

Introduction to Hydrodynamic Analysis with Ansys Aqwa

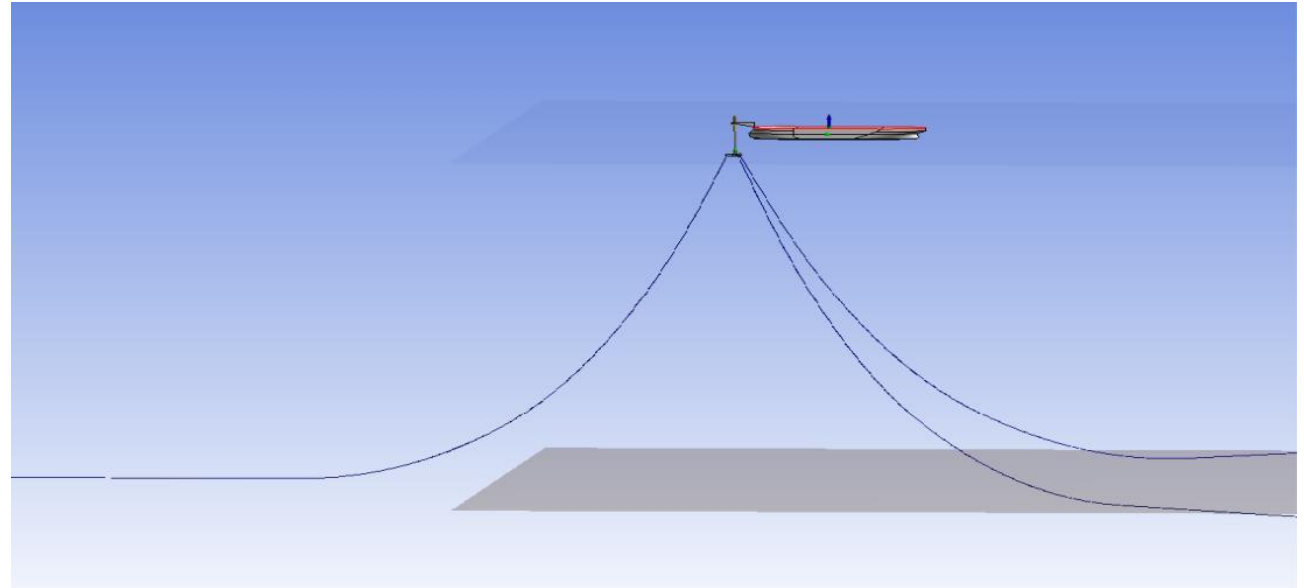
Workshop 06.1: Aqwa Articulations – FPSO and Turret

Release 2021 R2



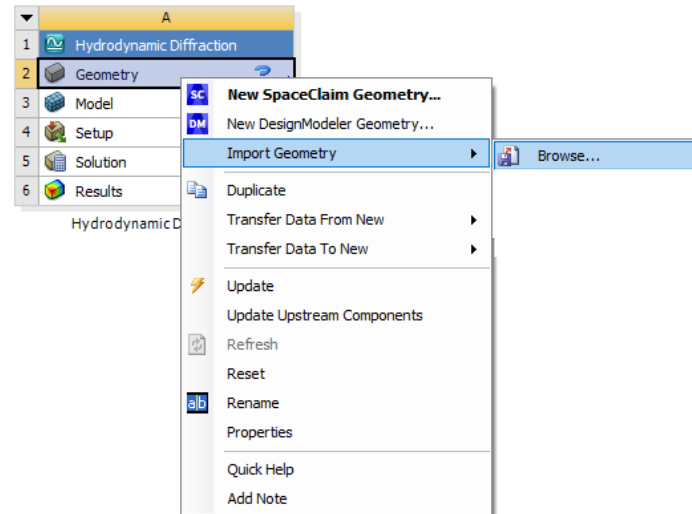
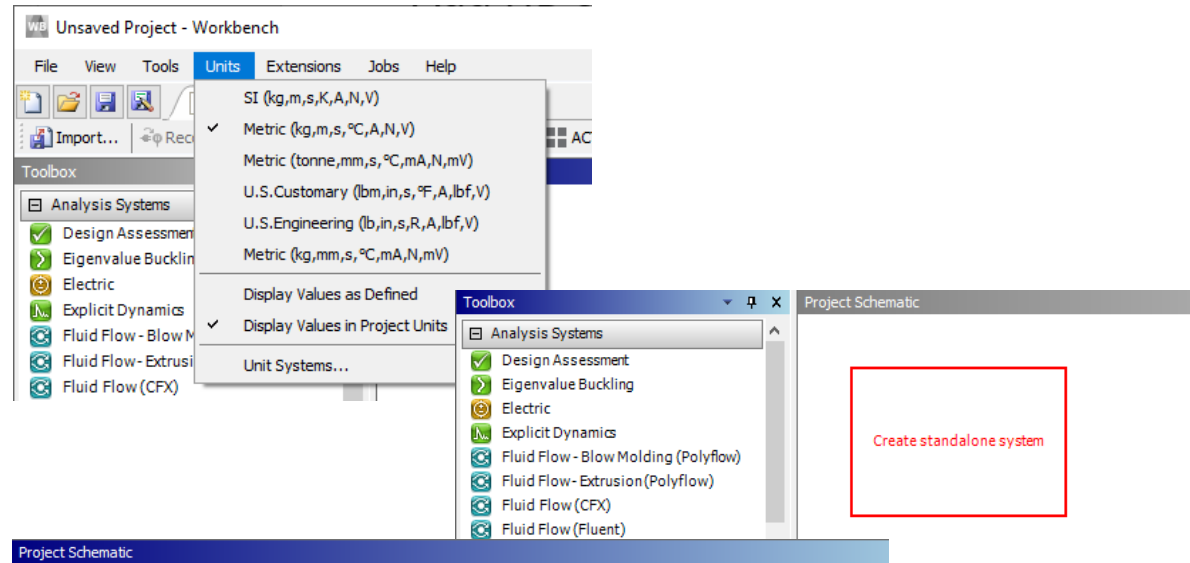
/FPSO & Turret

- The goal of this workshop is to:
 - Create the Hydrodynamic Diffraction (HD) system
 - Import multi-part CAD geometry
 - Create anchor points and mooring lines
 - Create a turret articulation
 - Set up the Hydrodynamic Response (HR) system



