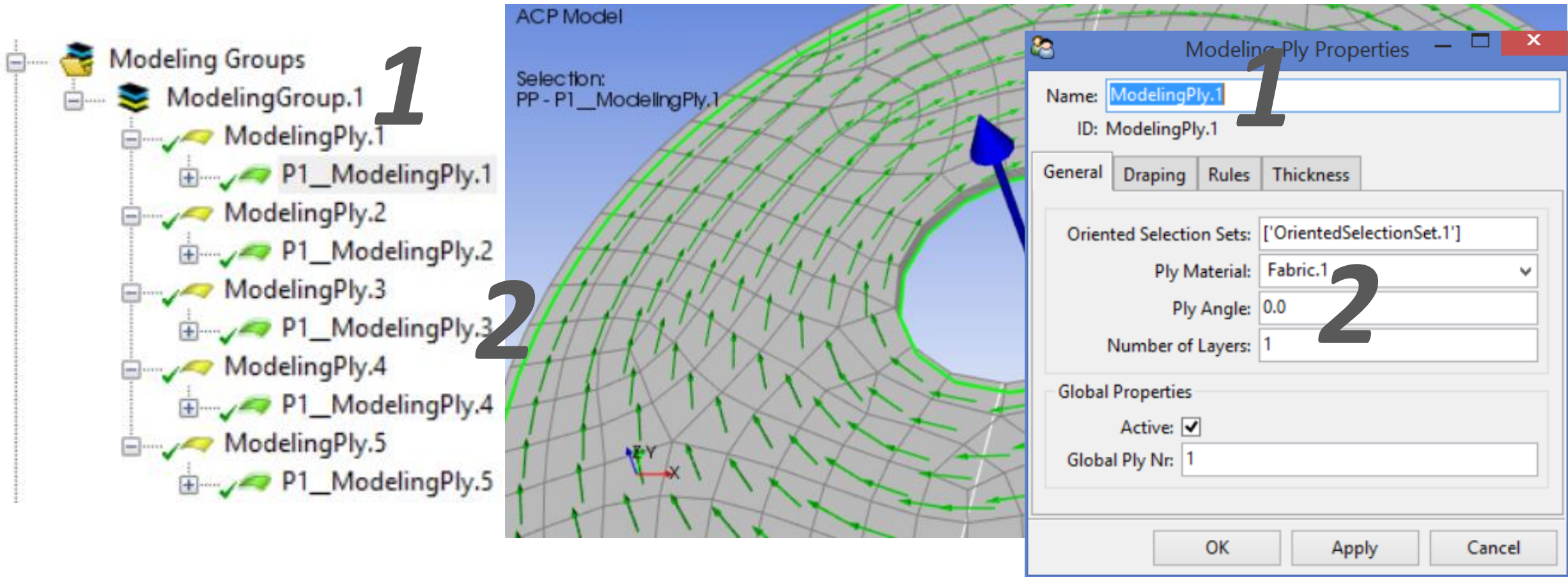
1. Double click on *Engineering Data rotor* and add two new materials from Engineering Data Sources, *Resin_Epoxy* and *Epoxy_Carbon_Woven_230GPa_Prepreg*
2. Double click on *Setup* in ACP (Pre)

15. Workshop Rotordynamics



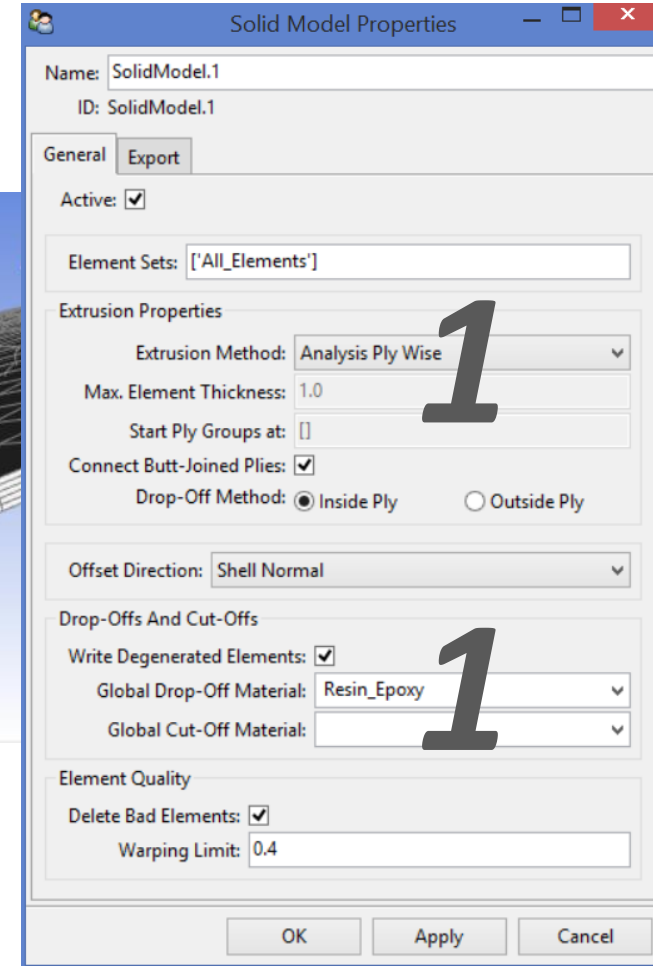
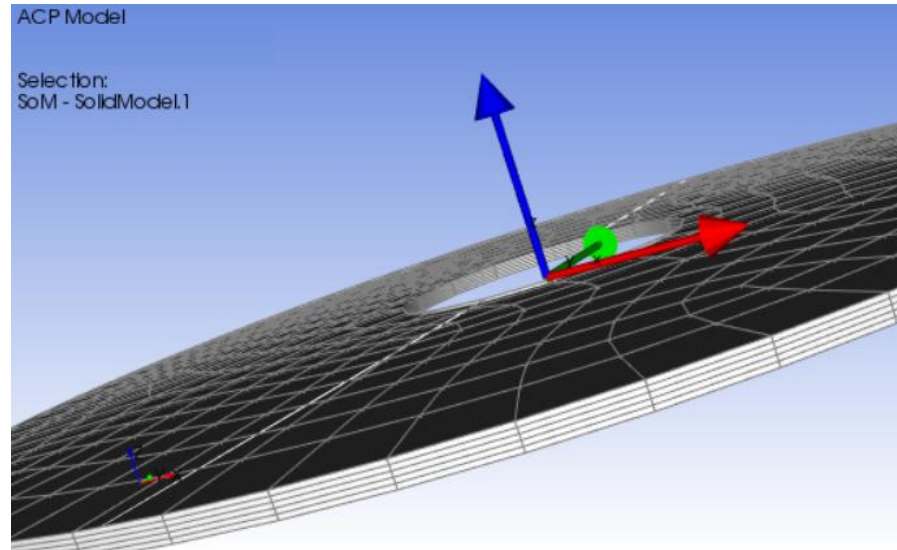
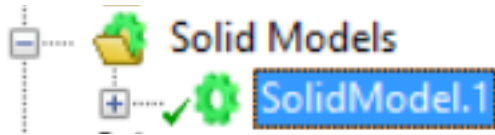
1. Create a new *Fabric*, 2. a new *Cylindrical Rosette*,
3. a new *Oriented Selection Set* for all the elements with the rosette defined before

