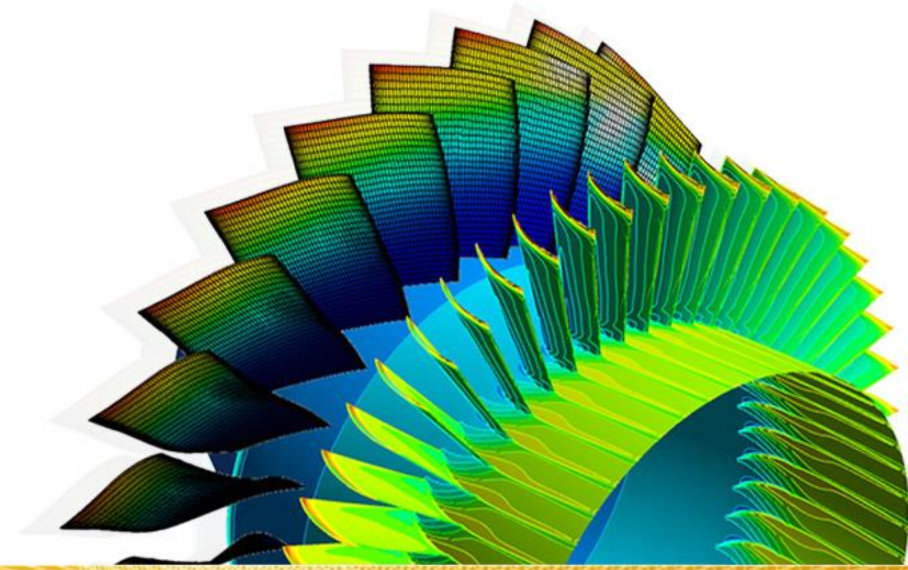
ANSYS Composite PrepPost 19.0

Workshop 10.6 – Rotordynamics

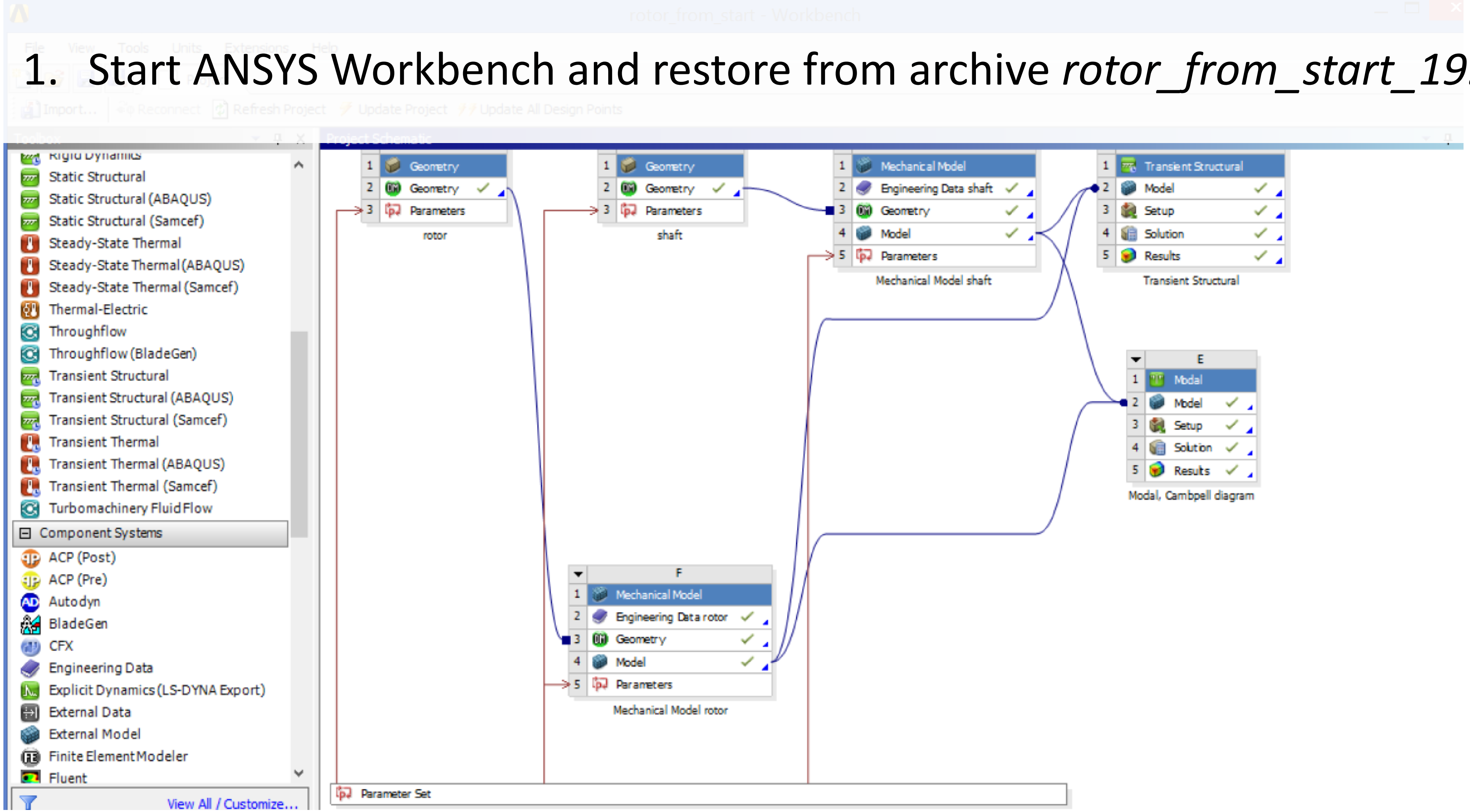


15. Workshop Rotordynamics

- 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

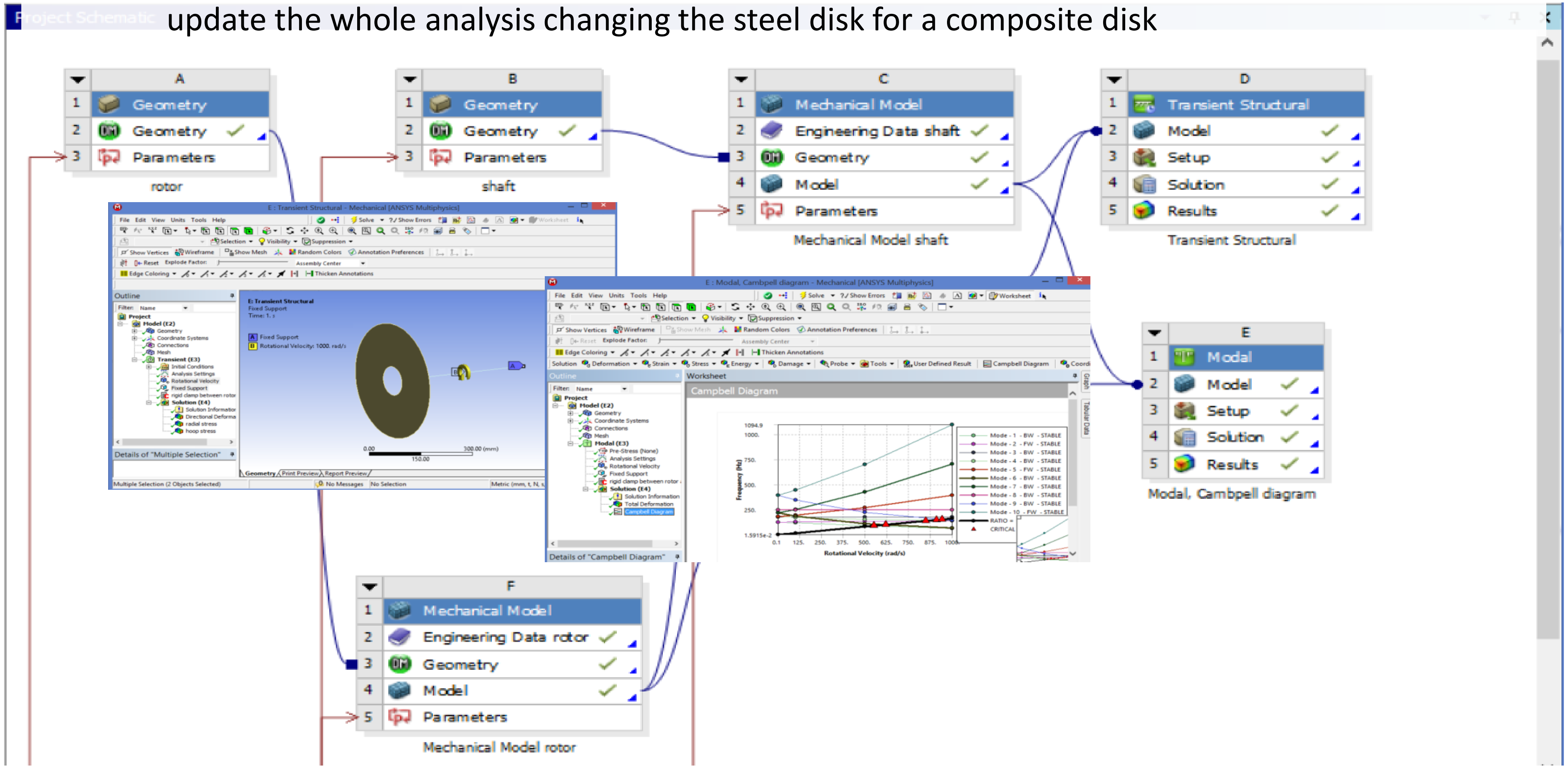
15. Workshop Rotordynamics

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

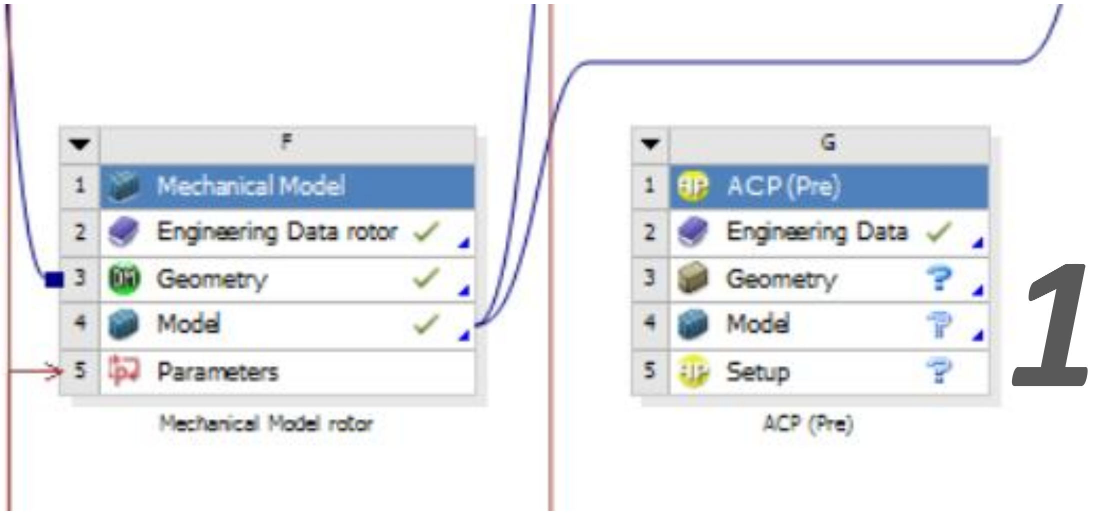


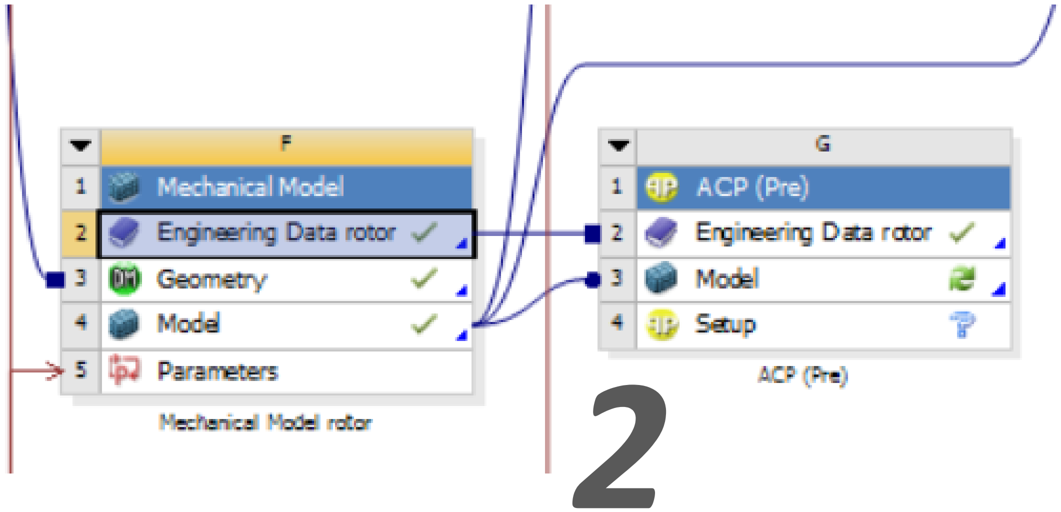