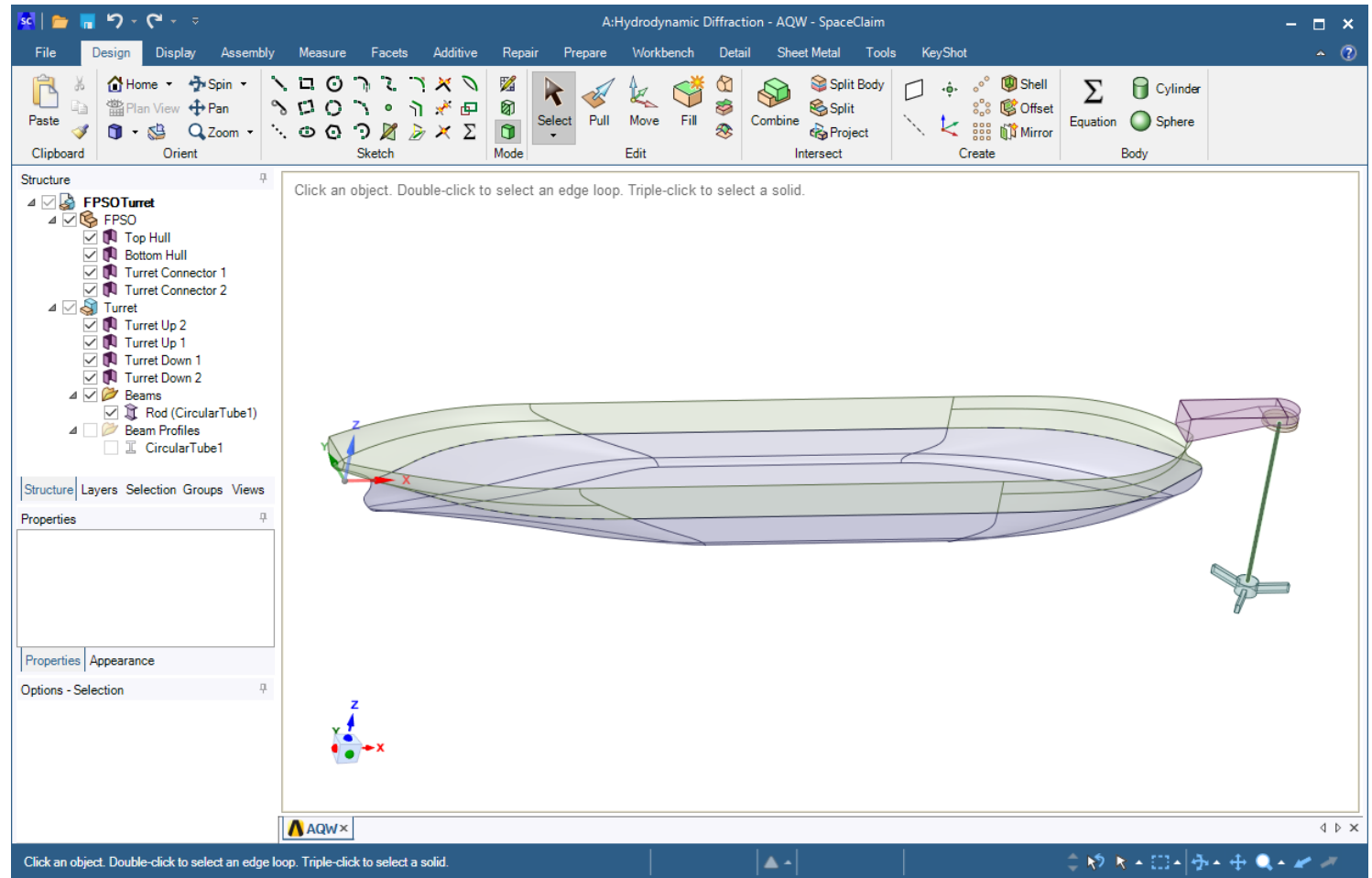
Create HD System

- Set Units
- Add HD system by drag & drop onto WB Project Schematic page.
- RMB on Geometry cell, Import Geometry > Browse, and browse to FPSOTurret.scdoc



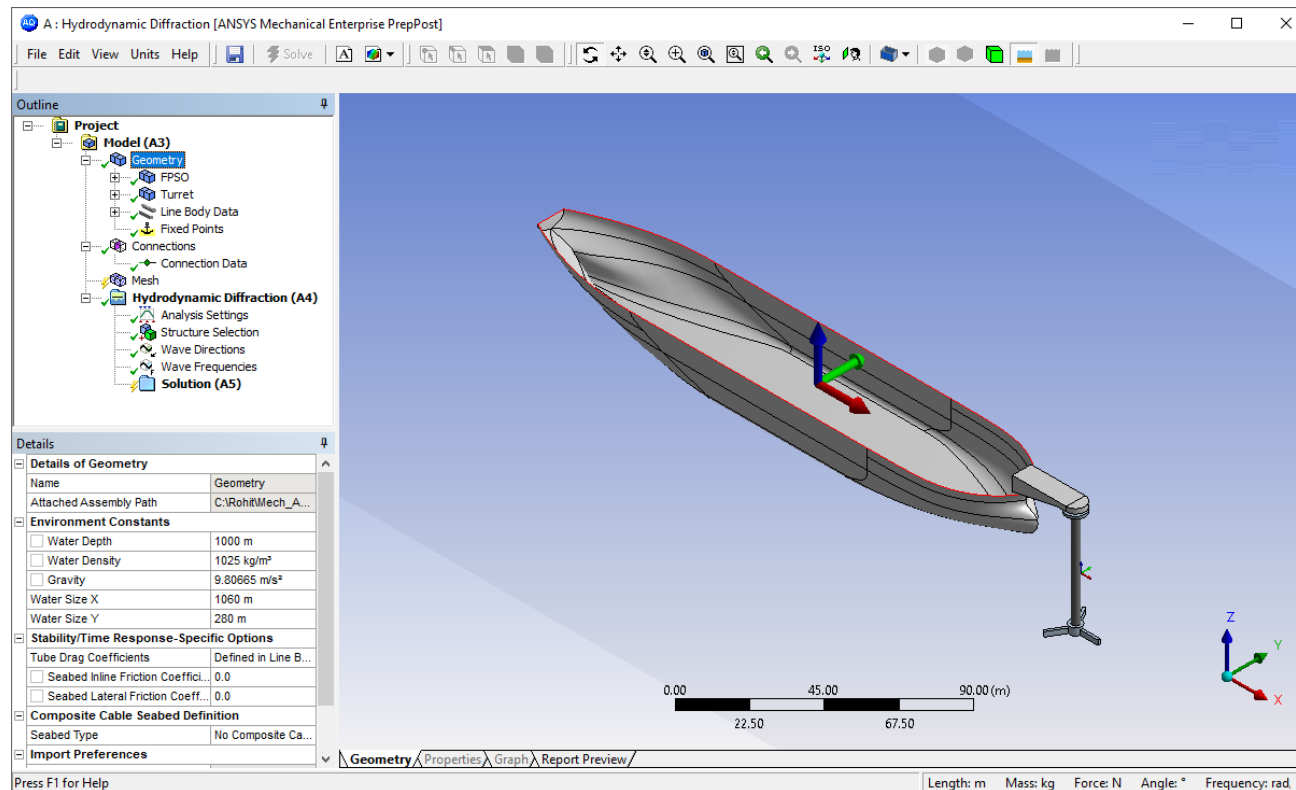
Review Geometry

- Double-click on Geometry in the Project Schematic to view the model for this exercise. The geometry consists of an FPSO which will be joined to a moored Turret.
- The Turret includes a line body ('Rod'), which will be represented by Morison elements in Aqwa. Note how the line body is assigned a Cross Section (CircularTube1).
- Close SpaceClaim.



/ Adding Aqwa Specific Parameters

- Double-click on the Model cell in the Project Schematic.
- Note that the line body in the Turret structure is now graphically represented with the diameter corresponding to its Cross Section in SpaceClaim.



Details	
Details of Circular Tube 1	
Name	Circular Tube 1
Solver Line Type	Cylindrical (TUBE)
Geometric Properties	
Cross Section Name	CircularTube1
Cross Section Type	Circular Tube
Inner Radius	1.48 m
Outer Radius	1.5 m
Cross Section Area	0.18724 m ²
Second Moment of Area	0.20785 m ⁴
Mass Properties	
<input type="checkbox"/> Material Density	7850 kg/m ³
Inertia/Unit Length	1631.65333 (kg.m ²)/m
Hydrodynamic Properties	
Displaced Area	7.06858 m ²
<input type="checkbox"/> Transverse Drag Coefficient	0.75
Axial Drag Coefficient	0.016
<input type="checkbox"/> Added Mass Coefficient	1
Inertia Coefficient	2