15. Workshop Rotordynamics



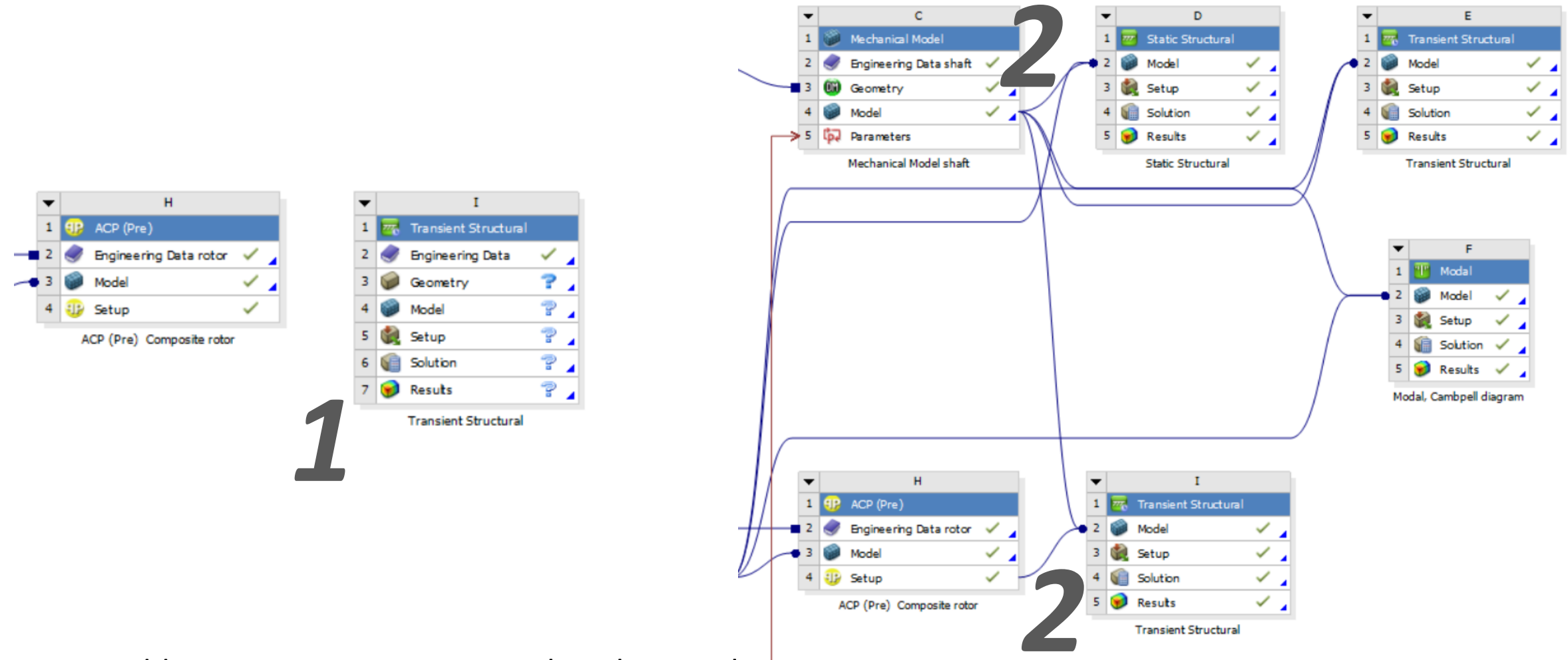
1. Create a new Modeling Group with fabric and oriented selection set defined before
2. Add 5 plies with Ply Angles oriented respectively at 0° , 90° , 45° , -90° , 0°

15. Workshop Rotordynamics



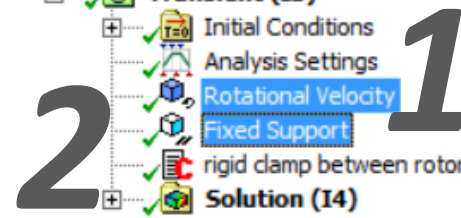
1. Extrude the shell to create a solid model, select *Analysis Ply Wise* and *Resin_Epoxy* as global drop-off material
2. Update and close ACP (Pre)

15. Workshop Rotordynamics



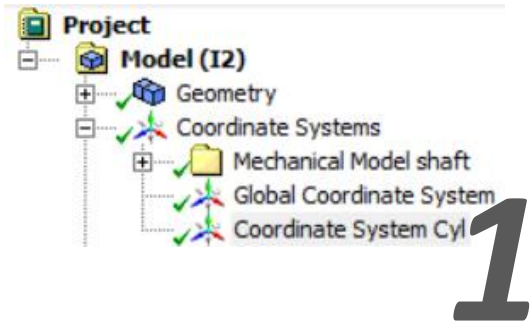
1. Add a new Transient Structural analysis in the project schematic
2. Connect the Mechanical Model of the Shaft and the Setup of ACP (Pre) to the Model of the transient analysis and open Mechanical for the transient analysis