15. Workshop Rotordynamics

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



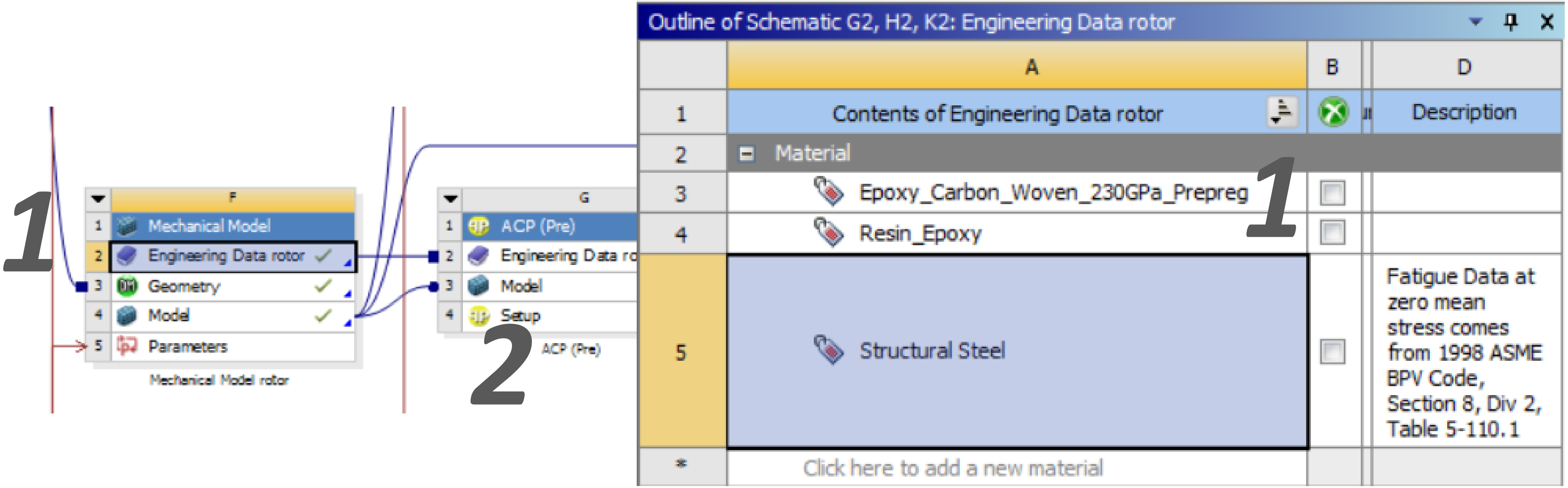
15. Workshop Rotordynamics





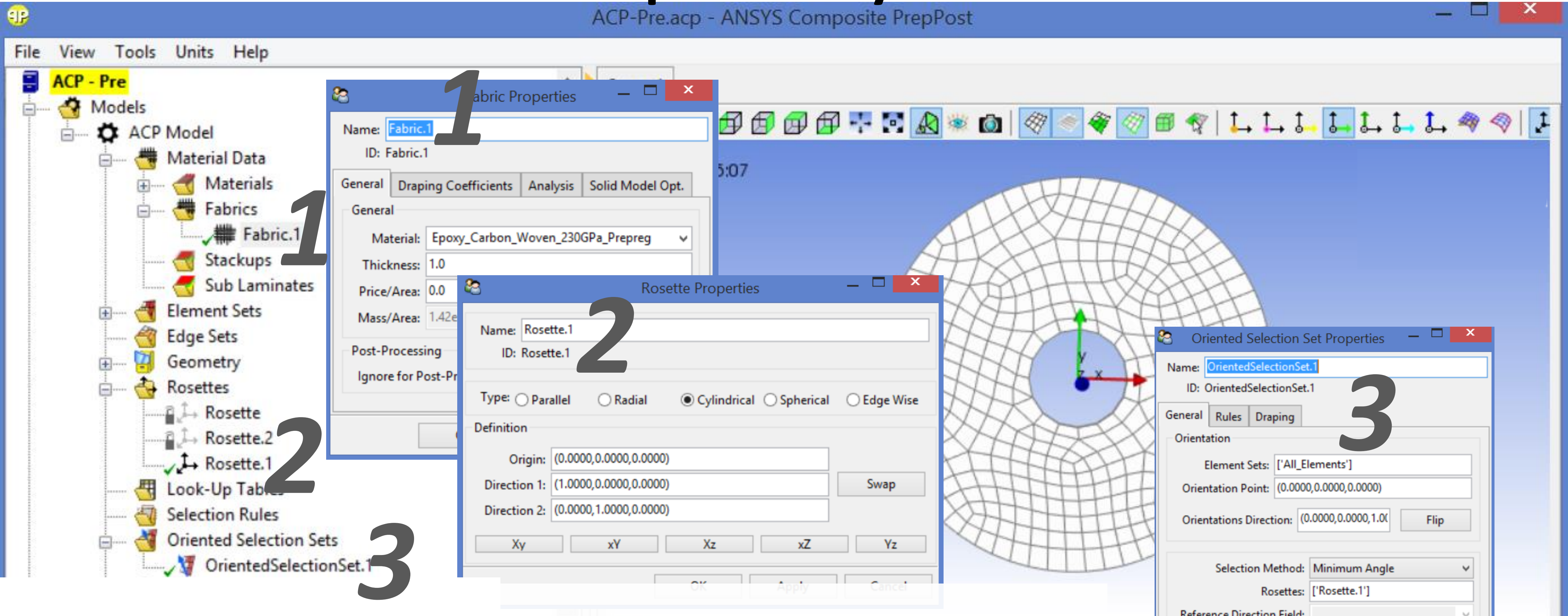
1. Drag and drop ACP (Pre) in the project schematic
2. Connect Model of the Mechanical Model of the rotor to the ACP (Pre) Model
3. Engineering Data rotor of the Mechanical Model of the rotor to the ACP (Pre) Engineering Data