Global Parameters

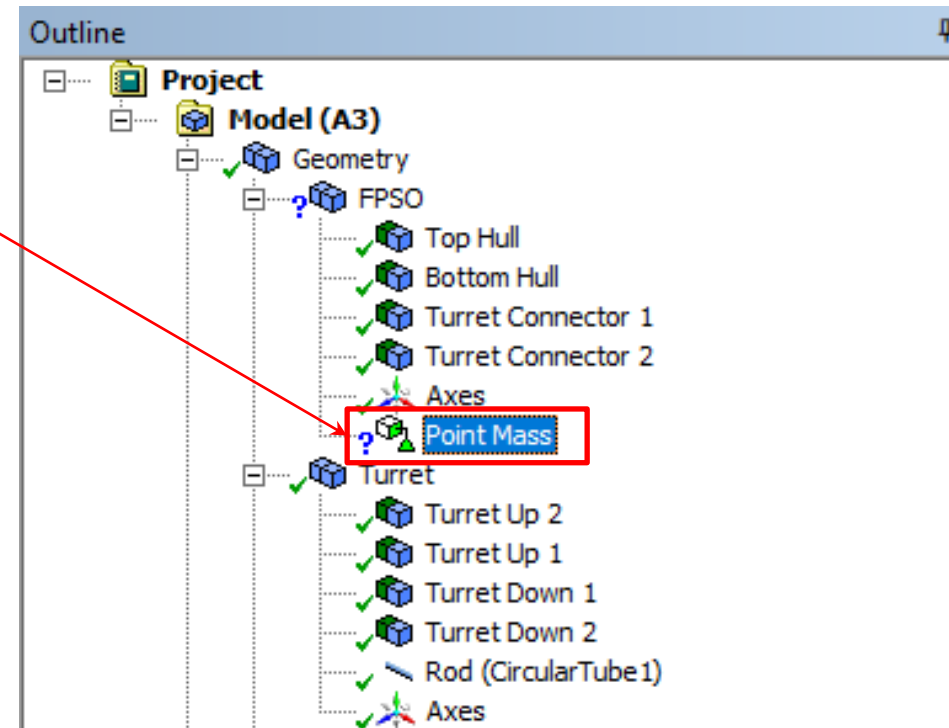
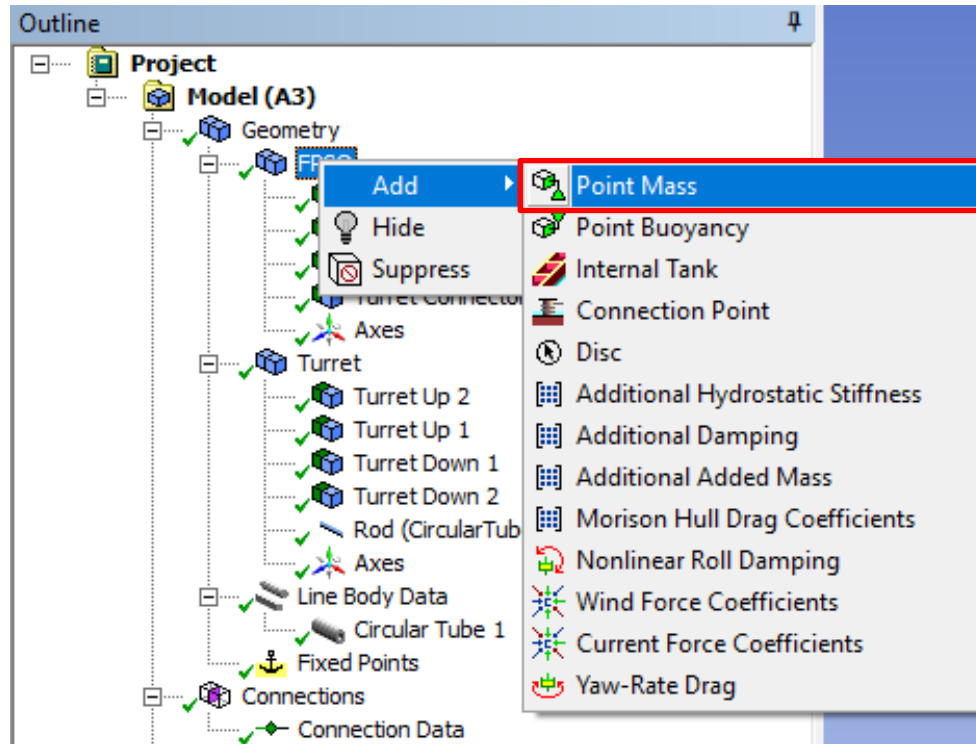
- Set the Water Depth to 500m in the Details of Geometry panel.

The screenshot displays the ANSYS Workbench interface. The **Outline** panel on the left shows a project hierarchy. Under **Model (A3)**, the **Geometry (A3)** component is expanded, showing sub-components: FPSO, Top Hull, Bottom Hull, Turret Connector 1, Turret Connector 2, Axes, Turret, Turret Up 2, Turret Up 1, Turret Down 1, Turret Down 2, Rod (CircularTube1), Axes, Line Body Data, Circular Tube 1, Fixed Points, Connections, Connection Data, Mesh, and Hydrodynamic Diffraction (A4). The **Details** panel on the right shows the **Details of Geometry** for the selected **Geometry** component. The **Environment Constants** section is expanded, and the **Water Depth** is set to 500 m, which is highlighted by a red rectangular box. Other parameters in this section include Water Density (1025 kg/m³), Gravity (9.80665 m/s²), Water Size X (1060 m), and Water Size Y (280 m). The **Stability/Time Response-Specific Options** section shows Tube Drag Coefficients defined in Line Body Details, and Seabed Friction Coefficients set to 0.0. The **Composite Cable Seabed Definition** section shows Seabed Type set to No Composite Cable Seabed. The **Import Preferences** section shows Import Solid Bodies, Import Surface Bodies, and Import Line Bodies all set to Yes.

Details of Geometry	
Name	Geometry
Attached Assembly Path	C:\Rohit\Mech_AQWA_19.2-20190826...
Environment Constants	
<input checked="" type="checkbox"/> Water Depth	500 m
<input type="checkbox"/> Water Density	1025 kg/m³
<input type="checkbox"/> Gravity	9.80665 m/s²
Water Size X	1060 m
Water Size Y	280 m
Stability/Time Response-Specific Options	
Tube Drag Coefficients	Defined in Line Body Details
<input type="checkbox"/> Seabed Inline Friction Coeffi...	0.0
<input type="checkbox"/> Seabed Lateral Friction Coeff...	0.0
Composite Cable Seabed Definition	
Seabed Type	No Composite Cable Seabed
Import Preferences	
Import Solid Bodies	Yes
Import Surface Bodies	Yes
Import Line Bodies	Yes

Provide Additional Aqwa Elements

- For each vessel/structure (FPSO & Turret) provide a Point Mass element



/FPSO Point Mass Input

- As before, if Mass Definition is Program Controlled the mass will equal the displacement.
- Set k_{xx} , k_{yy} and k_{zz} and VCG for FPSO using the same formulation as in the ship model in Workshop 1

Details	
Details of Point Mass	
Name	Point Mass
Visibility	Visible
Activity	Not Suppressed
Point Mass Properties	
Mass Definition	Program Controlled
<input type="checkbox"/> Z	8.5 m
Mass	Solve Hydrostatics to Update
Inertia Properties	
Define Inertia Values By	Radius of Gyration
<input type="checkbox"/> Kxx	13.6 m
<input type="checkbox"/> Kyy	50 m
<input type="checkbox"/> Kzz	52 m
<input type="checkbox"/> bxy	0.0 kg.m ²
<input type="checkbox"/> bxz	0.0 kg.m ²
<input type="checkbox"/> lyz	0.0 kg.m ²

Turret Point Mass Input

- Set the Mass definition to Manual and specify a Mass of 265.670 tonnes
- Set Define Inertia Values by to Direct Input of Inertia, and set I_{xx} , I_{yy} and I_{zz} to:
 - $I_{xx} = 67270000 \text{ kg.m}^2$ (you can just type '6.727e7')
 - $I_{yy} = 67270000 \text{ kg.m}^2$
 - $I_{zz} = 7432200 \text{ kg.m}^2$
- Set the VCG (Z coordinate) to -25.38 m and the LCG (X coordinate) to 220 m

Details of Point Mass

Name	Point Mass
Visibility	Visible
Activity	Not Suppressed

Point Mass Properties

Mass Definition	Program Controlled
<input type="checkbox"/> Z	Program Controlled
Mass	Manual Definition

Inertia Properties

Define Inertia Values By

<input type="checkbox"/> Kxx	
<input type="checkbox"/> Kyy	
<input type="checkbox"/> Kzz	
<input type="checkbox"/> bxy	
<input type="checkbox"/> bxz	
<input type="checkbox"/> lyz	

Details of Point Mass

Name	Point Mass
Visibility	Visible
Activity	Not Suppressed

Mass Properties

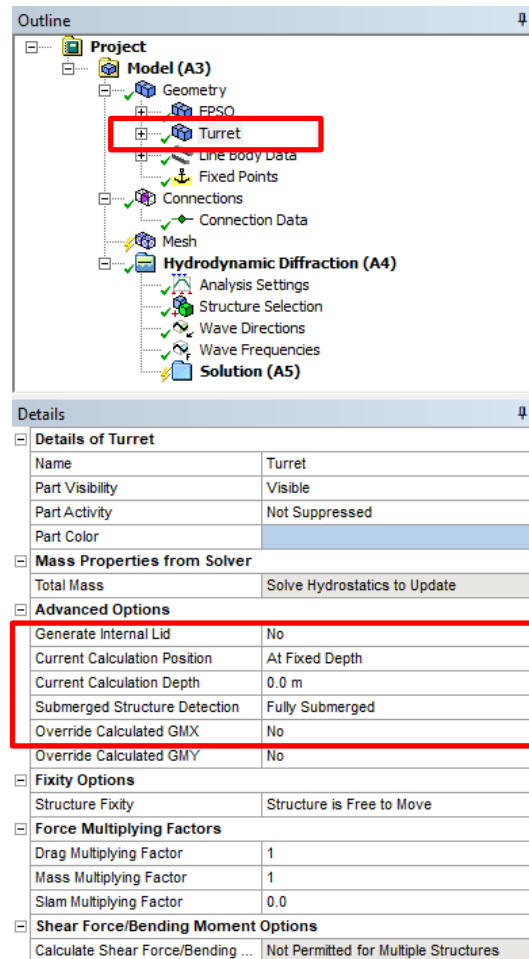
Mass Definition	Manual Definition
<input type="checkbox"/> X	220 m
<input type="checkbox"/> Y	0.0 m
<input type="checkbox"/> Z	-25.38 m
Mass	265670 kg