1

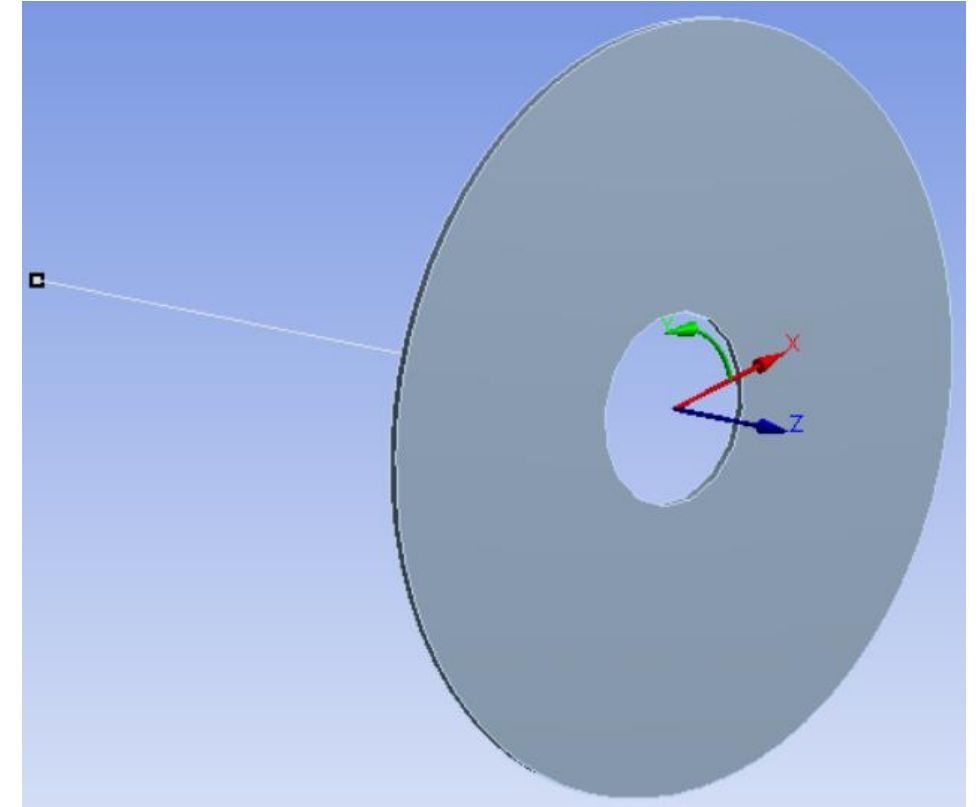


1. Insert a ramped rotation velocities for all the bodies (shaft and disk)
2. Add a fixed support at the end of the shaft

15. Workshop Rotordynamics



Details of "Coordinate System Cyl"	
[-] Definition	
Type	Cylindrical
Coordinate System	Program Controlled
Suppressed	No
[-] Origin	
Define By	Geometry Selection
Geometry	Click to Change
Origin X	-6.6214e-004 mm
Origin Y	1.5091e-004 mm
Origin Z	5. 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	[-6.6214e-004 1.5091e-004 5.]



1. Create a new cylindrical coordinate system, it will be later used to plot solution quantities

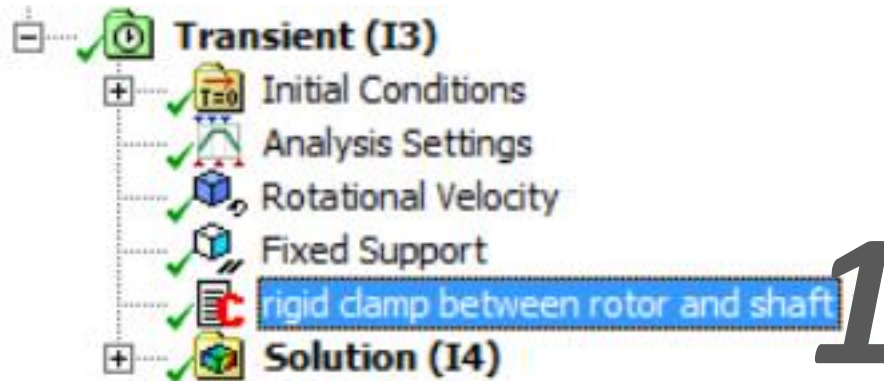
15. Workshop Rotordynamics

The clamp is modeled with constraint equations. The inertia properties of the clamp are:

Mass = 6.8748 kg

Inertia (XX,YY) = 0.0282 kg.m²

Inertia (ZZ) = 0.0355 kg.m²



```
Commands

! ** clamp between shaft and rotor
et,3,21

r,3,6.8748,6.8748,6.8748,0.0282,0.0282,0.0355
type,3
real,3

n,
ncent = node(0,0,0)

e,ncent

cerig,ncent,node(0,0,-50),all

csys,1

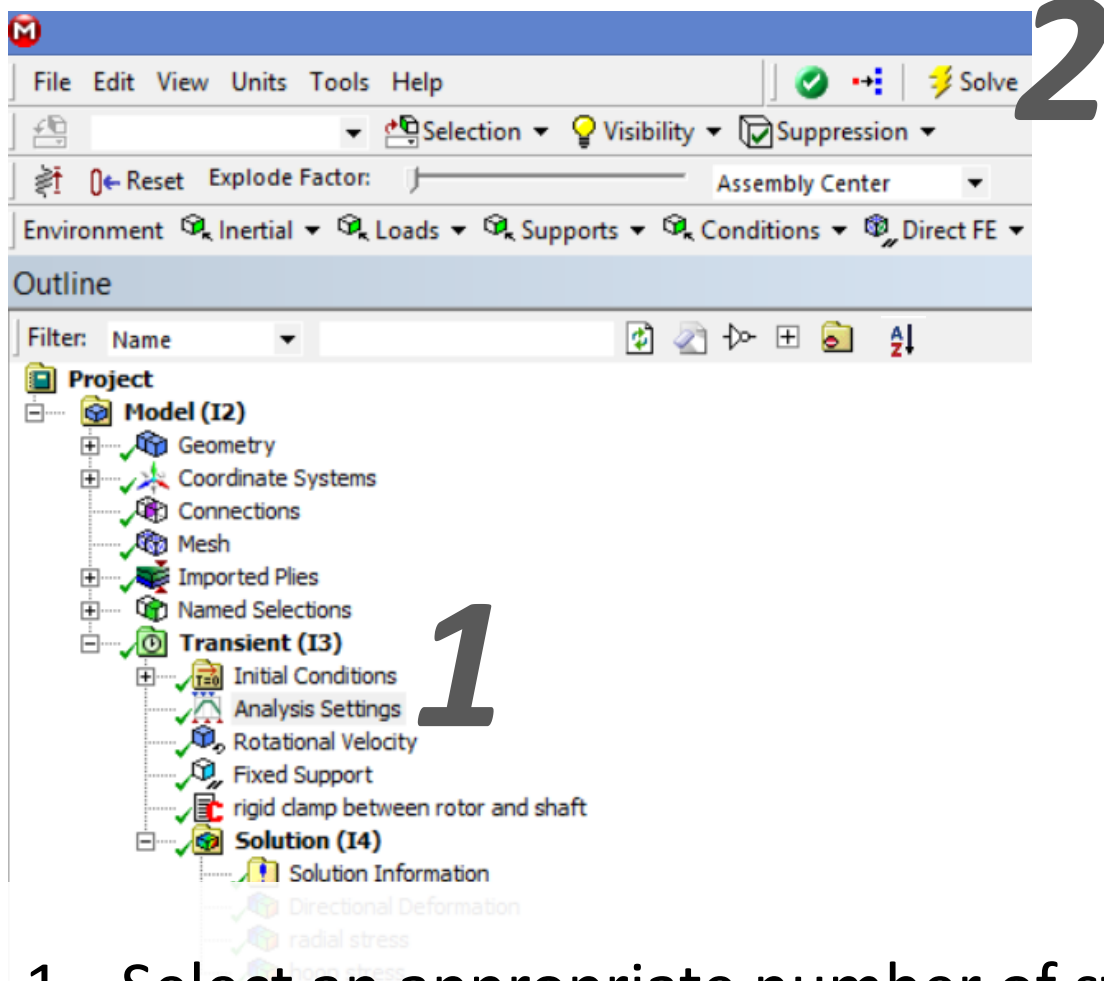
nset,,loc,x,50
nset,a,node,,ncent

cerig,ncent,all,all

allsel
csys,0
```