15. Workshop Rotordynamics



1. 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)

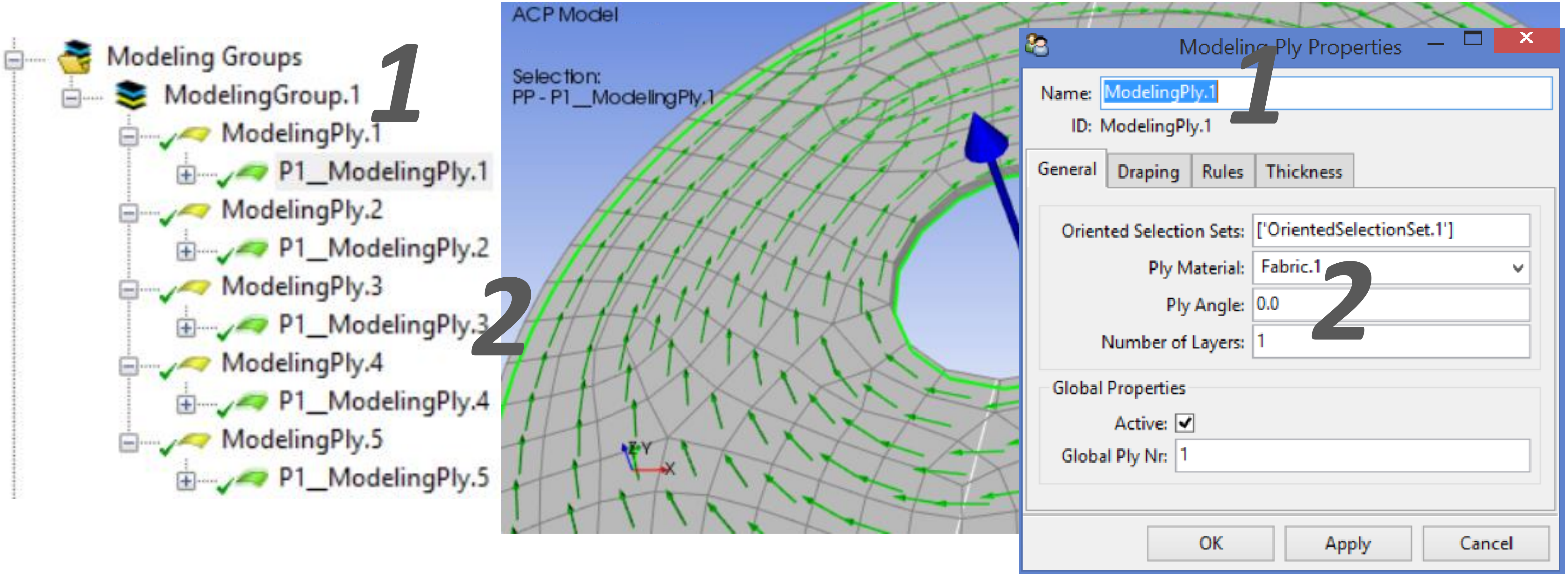
15. Workshop Rotordynamics



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

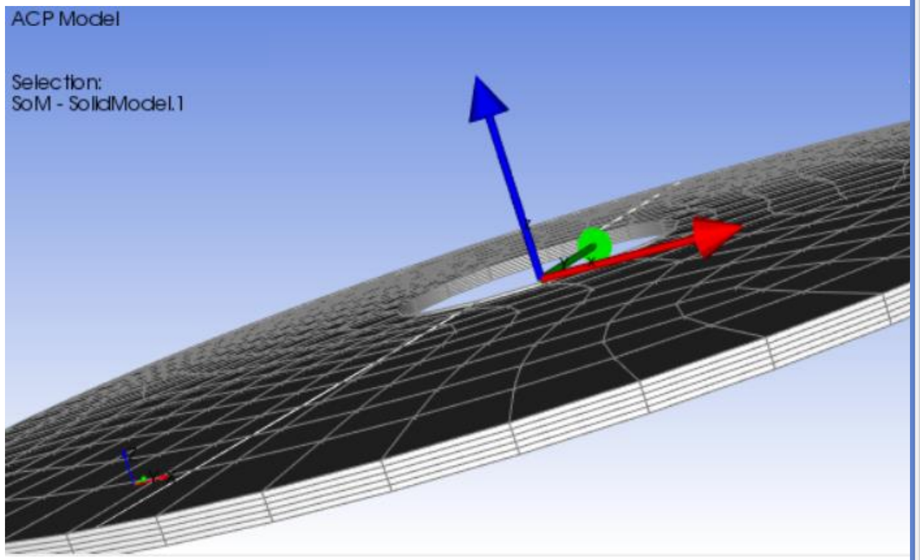
ANSYS

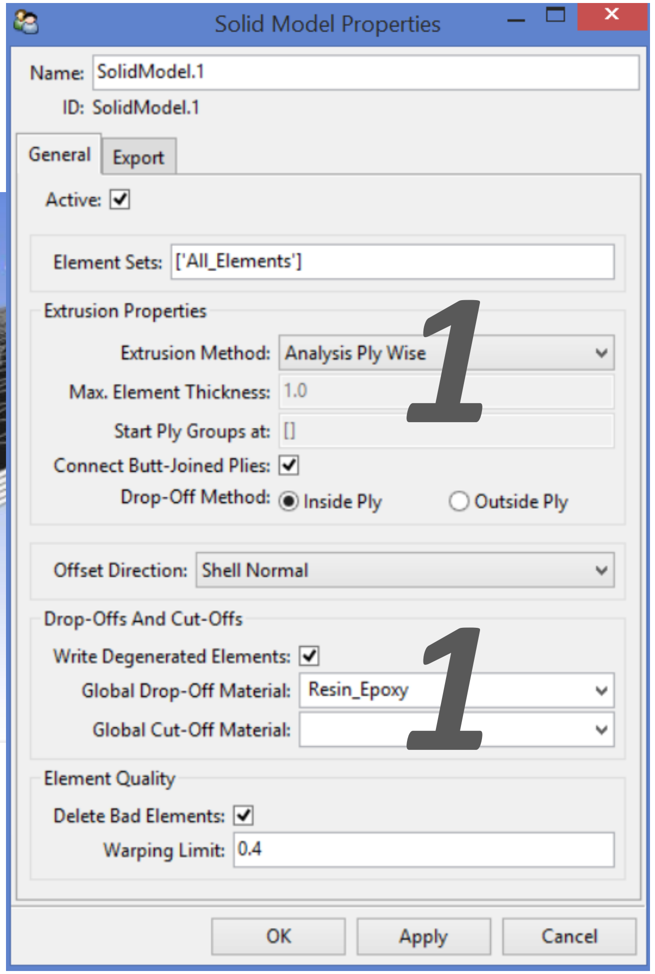
15. Workshop Rotordynamics



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)