Inertia Properties

Define Inertia Values By	Direct Input of Inertia
Kxx	15.9125380799133 m
Kyy	15.9125380799133 m
Kzz	5.28916890565765 m
<input type="checkbox"/> Ixx	67270000 kg.m ²
<input type="checkbox"/> Ixy	0.0 kg.m ²
<input type="checkbox"/> Ixz	0.0 kg.m ²
<input type="checkbox"/> Iyy	67270000 kg.m ²
<input type="checkbox"/> Iyz	0.0 kg.m ²
<input type="checkbox"/> Izz	7432200 kg.m ²

Turret Submerged Structure Setting

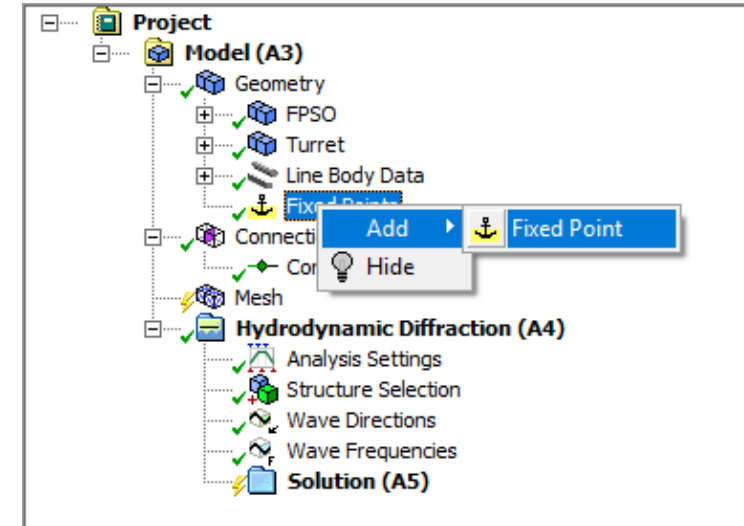
- Since the Turret does not have diffracting elements at the water line we need to set up the structure as a Fully Submerged Body.



- Select Turret In the Geometry tree
- Set Submerged Structure Detection to Fully Submerged

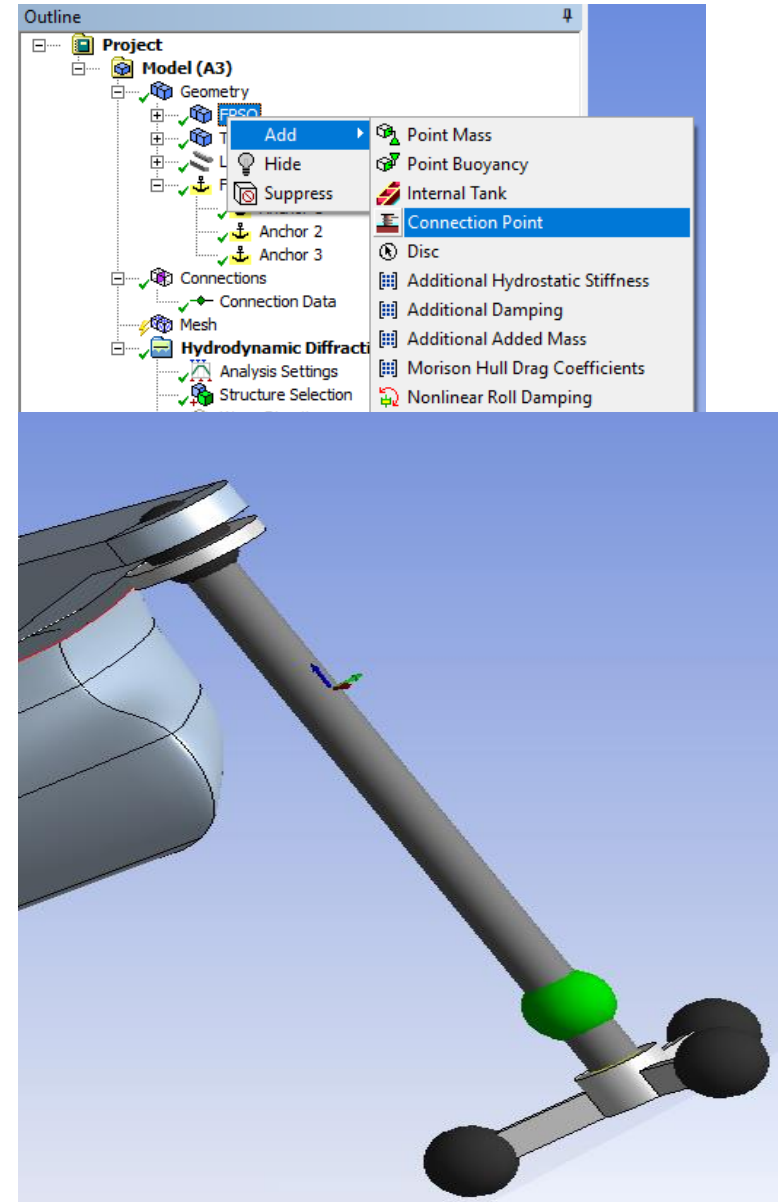
/ Anchor Connection Points

- Select the Fixed Points object in the tree and add three fixed points for the mooring system representing the anchor locations
- Set the x, y, z coordinates as follows:
 - Anchor 1 -700m, 700m, -500m
 - Anchor 2 -700m, -700m, -500m
 - Anchor 3 1300m, 0m, -500m



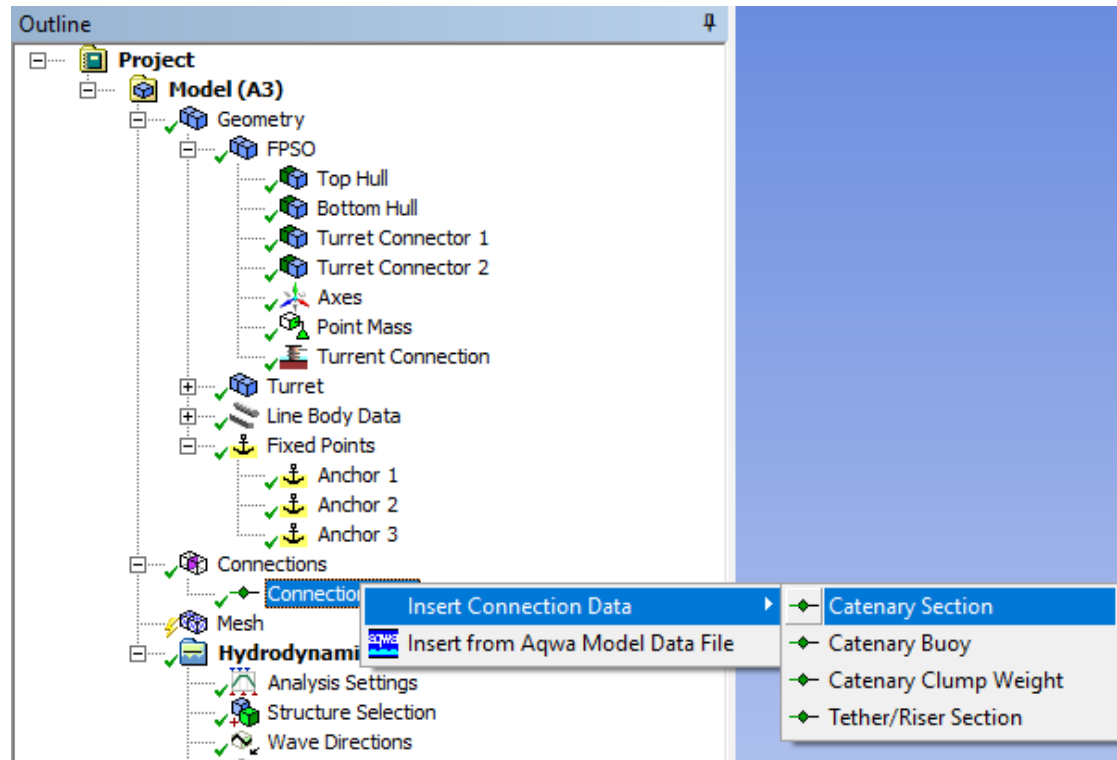
/ Connection Points

- Select the part FPSO and add a connection point
- Set the X, Y, Z, coordinates as follows and rename Turret Connection;
 - Turret Connection 220m, 0m, 13m
- Select the part Turret and add four connection points
- Define names and set the X, Y, Z, coordinates as follows:
 - FPSO Connection 220m, 0m, 12m
 - Mooring 1 215.0m, 8.66m, -32.0m
 - Mooring 2 215.0m, -8.66m, -32.0m
 - Mooring 3 230.0m, 0.0m, -32.0m
- Check the locations of the connection points. Note that all coordinates defined are in the global system (FRA)



/ Set Up Mooring Line Properties

- As in Workshop 2 we are going to use composite catenary lines for the mooring system. These are lines made up of one or more segments with varying properties e.g. chain/wire/chain.
- Select Connections > Connection Data > Insert Connection Data > Catenary Section



Mooring Line Properties

- Provide data for Mass/Unit Length, Equivalent Cross Sectional Area, Stiffness, Maximum Tension and Equivalent Diameter as below for three catenary sections. Use the Duplicate function to avoid entering the same data many times.