1. Add a command snippet in the model to constrain disk a and shaft together, the mass and inertia of the rigid clamp are added to a point mass

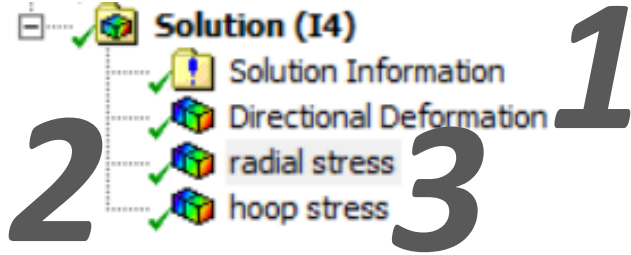
15. Workshop Rotordynamics



Details of "Analysis Settings"	
Step Controls	
Number Of Steps	1.
Current Step Number	1.
Step End Time	1. s
Auto Time Stepping	On
Define By	Substeps
Initial Substeps	20.
Minimum Substeps	1.
Maximum Substeps	100.
Time Integration	On
Solver Controls	
Solver Type	Direct
Weak Springs	Off
Large Deflection	On

1. Select an appropriate number of steps for the analysis
2. Solve the model

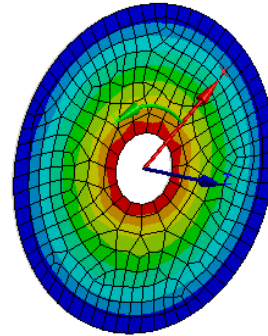
15. Workshop Rotordynamics



(1) In the solution insert *directional deformation* in radial direction, (2) *hoop stress* and (3) *radial stress* for the rotor disk (use the cylindrical system defined before)

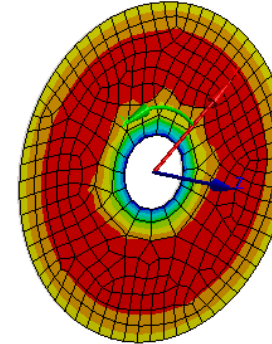
H: Transient Structural
Normal Stress
Type: Normal Stress(X Axis) - Top/Bottom - Layer 0
Unit: MPa
Coordinate System Cyl
Time: 0.55369
17.12.2015 15:43

0.10112 Max
0.090387
0.079656
0.068925
0.058194
0.047463
0.036732
0.026001
0.01527
0.0045389 Min



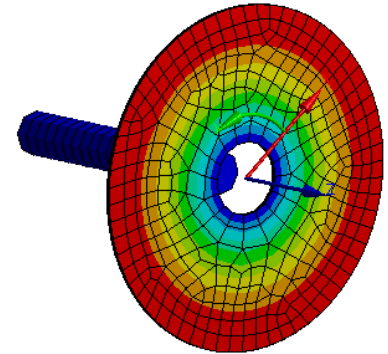
H: Transient Structural
hoop stress
Type: Normal Stress(Y Axis) - Top/Bottom - Layer 0
Unit: MPa
Coordinate System Cyl
Time: 1
17.12.2015 15:43

0.14704 Max
0.13393
0.12082
0.10771
0.094598
0.081487
0.068375
0.055263
0.042152
0.02904 Min



H: Transient Structural
Directional Deformation
Type: Directional Deformation(X Axis)
Unit: mm
Coordinate System Cyl
Time: 1
17.12.2015 15:42

0.00037258 Max
0.00033107
0.00028957
0.00024806
0.00020655
0.00016505
0.00012354
8.2039e-5
4.0534e-5
-9.7127e-7 Min



Details of "radial stress"

Scope	
Scoping Method	Geometry Selection
Geometry	1 Face
Sub Scope By	Layer
Layer	Entire Section
Position	Top/Bottom
Definition	
Type	Normal Stress
Orientation	X Axis
By	Time
<input type="checkbox"/> Display Time	Last
Coordinate System	Coordinate System Cyl
Calculate Time History	Yes
Identifier	
Suppressed	No
Integration Point Results	
Display Option	Averaged
Average Across Bodies	No
Results	

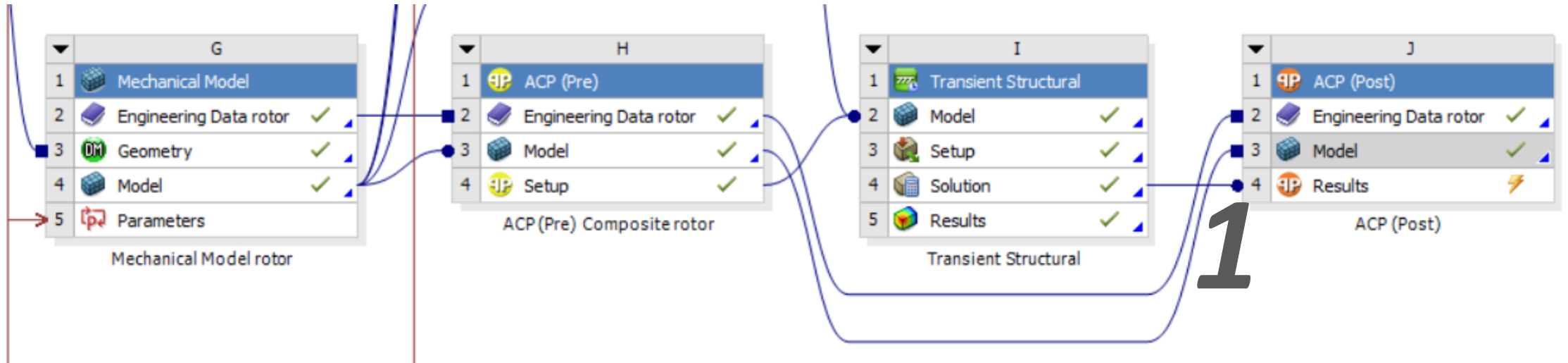
Details of "hoop stress"

Scope	
Scoping Method	Geometry Selection
Geometry	1 Face
Sub Scope By	Layer
Layer	Entire Section
Position	Top/Bottom
Definition	
Type	Normal Stress
Orientation	Y Axis
By	Time
<input type="checkbox"/> Display Time	Last
Coordinate System	Coordinate System Cyl
Calculate Time History	Yes
Identifier	
Suppressed	No
Integration Point Results	
Display Option	Averaged
Average Across Bodies	No
Results	

Details of "Directional Deformation"