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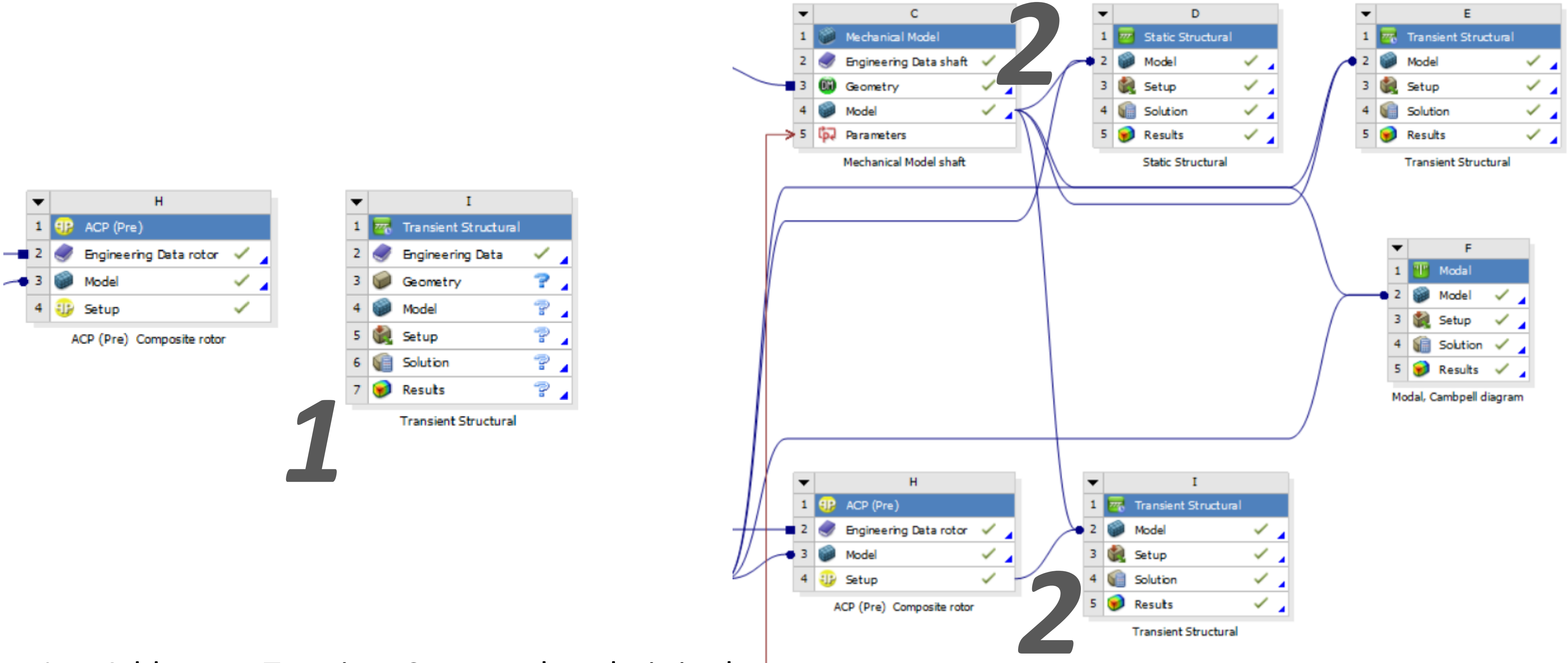
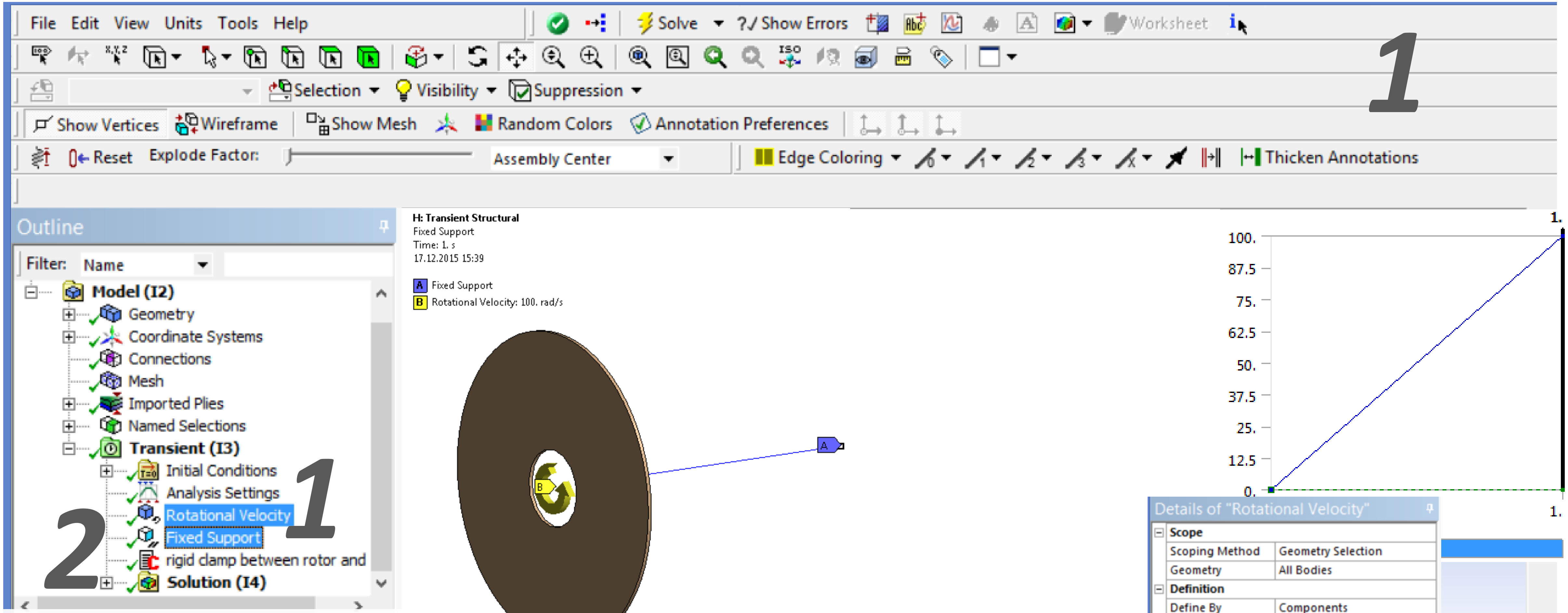
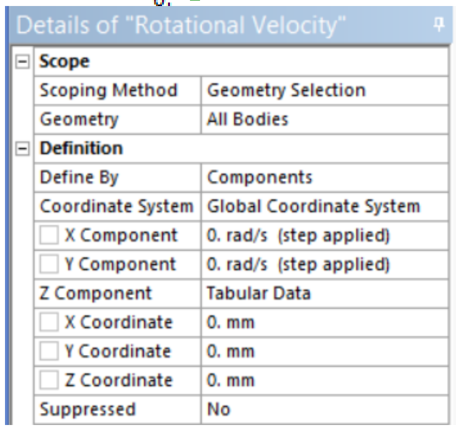
15. Workshop Rotordynamics



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

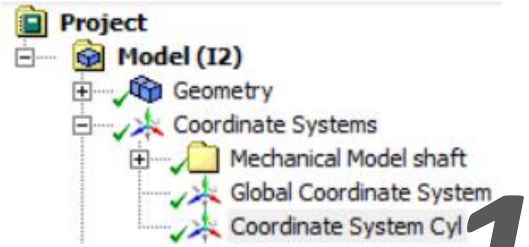
15. Workshop Rotordynamics





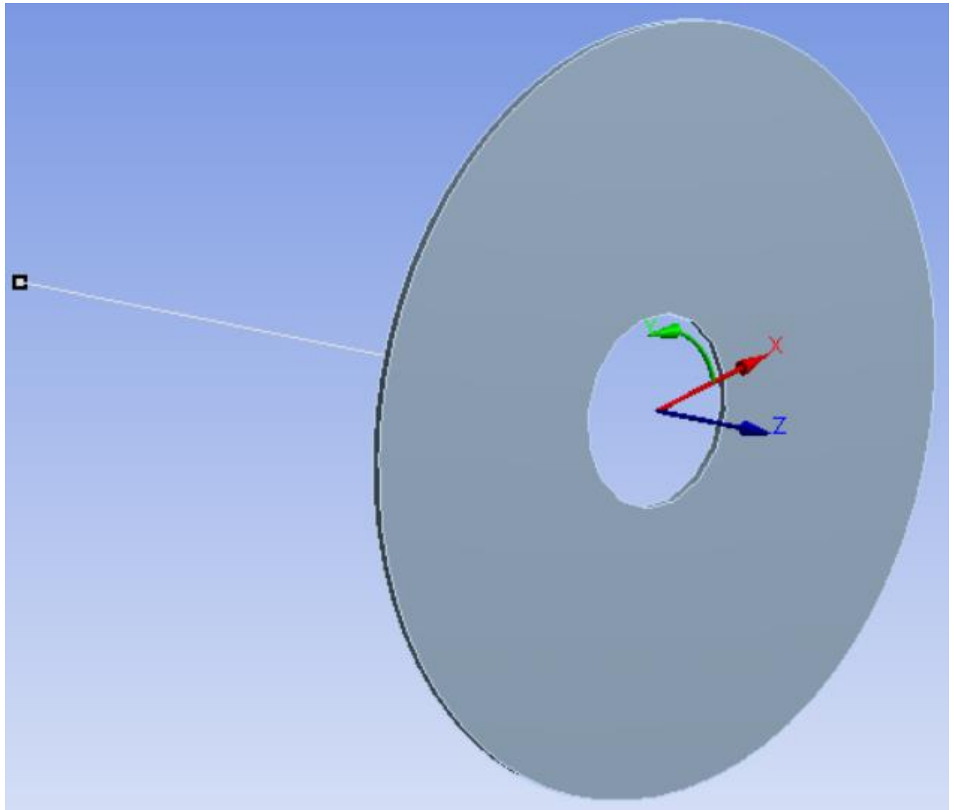
1. Insert a ramped rotation velocities for all the bodies (shaft and disk)
2. Add a fixed support at the end of the shaft