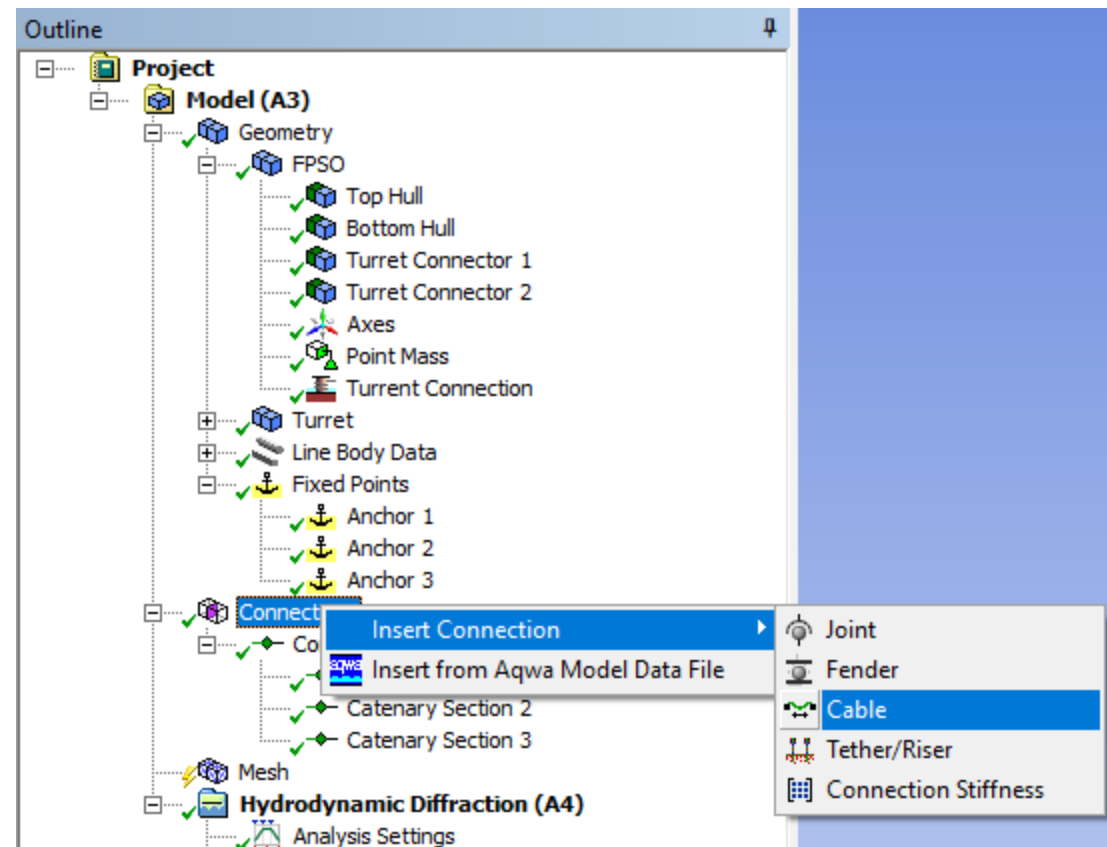
Details		
Details of Catenary Section 1		
Name	Catenary Section 1	
Section Properties		
<input type="checkbox"/> Mass/Unit Length	150 kg/m	
<input type="checkbox"/> Equivalent Cross-Sectional A...	0.01 m ²	
<input type="checkbox"/> Stiffness, EA	600000000 N	
<input type="checkbox"/> Maximum Tension	7500000 N	
<input type="checkbox"/> Bending Stiffness, EI	0.0 N.m ²	
<input type="checkbox"/> Axial Stiffness Coefficient k1	0.0 N	
<input type="checkbox"/> Axial Stiffness Coefficient k2	0.0 N	
<input type="checkbox"/> Axial Stiffness Coefficient k3	0.0 N	
Section Hydrodynamic Properties		
<input type="checkbox"/> Added Mass Coefficient	1	
<input type="checkbox"/> Transverse Drag Coefficient	1	
<input type="checkbox"/> Equivalent Diameter	0.2 m	
<input type="checkbox"/> Longitudinal Drag Coefficient	0.025	

Details		
Details of Catenary Section 2		
Name	Catenary Section 2	
Section Properties		
<input type="checkbox"/> Mass/Unit Length	120 kg/m	
<input type="checkbox"/> Equivalent Cross-Sectional A...	0.01 m ²	
<input type="checkbox"/> Stiffness, EA	900000000 N	
<input type="checkbox"/> Maximum Tension	7500000 N	
<input type="checkbox"/> Bending Stiffness, EI	0.0 N.m ²	
<input type="checkbox"/> Axial Stiffness Coefficient k1	0.0 N	
<input type="checkbox"/> Axial Stiffness Coefficient k2	0.0 N	
<input type="checkbox"/> Axial Stiffness Coefficient k3	0.0 N	
Section Hydrodynamic Properties		
<input type="checkbox"/> Added Mass Coefficient	1	
<input type="checkbox"/> Transverse Drag Coefficient	1	
<input type="checkbox"/> Equivalent Diameter	0.25 m	
<input type="checkbox"/> Longitudinal Drag Coefficient	0.025	

Details		
Details of Catenary Section 3		
Name	Catenary Section 3	
Section Properties		
<input type="checkbox"/> Mass/Unit Length	170 kg/m	
<input type="checkbox"/> Equivalent Cross-Sectional A...	0.01 m ²	
<input type="checkbox"/> Stiffness, EA	900000000 N	
<input type="checkbox"/> Maximum Tension	7500000 N	
<input type="checkbox"/> Bending Stiffness, EI	0.0 N.m ²	
<input type="checkbox"/> Axial Stiffness Coefficient k1	0.0 N	
<input type="checkbox"/> Axial Stiffness Coefficient k2	0.0 N	
<input type="checkbox"/> Axial Stiffness Coefficient k3	0.0 N	
Section Hydrodynamic Properties		
<input type="checkbox"/> Added Mass Coefficient	1	
<input type="checkbox"/> Transverse Drag Coefficient	1	
<input type="checkbox"/> Equivalent Diameter	0.2 m	
<input type="checkbox"/> Longitudinal Drag Coefficient	0.025	

Mooring Line Connections

- To add a line select Connections > Insert Connection > Cable



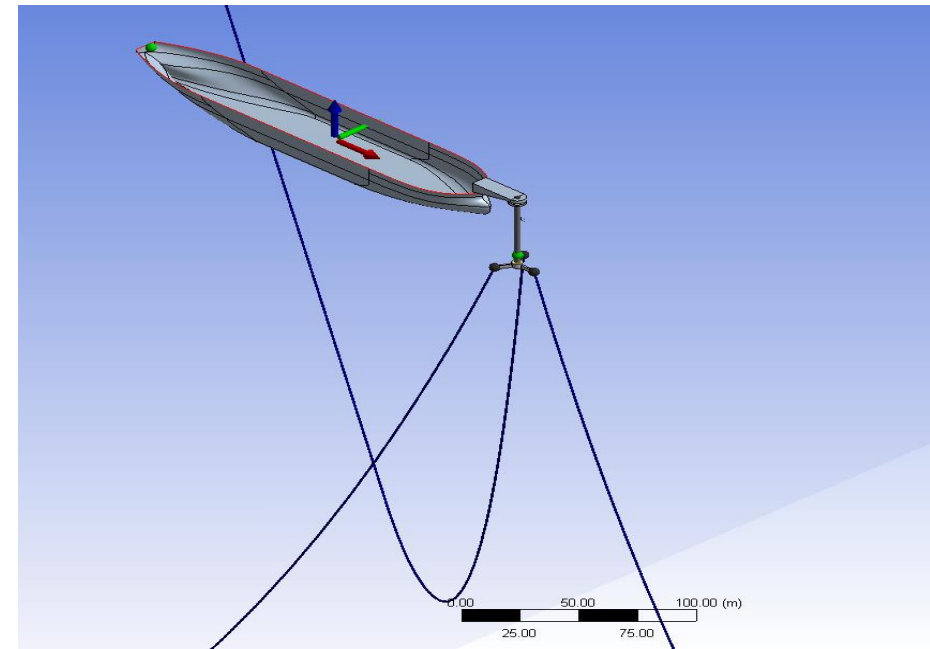
Mooring Line Connections

- Create cable 1 using the information highlighted opposite
- The composition of the line is now defined
 - Segment allocation
 - Line length
- Segments are defined from the anchor location up to the connection point on the turret
- Section 1 type should be set to Catenary Section 1
- Length 400 m
- Repeat for sections 2 and 3 as shown
- Finally set the dZ Range parameters under Cable Properties to 10m