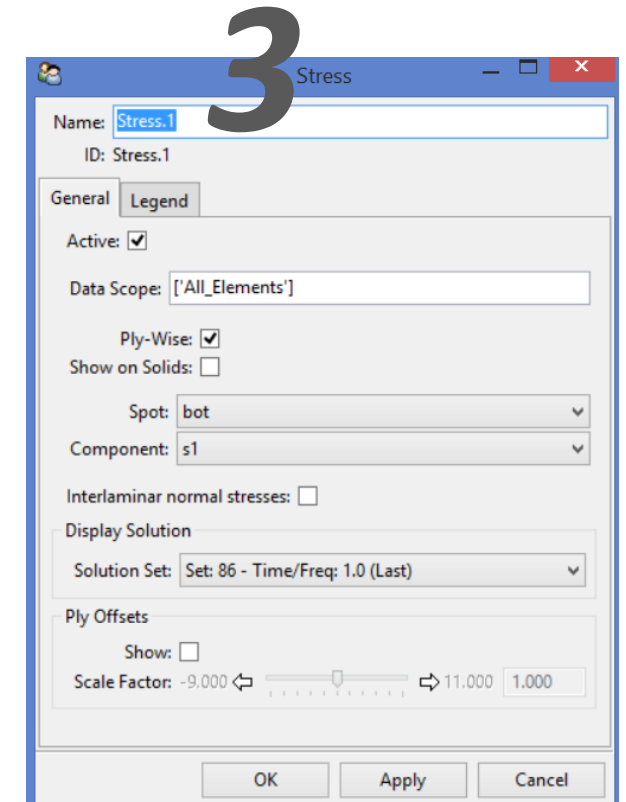
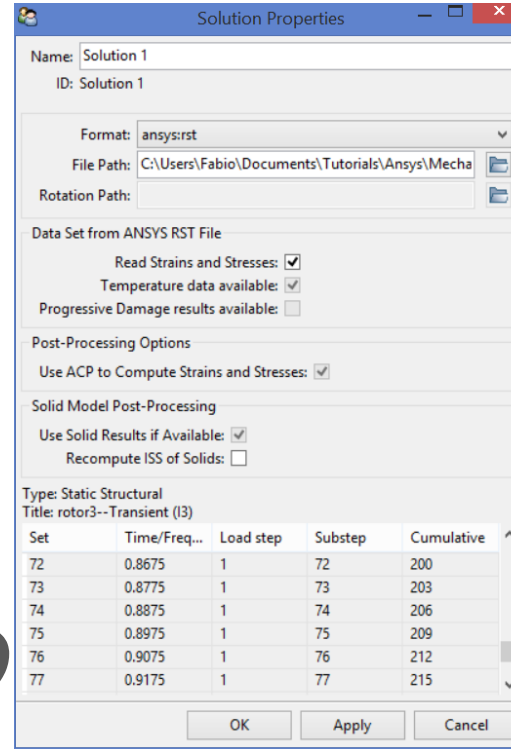
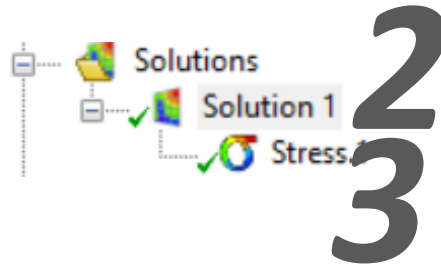
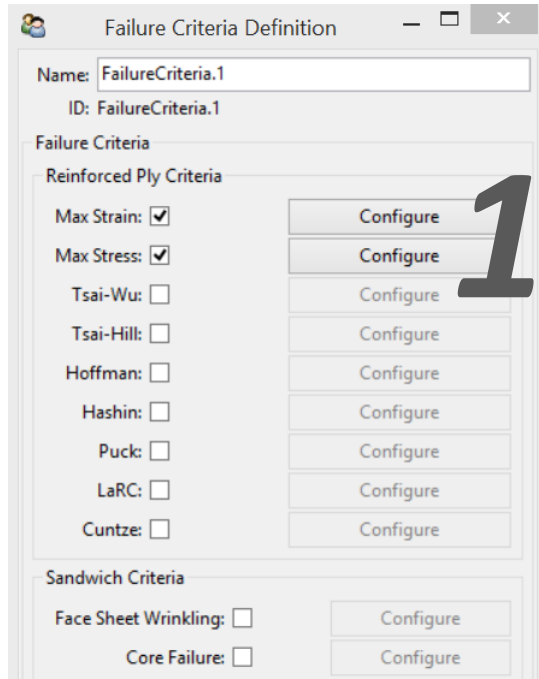
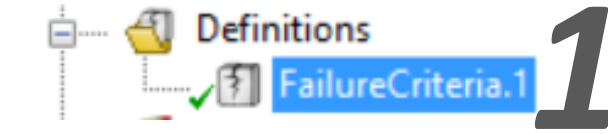
Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Directional Deformation
Orientation	X Axis
By	Time
<input type="checkbox"/> Display Time	Last
Coordinate System	Coordinate System Cyl
Calculate Time History	Yes
Identifier	
Suppressed	No
Results	
<input type="checkbox"/> Minimum	-2.0207e-004 mm
<input type="checkbox"/> Maximum	3.746e-002 mm
Minimum Occurs On	Line Body(Mechanical Model shaft)
Maximum Occurs On	SolidModel.1
Minimum Value Over Time	
<input type="checkbox"/> Minimum	-2.0207e-004 mm
<input type="checkbox"/> Maximum	-9.7184e-007 mm
Maximum Value Over Time	
<input type="checkbox"/> Minimum	3.735e-004 mm
<input type="checkbox"/> Maximum	3.746e-002 mm
Information	

15. Workshop Rotordynamics



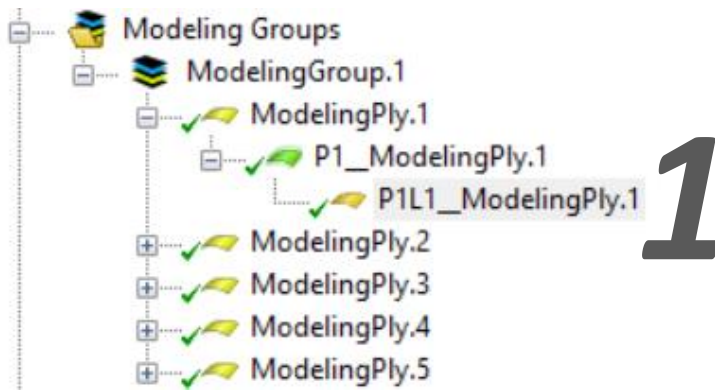
1. Add ACP(Post) in the project schematic, drag and drop onto model of ACP (Pre) and connect it as shown in the picture above to the transient structural solution)
2. Update the project and open ACP(Post)