15. Workshop Rotordynamics



1

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

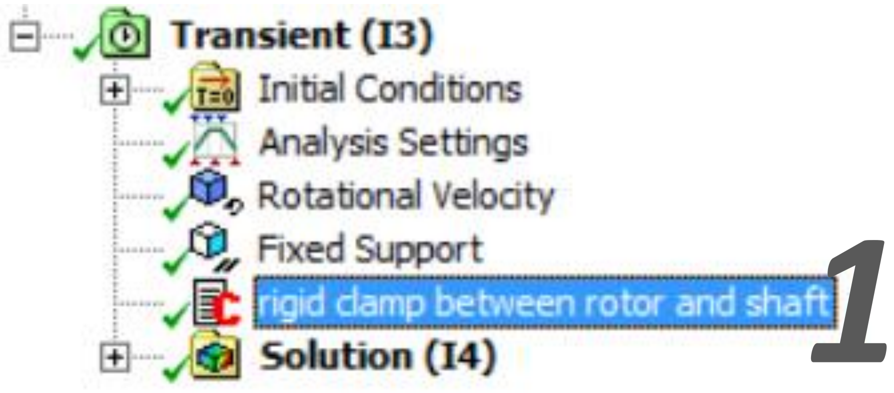
15. Workshop Rotordynamics

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

Mass = 6.8748 kg

Inertia (XX,YY) = 0.0282 kg.m^2

Inertia (ZZ) = 0.0355 kg.m^2



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

nsel,,loc,x,50
nsel,a,node,,ncent

cerig,ncent,all,all

allsel
csys,0
```

1

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

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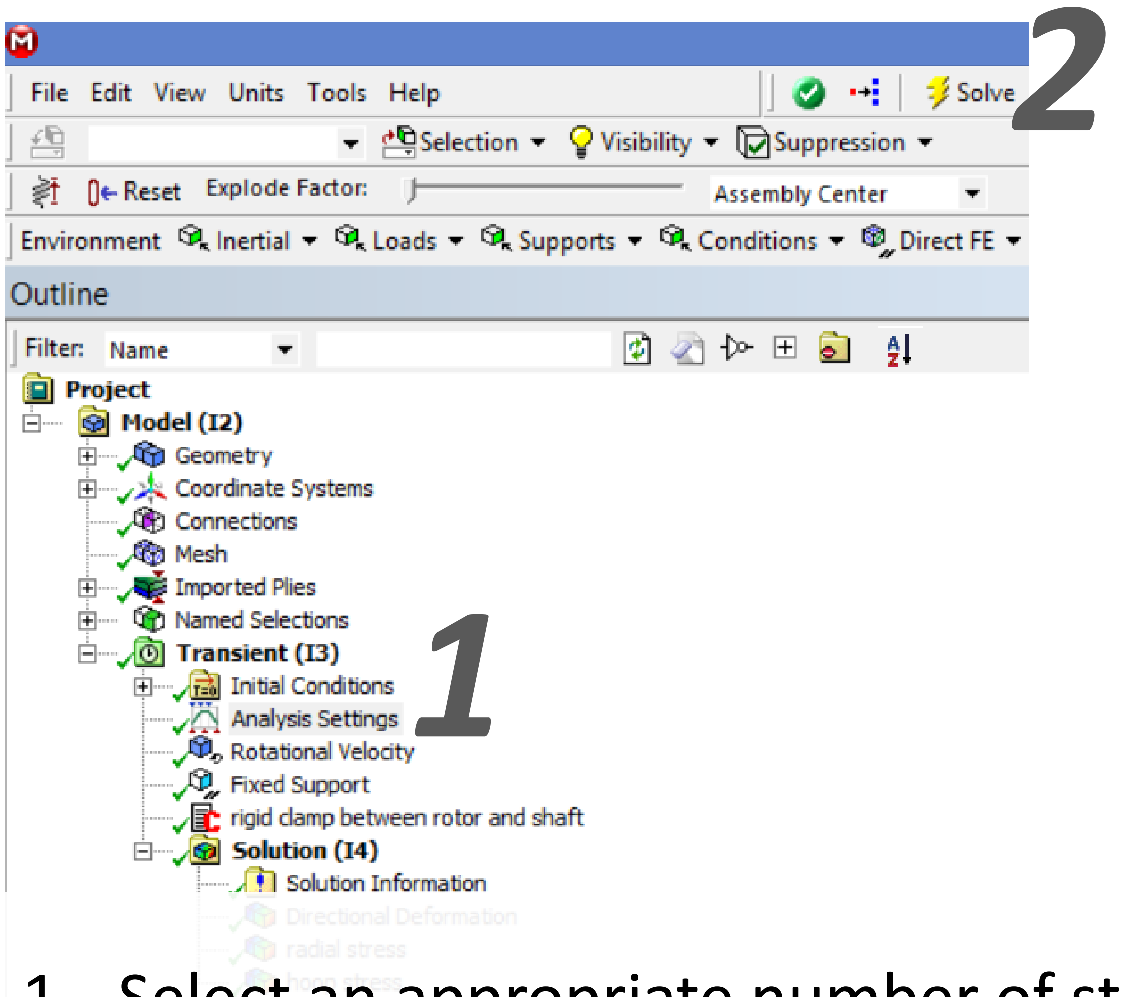
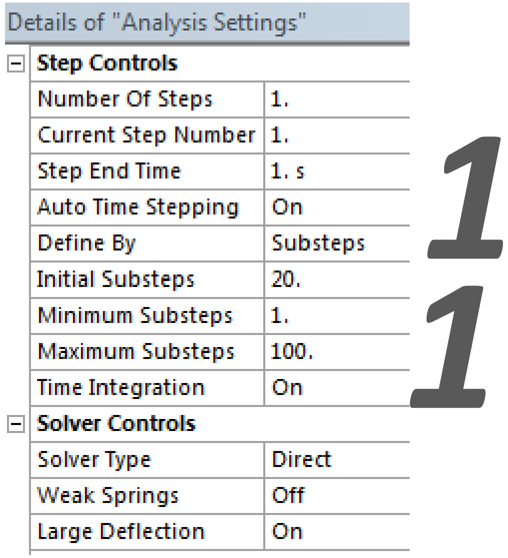
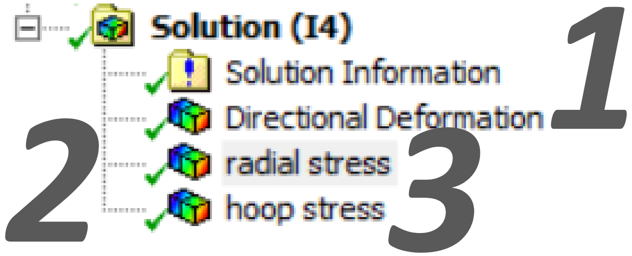
15. Workshop Rotordynamics

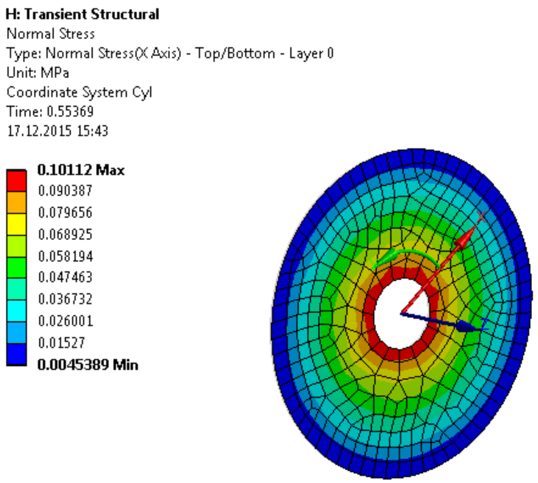


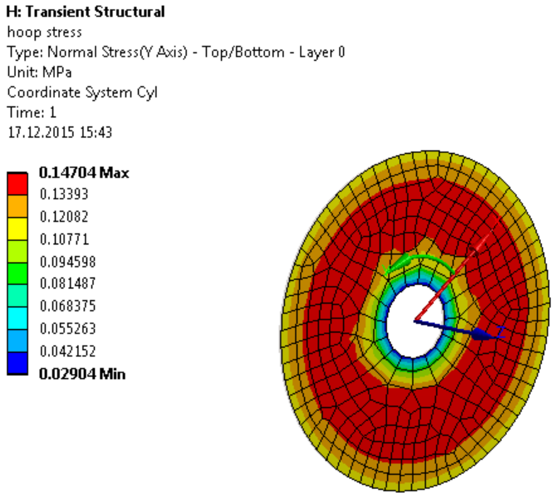