Details	
Details of Cable 1	
Name	Cable 1
Visibility	Visible
Activity	Not Suppressed
General Attributes	
Type	Nonlinear Catenary
Connectivity	Fixed Point to Structure
Start Fixed Point	Anchor 1 (Fixed)
End Connection Point	Mooring 1 (Turret)
Initial Attachment Point Separation	1238.62827175872 m (Point to Point)
Cable Dynamics Properties	
Use Dynamics	Defer to Analysis Settings "Use Cable ...
<input type="checkbox"/> Number of Elements	100
Catenary Section Selection	
Section 1: Type	Catenary Section 1
<input type="checkbox"/> Section 1: Length	400 m
Joint 1/2: Mass/Buoyancy	None
Section 2: Type	Catenary Section 2
<input type="checkbox"/> Section 2: Length	500 m
Joint 2/3: Mass/Buoyancy	None
Section 3: Type	Catenary Section 3
<input type="checkbox"/> Section 3: Length	500 m
Section 4: Type	None
Cable Properties	
<input type="checkbox"/> Negative dZ Range of Expect...	10 m
<input type="checkbox"/> Positive dZ Range of Expecte...	10 m
<input type="checkbox"/> Number of Vertical Partitions	15
<input type="checkbox"/> Number of X Coordinates	40
Initial Cable Data	
<input type="checkbox"/> Initial Cable Tension at Start	312786.969 N
<input type="checkbox"/> Initial Cable Tension at End	1021422.625 N

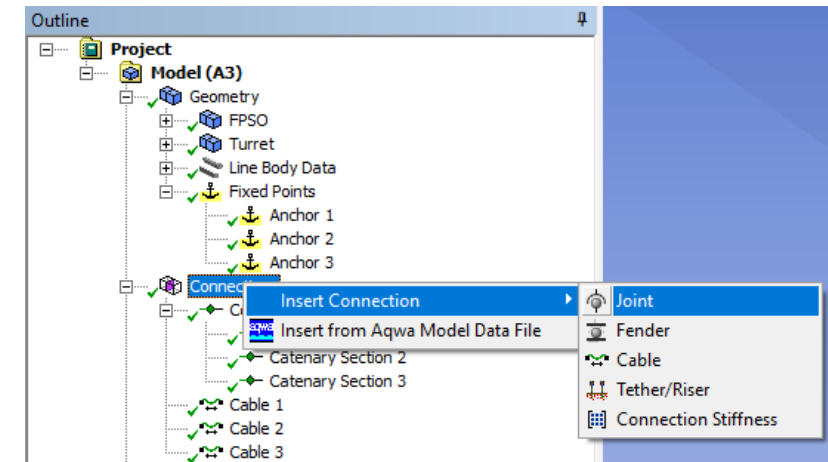
/ Mooring Line Connections

- Use the same information to populate cables 2 and 3 (using Duplicate to save data entry).
- Change the fixed point and end point connections as follows:
 - Cable 2 Anchor 2 (Fixed), Mooring 2 (Turret)
 - Cable 3 Anchor 3 (Fixed), Mooring 3 (Turret)
- Select Connections in the Outline to see the final mooring configuration



/ Articulation

- Select Connections in the outline and Insert Connection > Joint
- Set the Joint type to Hinged
- Set the connection points as shown
- Set the stiffness about the X axis to $1000\text{N}/^\circ$
- Set the damping about the X axis to $20000\text{N.m}/(^\circ/\text{s})$
- Note that the orientation of the hinge is incorrect
- The axis system local to the hinge can be rotated

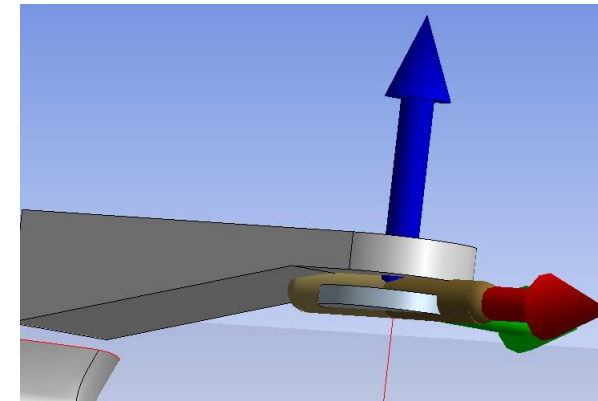


The screenshot shows the 'Details' pane for 'Joint 1'. The 'Details of Joint 1' section is expanded, showing the following properties:

Details of Joint 1	
Name	Joint 1
Visibility	Visible
Activity	Not Suppressed
Type	Hinged
Connectivity	Structure to Structure
Connection Point On Structure A	Turret Connection (FPSO)
Connection Point On Structure B	FPSO Connection (Turret)

The 'Joint Properties' section is also expanded, showing the following properties:

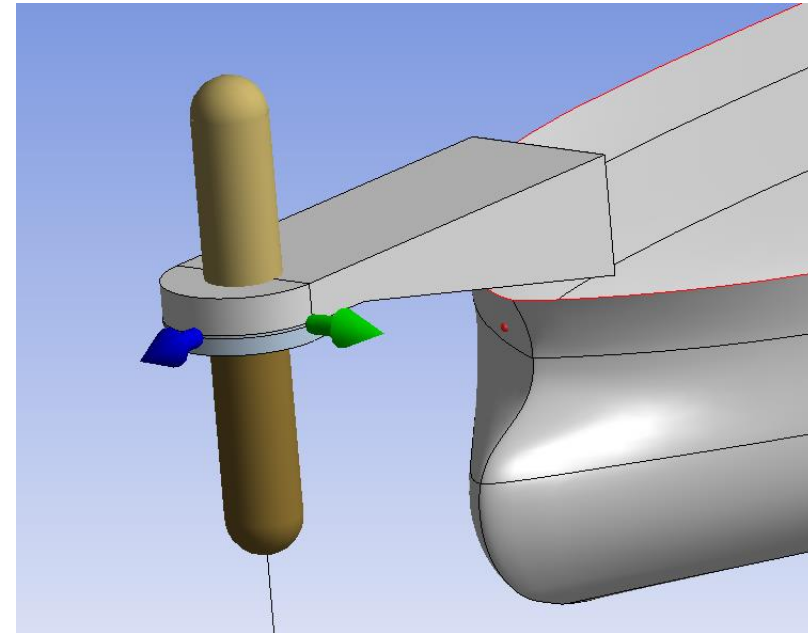
Joint Properties	
<input type="checkbox"/> Stiffness About Local Joint X	1000 N.m/°
<input type="checkbox"/> Damping About Local Joint X	20000 N.m/(°/s)