15. Workshop Rotordynamics



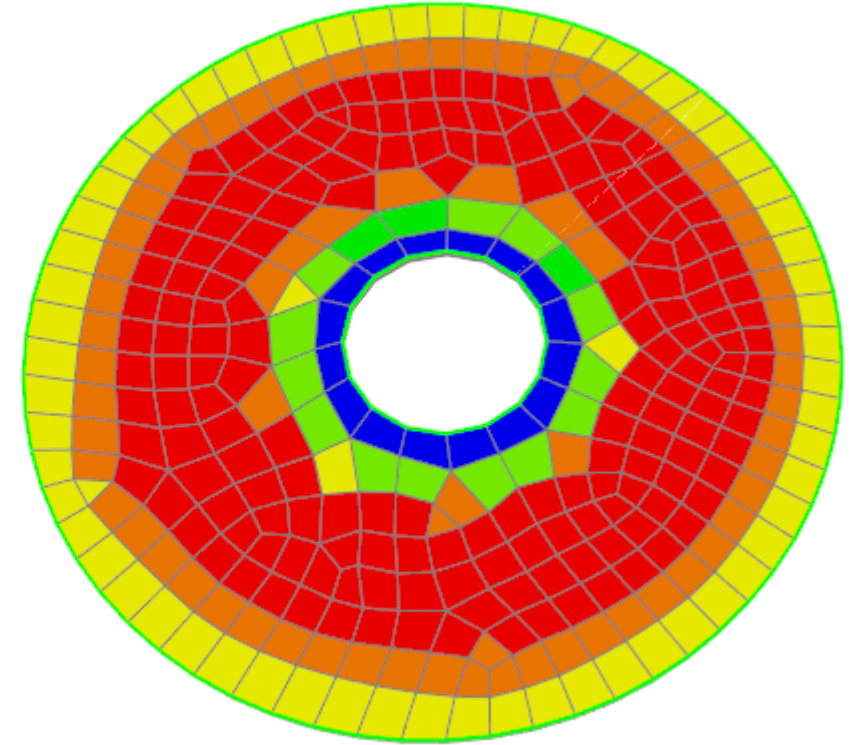
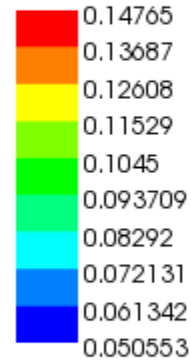
1. Add Max Stress and Max Strain failure criteria
2. Double click Solution 1. Select the last set (time 1.0) in Solution 1
3. Right click Solution 1, select Create Stress from the menu

15. Workshop Rotordynamics



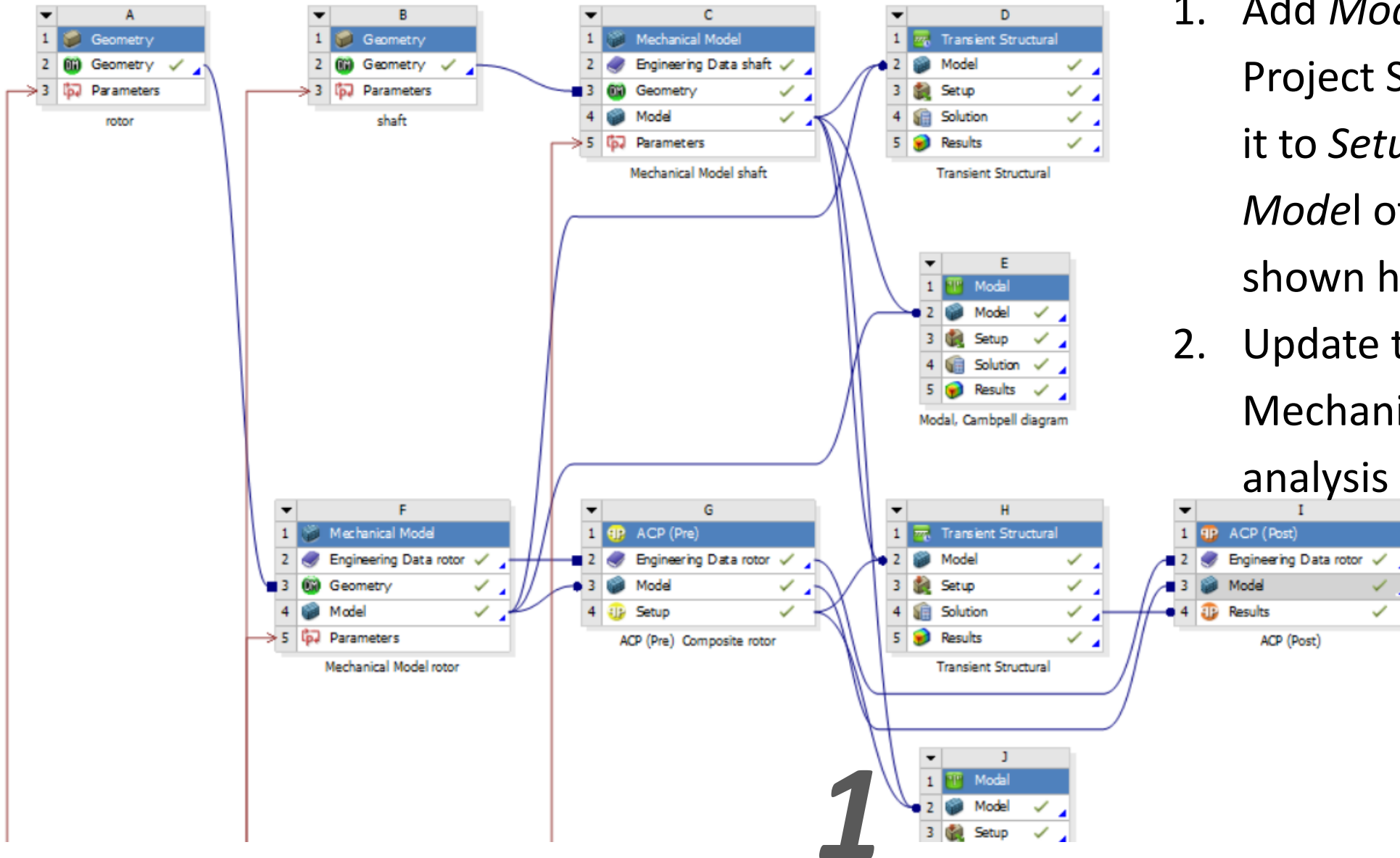
Stress - s1 - bot
Ply-Wise
Unit: MPa
Set: 95 - Time/Freq: 1.0 (Last)
Max: 0.14765
Min: 0.050553