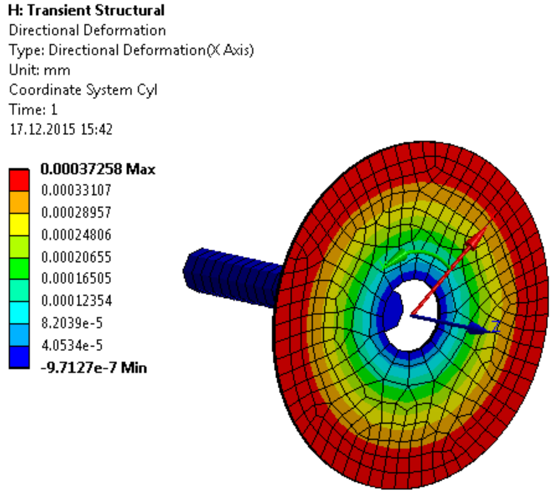
1. Select an appropriate number of steps for the analysis
2. Solve the model

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)

3

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
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	

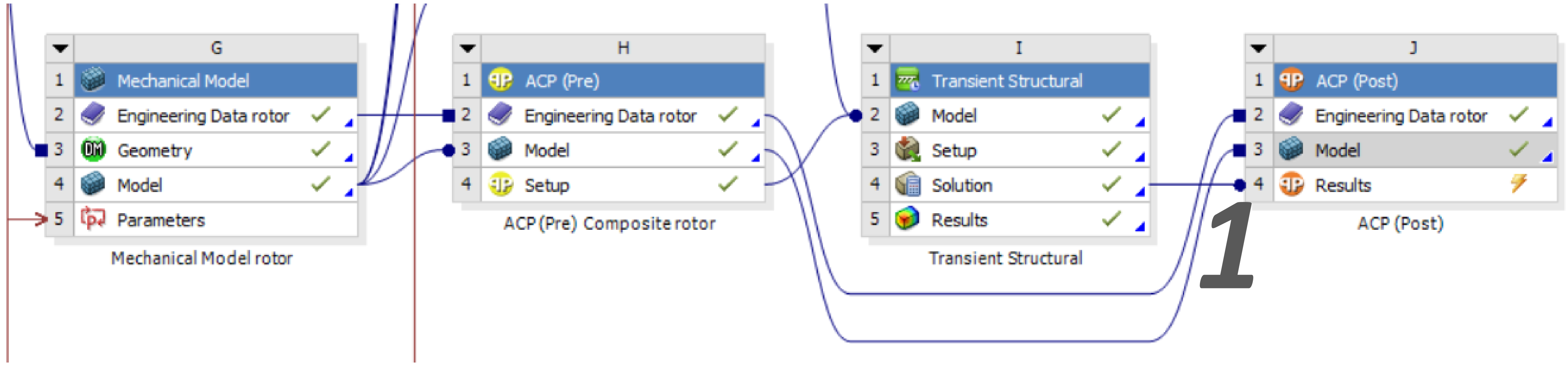
2

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
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	

1

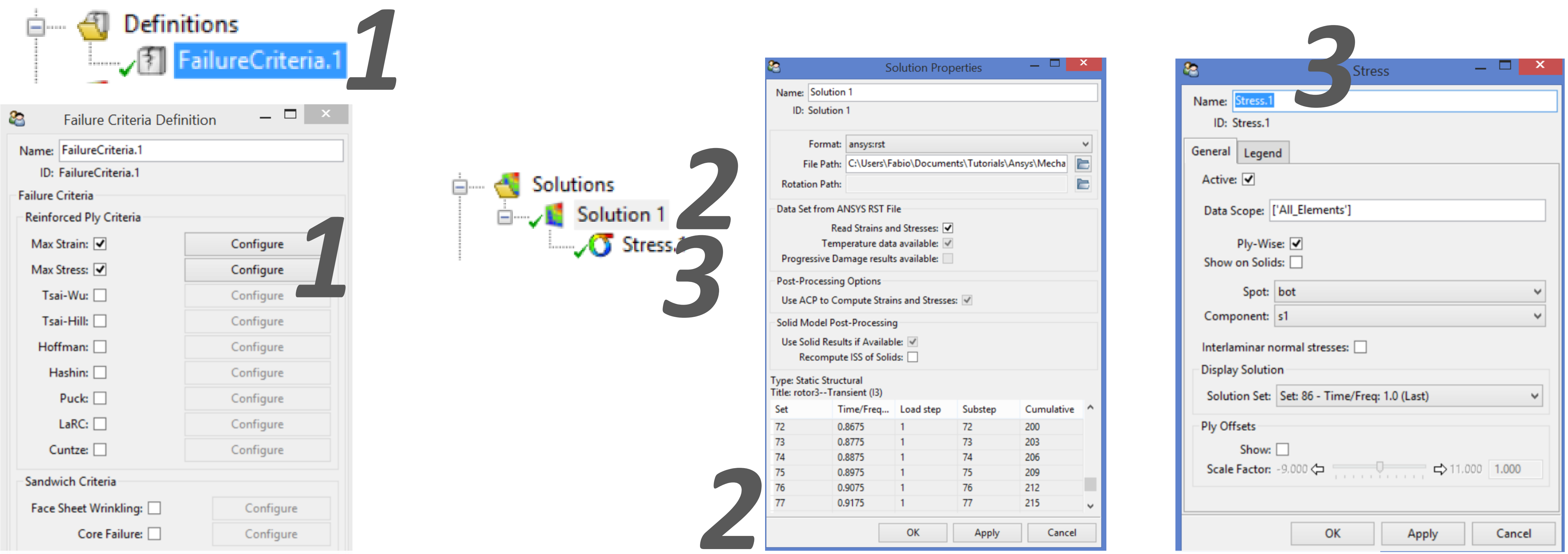
Details of "Directional Deformation"	
Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Directional Deformation
Orientation	X Axis
By	Time
Display Time	Last
Coordinate System	Coordinate System Cyl
Calculate Time History	Yes
Identifier	
Suppressed	No
Results	