/ Articulation

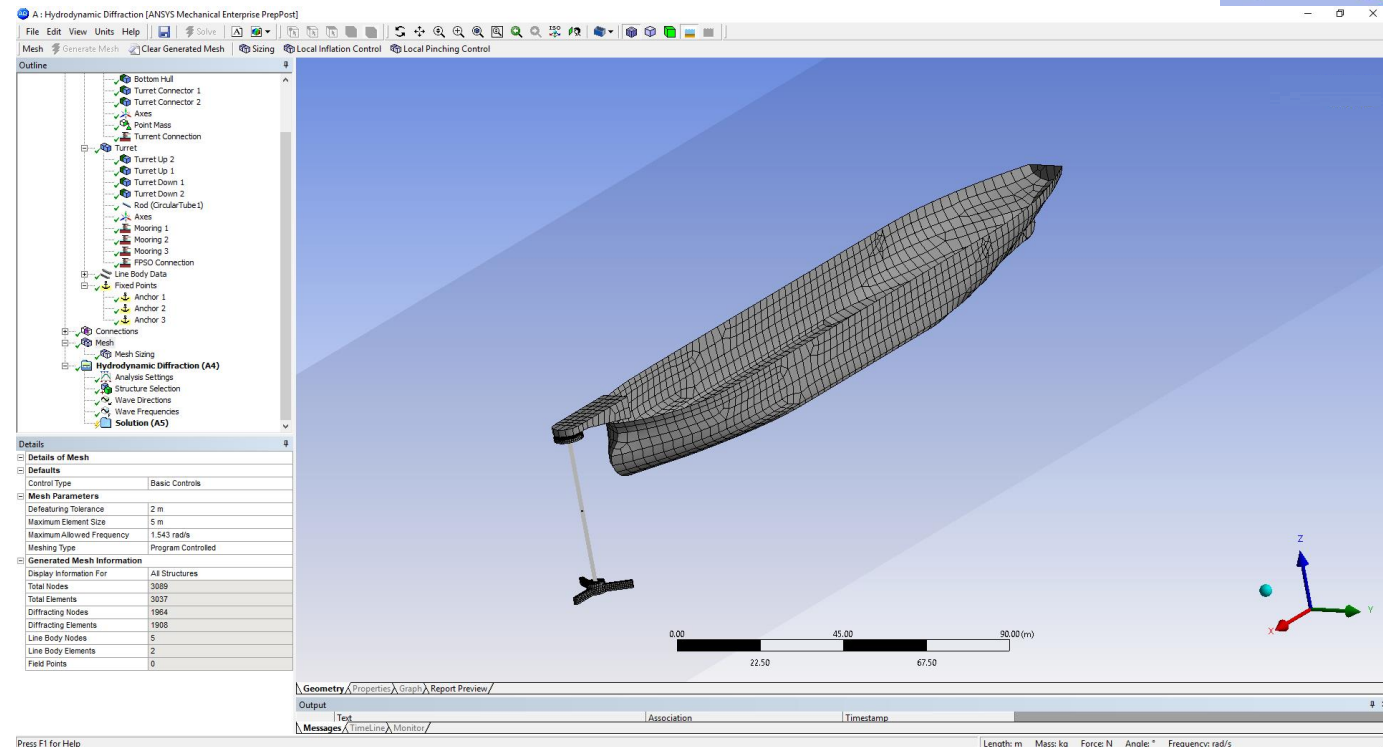
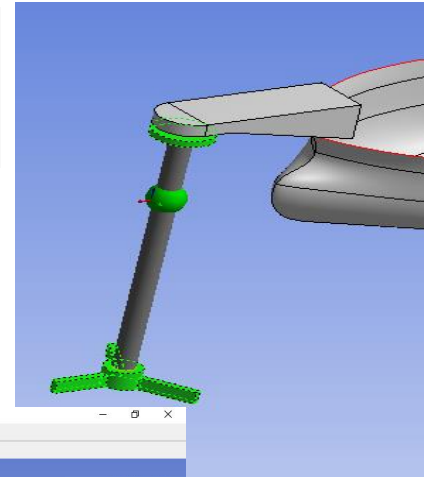
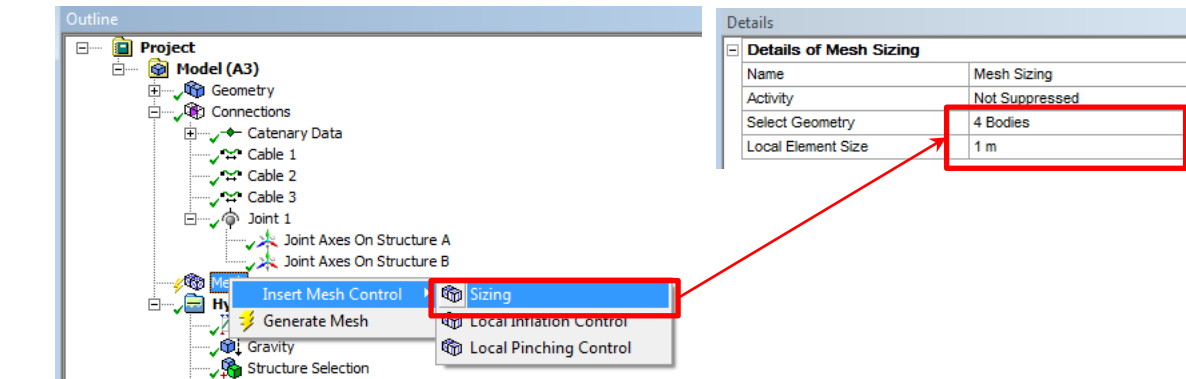
- To change the joint axis, under Joint 1, select Joint Axes On Structure A
- Change the Alignment Method to Direction Entry as shown
- Then change the Rotation About Local Y to 90
- Do likewise for Joint Axes On Structure B
- Finally confirm the hinge is orientated correctly

Details	
Details of Joint Axes On Structure A	
Name	Joint Axes On Structure A
Visibility	Visible
Axes Alignment	
Alignment Method	Direction Entry
Rotation About Global Z	0.0°
Rotation About Local Y	90°
Rotation About Local X	0.0°
Unit Vector X	[0.0, 0.0, -1]
Unit Vector Y	[0.0, 1, 0.0]
Unit Vector Z	[1, 0.0, 0.0]



/ Meshing

- Set Max Element Size to 4m
- Apply a Mesh Sizing Control to the Turret with Local Element Size of 1m
- Generate Mesh
- Hint: When scoping the geometry for the Mesh Sizing select the bodies in the turret from top to bottom



/ Analysis Settings

- Set Ignore Modelling Rule Violations to “Yes”
- Set Include Multi-Directional Wave Interaction to “No”
- Set Calculate Full QTF Matrix to “No”

Details		⌵
[-] Details of Analysis Settings		
Name	Analysis Settings	
External Operation before Solving	None	
External Operation after Solving	None	
Parallel Processing	Program Controlled	
Generate Wave Grid Pressures	Yes	
Wave Grid Size Factor	2	
[-] Common Analysis Options		
Ignore Modelling Rule Violations	Yes	
Calculate Extreme Low/High Fre...	Yes	
Include Multi-Directional Wave Int...	No	
Near Field Solution	Program Controlled	
Linearized Morison Drag	No	
[-] QTF Options		
Calculate Full QTF Matrix	No	
[-] Output File Options		
Source Strengths	No	
Potentials	No	
Centroid Pressures	No	
Element Properties	No	
ASCII Hydrodynamic Database	No	
Example of Hydrodynamic Datab...	No	
Generate AHD Pressure Output	No	

Structure Selection

- Structure Selection enables the definition of interacting structure groups (for multi-body problems). By default all vessels are assumed interacting.

Details	
Details of Structure Selection	
Name	Structure Selection
Structures to Exclude	None
Group of Structures	
Interacting Structure Group 1	All
Interacting Structure Group 2	None
Motion Locks	
Apply Motion Lock to Group 1	No
Structure Ordering	
Structure 1	FPSO
Structure 2	Turret

- To reduce the computation time select the first Interacting Structure Group and set this to None by clicking in empty space in the Graphics window and selecting Apply

Details	
Details of Structure Selection	
Name	Structure Selection
Structures to Exclude	None
Group of Structures	
Interacting Structure Group 1	None
Structure Ordering	
Structure 1	FPSO
Structure 2	Turret

Wave Directions and Frequencies

- Computing additional wave directions is computationally cheap. In Wave Directions, increase the Number of Intermediate Directions to 11.