Selection:
AP - P1L1__ModelingPly.1
Stress.1



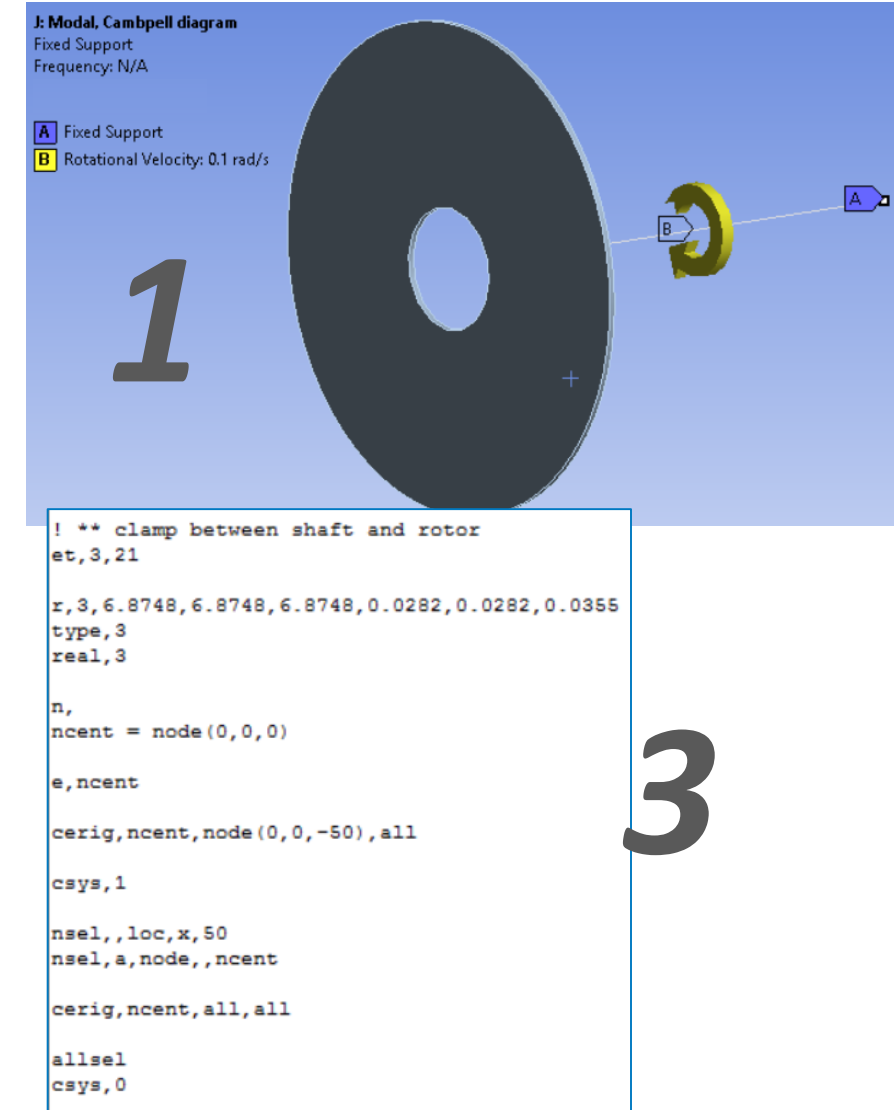
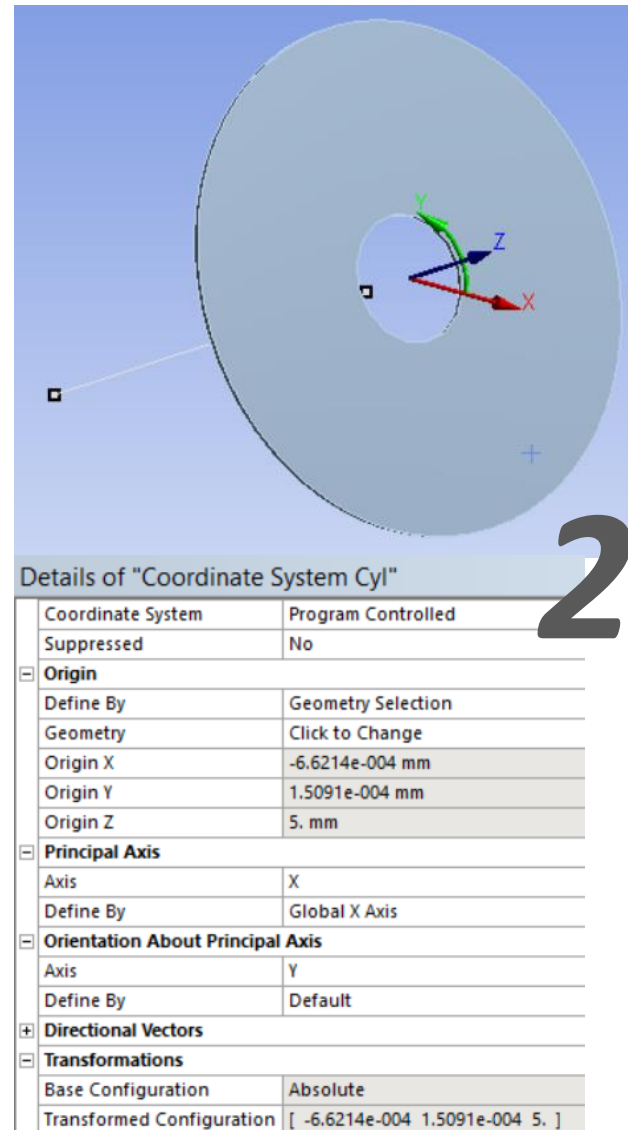
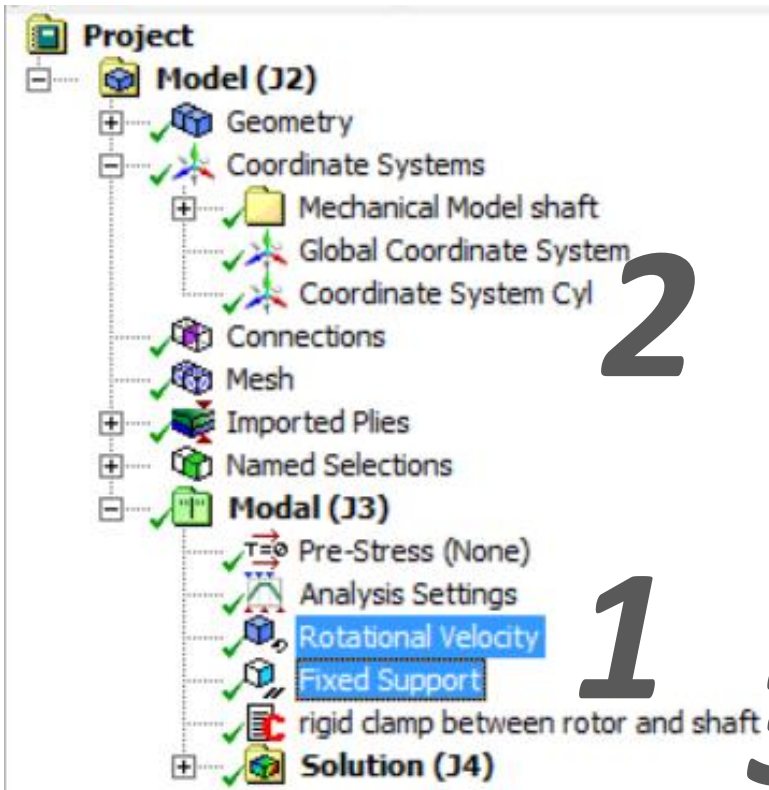
1. Visualize the stress plot by selecting the appropriate ply
2. Exit ACP (Post)