Minimum	-2.0207e-004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

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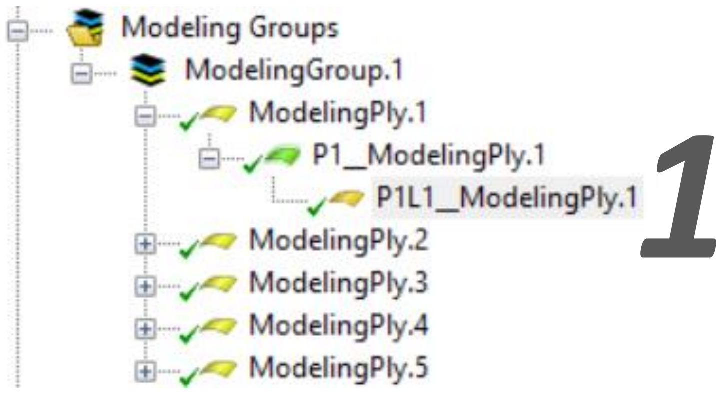
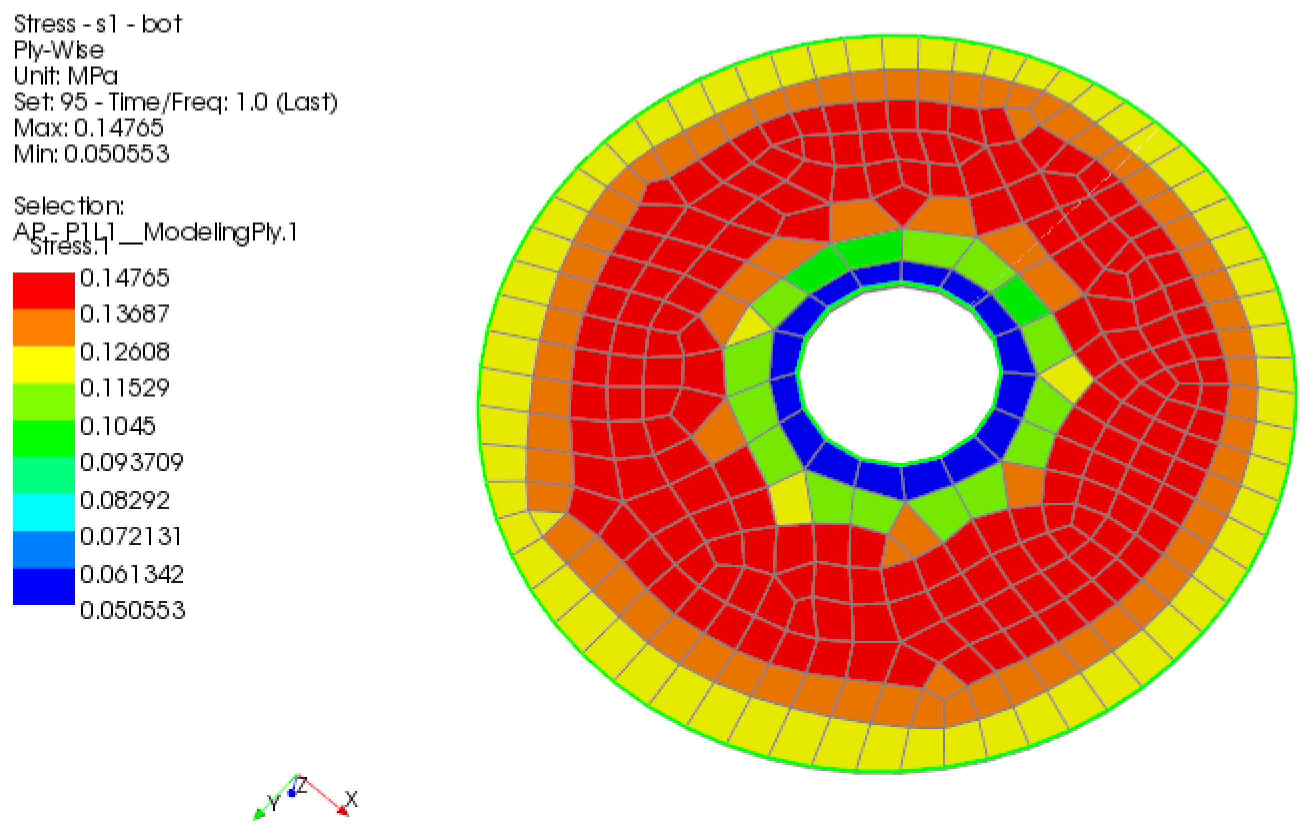
15. Workshop Rotordynamics





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

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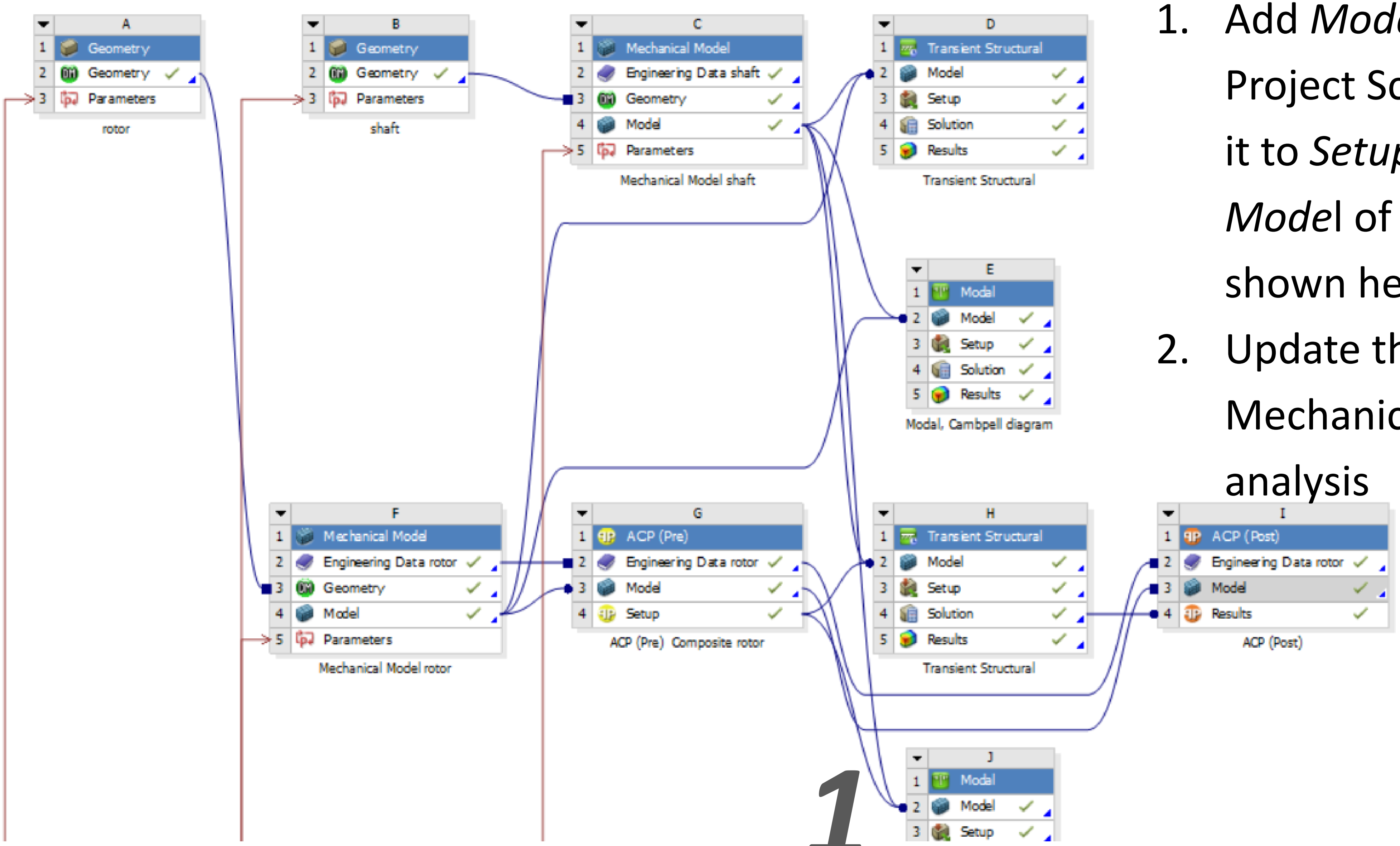
15. Workshop Rotordynamics



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

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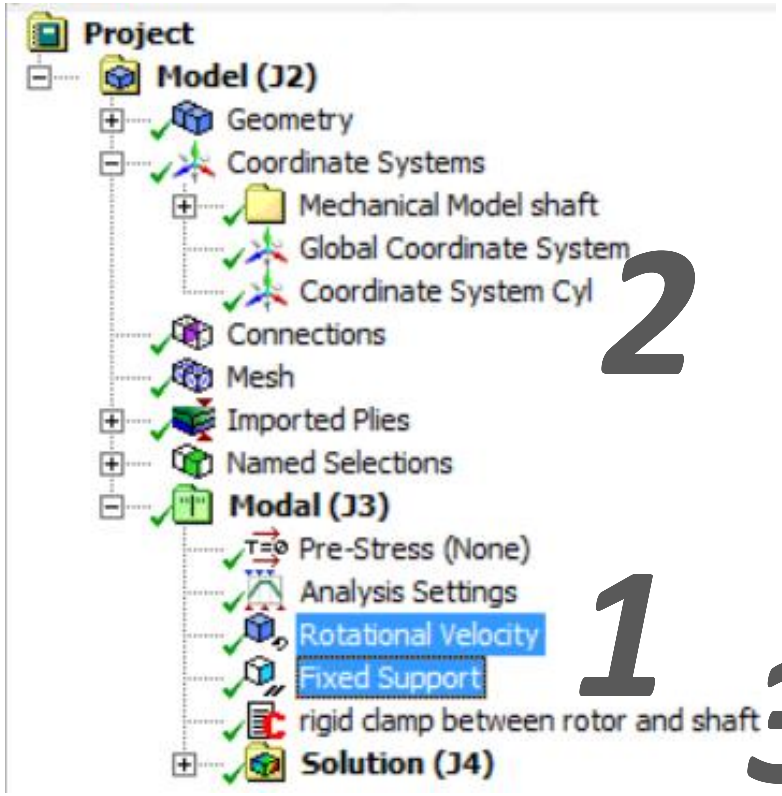
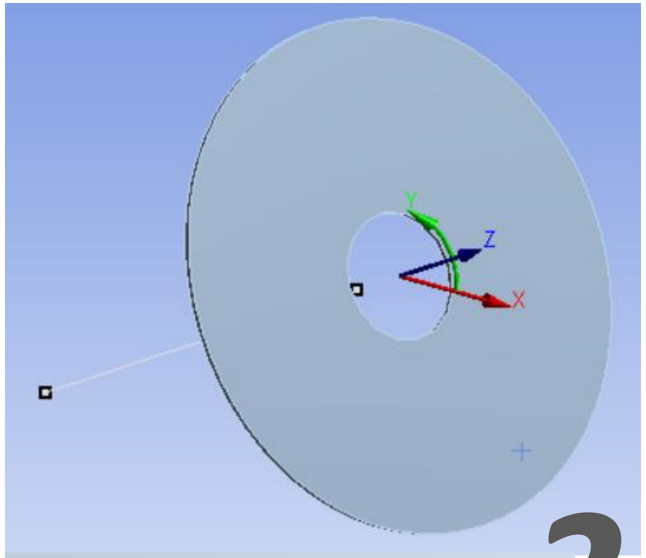
15. Workshop Rotordynamics



2

1

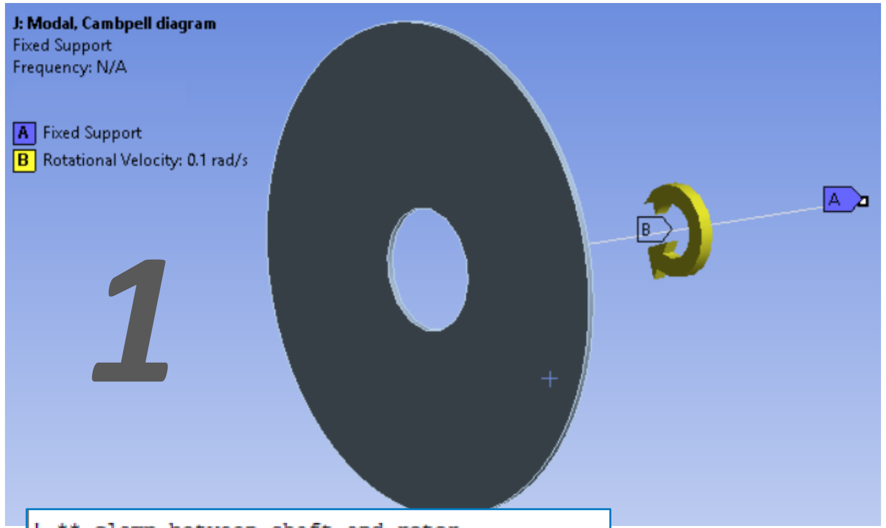
3



2

Details of "Coordinate System Cyl"

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