15. Workshop Rotordynamics



1. Add *Modal Analysis* to the Project Schematic and connect it to *Setup* of ACP (*Pre*) and *Model* of *Mechanical Model* as shown here
2. Update the project and open Mechanical of the Modal analysis

15. Workshop Rotordynamics



As before add (1) Fixed support and Rotational Velocity, (2) Cylindrical Coordinate System, (3) Command snippet to clamp shaft and rotor

15. Workshop Rotordynamics



Details of "Rotational Velocity"

Scope

Scoping Method	Geometry Selection
Geometry	All Bodies

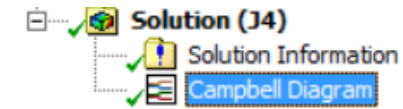
Definition

Define By	Vector
Magnitude	Tabular Data
Axis	Click to Change
Suppressed	No

Tabular Data

	Points	Rotational Velocity [rad/s]
1	1	0.1
2	2	50.
3	3	100.
4	4	500.
*		

1. Tabular Data for the added rotational velocity



Details of "Campbell Diagram"

Scope

Rotational Velocity Selection	Rotational Velocity
-------------------------------	---------------------

Campbell Diagram Controls

Y Axis Data	Frequency
Critical Speed	Yes
<input type="checkbox"/> Ratio	1.
Sorting	Yes

Axis

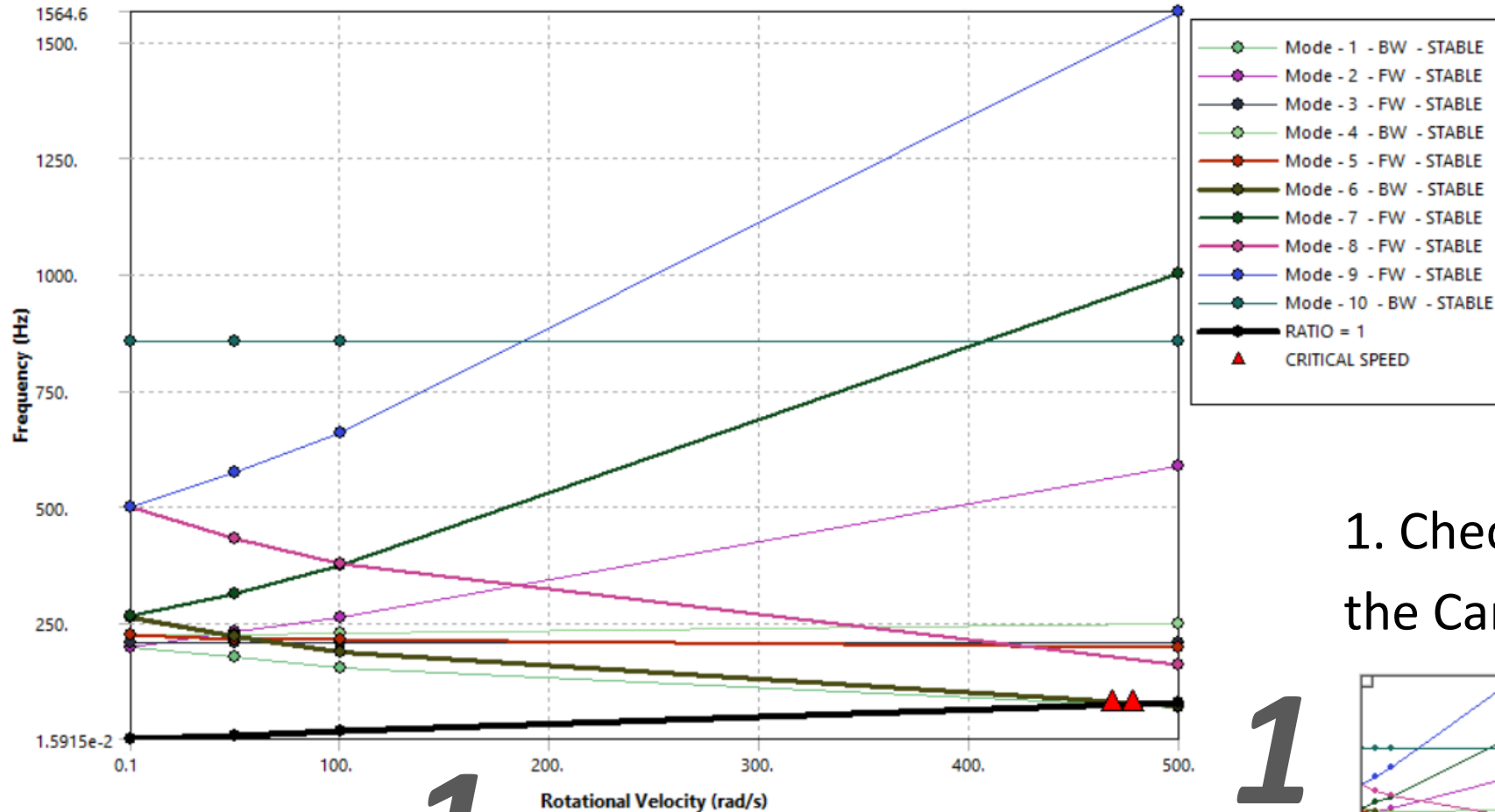
X Axis Label	Rotational Velocity
X Axis Range	Program Controlled
X Axis Minimum	0.1 rad/s
X Axis Maximum	500. rad/s
Y Axis Label	Frequency
Y Axis Range	Program Controlled
Y Axis Minimum	1.5915e-002 Hz
Y Axis Maximum	1564.6 Hz

Definition

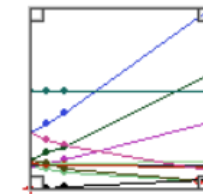
Suppressed	No
------------	----

2. Insert Campbell Diagram in the solution

15. Workshop Rotordynamics



1. Check the critical speeds using the Campbell Diagram



Mode	Whirl Direction	Mode Stability	Critical Speed	0.1 rad/s	50. rad/s	100. rad/s	500. rad/s
1.	BW	STABLE	468.13 rad/s	197.81 Hz	175.07 Hz	154.43 Hz	67.587 Hz
2.	FW	STABLE	NONE	198.4 Hz	231.55 Hz	259.77 Hz	585.87 Hz
3.	FW	STABLE	NONE	207.13 Hz	207.07 Hz	207. Hz	208.3 Hz
4.	BW	STABLE	NONE	222.76 Hz	224.16 Hz	226.37 Hz	248. Hz