```
! ** 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

nsel,,loc,x,50
nsel,a,node,,ncent

cerig,ncent,all,all

allsel
csys,0
```

3

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

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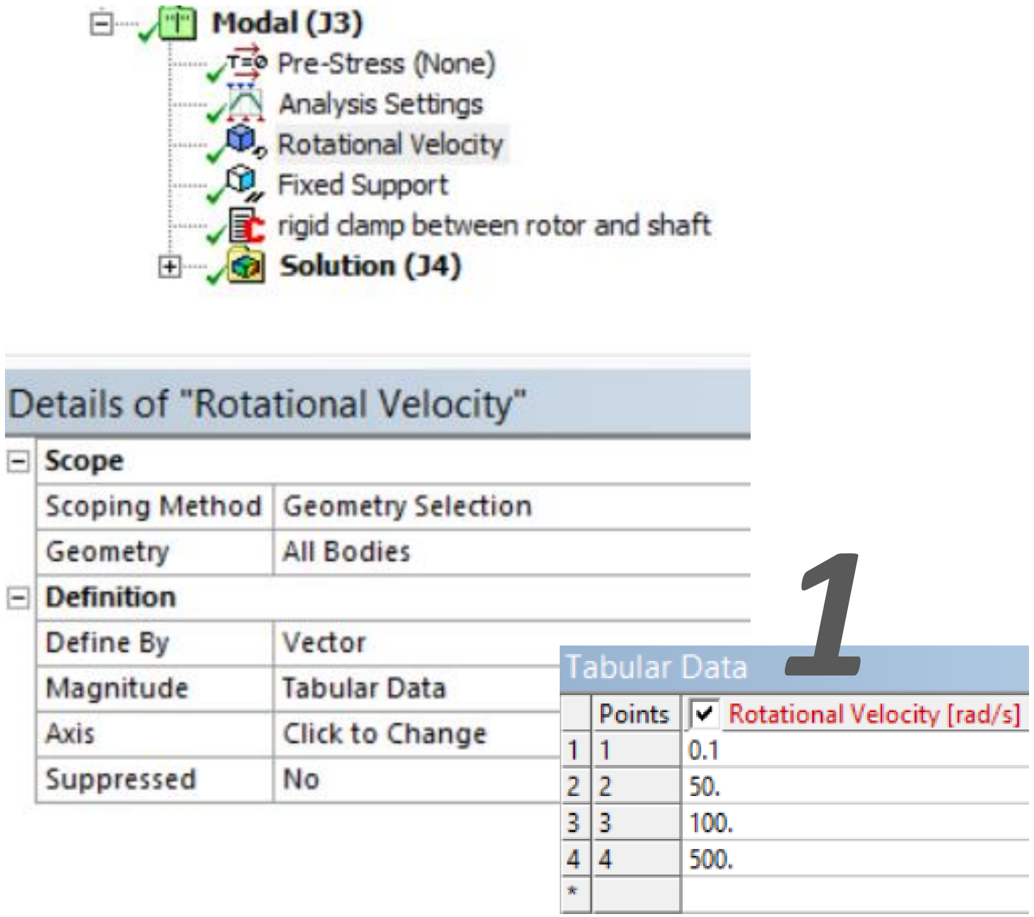
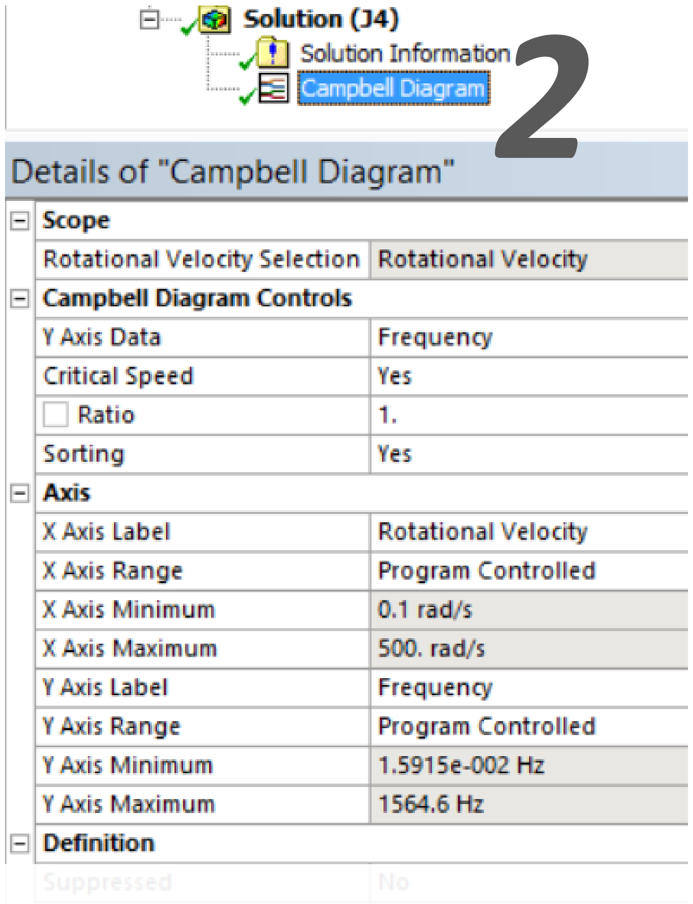
15. Workshop Rotordynamics



1. Tabular Data for the added rotational velocity



2. Insert Campbell Diagram in the solution

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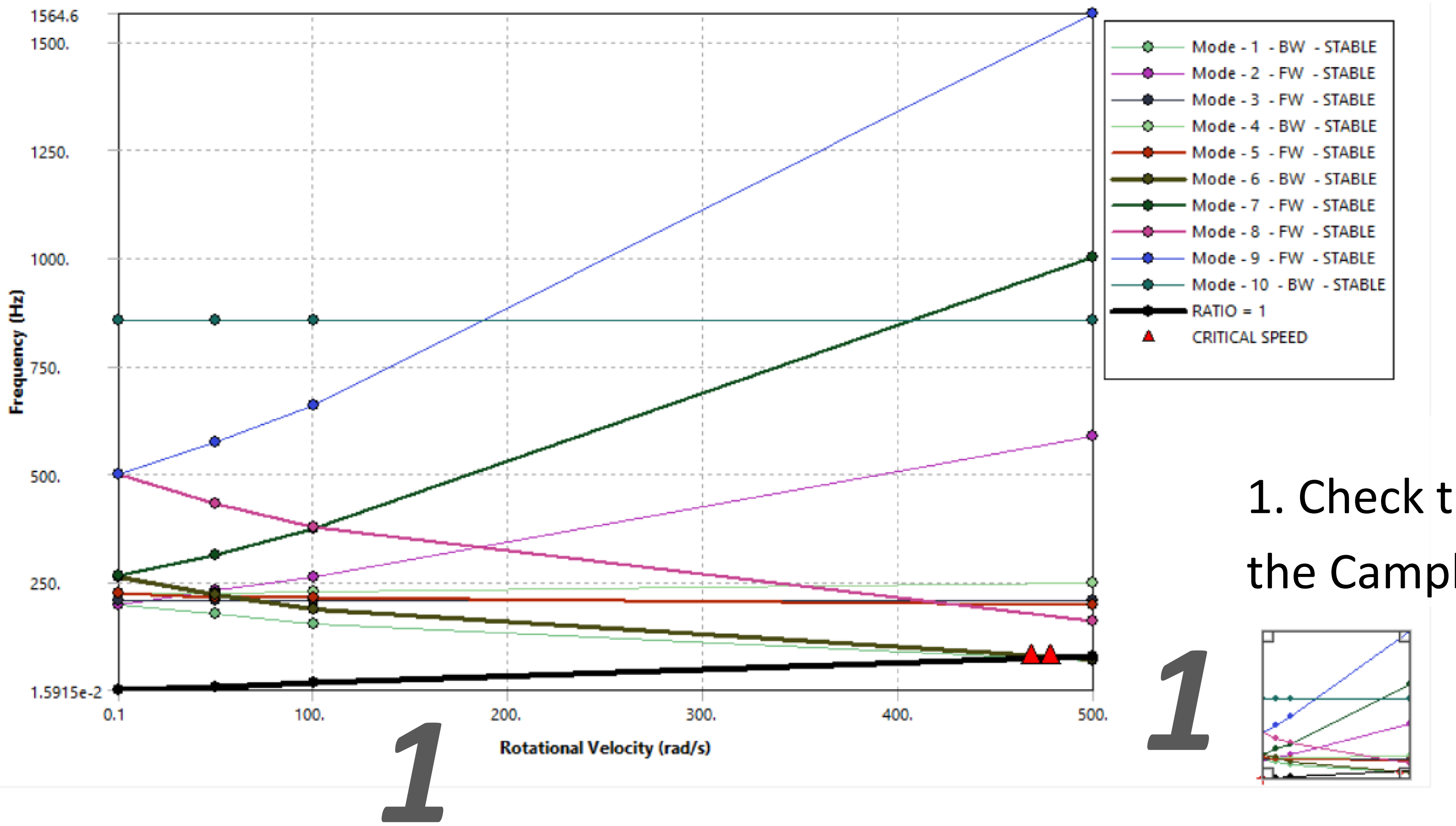
15. Workshop Rotordynamics



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