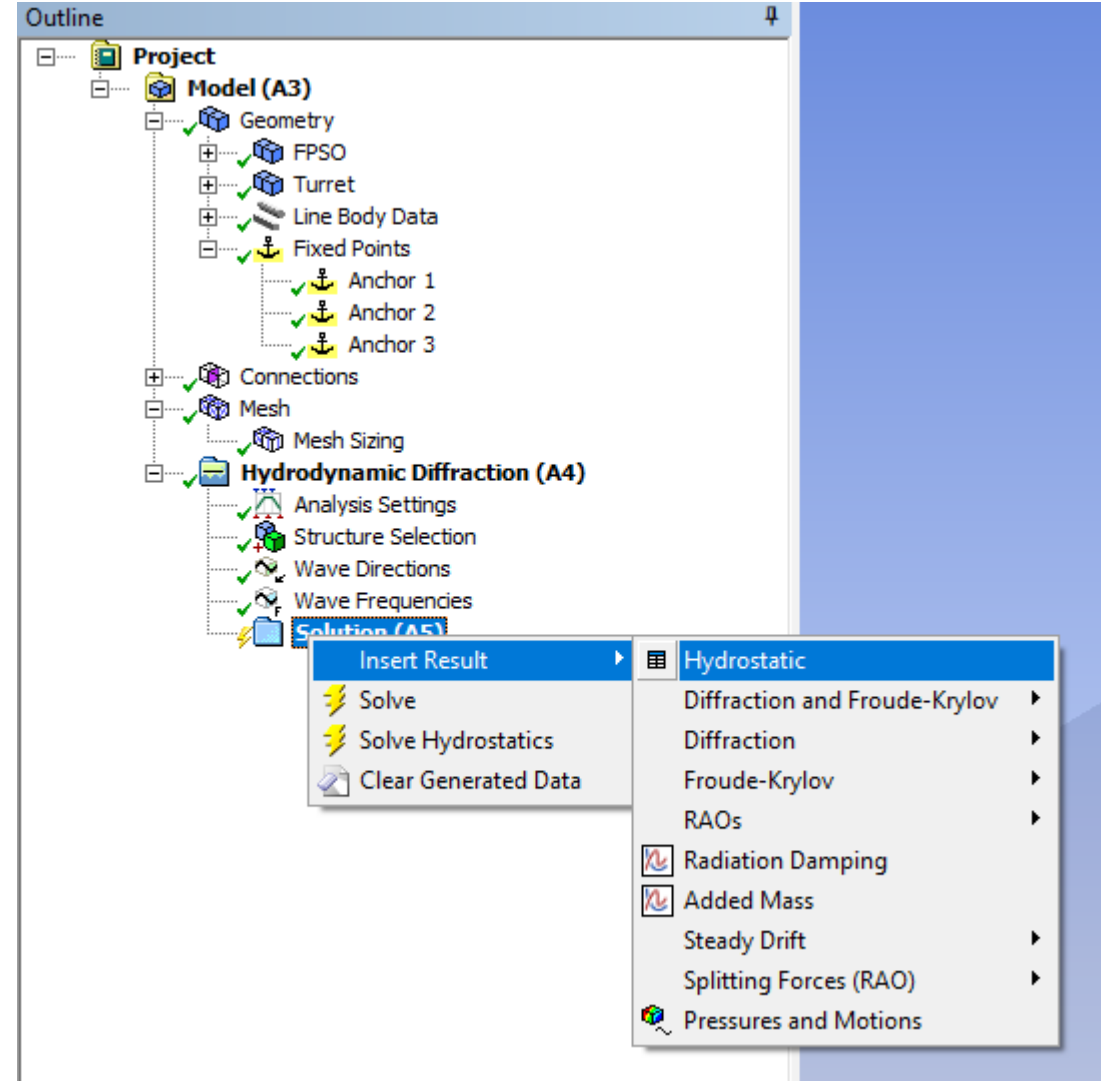
Details		4
<input type="checkbox"/>	Details of Wave Directions	
	Name	Wave Directions
	Visibility	Visible
	Type	Range of Directions, No Forward Speed
<input type="checkbox"/>	Required Wave Input	
	Wave Range	-180° to 180°
	Interval	30°
	Number of Intermediate Directions	11

- The computational cost scales linearly with the number of frequencies, however, so we will reduce this to 15. In Wave Frequencies:

Details		
[-] Details of Wave Frequencies		
Name	Wave Frequencies	
Intervals Based Upon	Frequency	
[-] Incident Wave Frequency/Period Definition		
Range	Program Controlled	
Total Number of Frequencies	15	

Review Results

- Solve full analysis
- Insert some results
 - Hydrostatic Table for FPSO
 - Hydrodynamic Graphs
 - ☐ RAOs in X and Z for FPSO with a wave direction of -180 degrees
 - Pressures and Motions
 - ☐ Since we have two non-interacting structures it is possible to plot information for each of these individually



Hydrostatics

- When selected these results appear on the Properties tab.
- Since we now have two structures, ensure the required one is selected

The screenshot displays the ANSYS Mechanical Enterprise PrepPost interface. The Outline tree on the left shows the project hierarchy, with 'Hydrostatic' selected under the 'Solution (A5)' branch. The Details panel at the bottom left shows the 'Details of Hydrostatic' section, where 'Name' is 'Hydrostatic' and 'Structure' is 'FPSO'. The main Results area on the right displays the 'Hydrostatic Results' for the 'FPSO' structure.

Hydrostatic Results

Structure
FPSO

Hydrostatic Stiffness

Center of Gravity (CoG) Position:

	X:	Y:	Z:
Center of Gravity (CoG) Position:	108.99535 m	-4.7074e-3 m	8.5 m

Heave (Z): 60466572 N/m
Roll (RX): 284642.13 N.m/m
Pitch (RY): 1.44852e8 N.m/m

Hydrostatic Displacement Properties

Actual Volumetric Displacement: 44025.262 m³
Equivalent Volumetric Displacement: 44025.266 m³

Center of Buoyancy (CoB) Position:

	X:	Y:	Z:
Center of Buoyancy (CoB) Position:	108.99525 m	-4.7081e-3 m	-3.8298883 m

Out of Balance Forces/Weight:

	FX:	FY:	FZ:
Out of Balance Forces/Weight:	-5.5389e-9	2.8158e-8	-1.5185e-6

Out of Balance Moments/Weight:

	MX:	MY:	MZ:
Out of Balance Moments/Weight:	5.1691e-8 m	1.1012e-4 m	2.2823e-7 m

Cut Water Plane Properties

Cut Water Plane Area: 6015.4873 m²
Center of Floatation:

	X:	Y:
Center of Floatation:	106.59978 m	2.9337e-8 m

Principal 2nd Moments of Area:

	X:	Y:
Principal 2nd Moments of Area:	576190.19 m⁴	14658782 m⁴

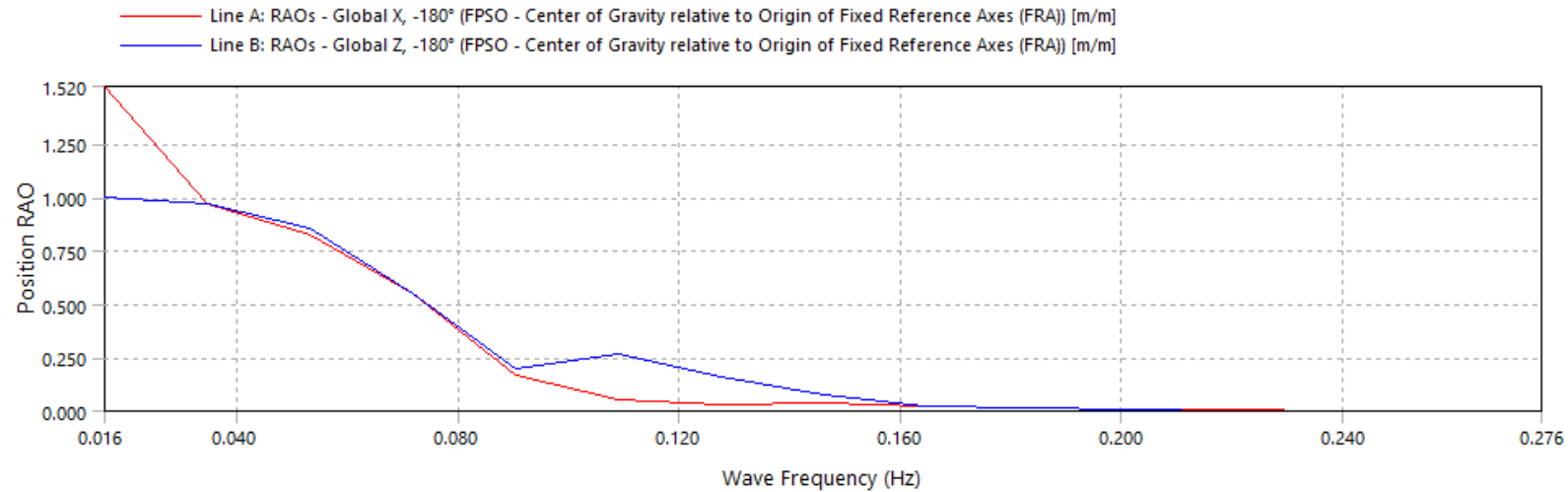
Angle between Principal X Axis and Global X Axis: -4.8942e-7°

Small Angle Stability Parameters

with respect to Principal Axes

CoG to CoB (BG): 12.329888 m
Metacentric Heights (GMX/GMY): 0.7578287 m 320.63309 m
CoB to Metacentre (BMX/BMY): 13.087717 m 332.96298 m
Restoring Moments (MX/MY): 5853221. N.m° 2.47646e9 N.m°

Hydrodynamic Graphs

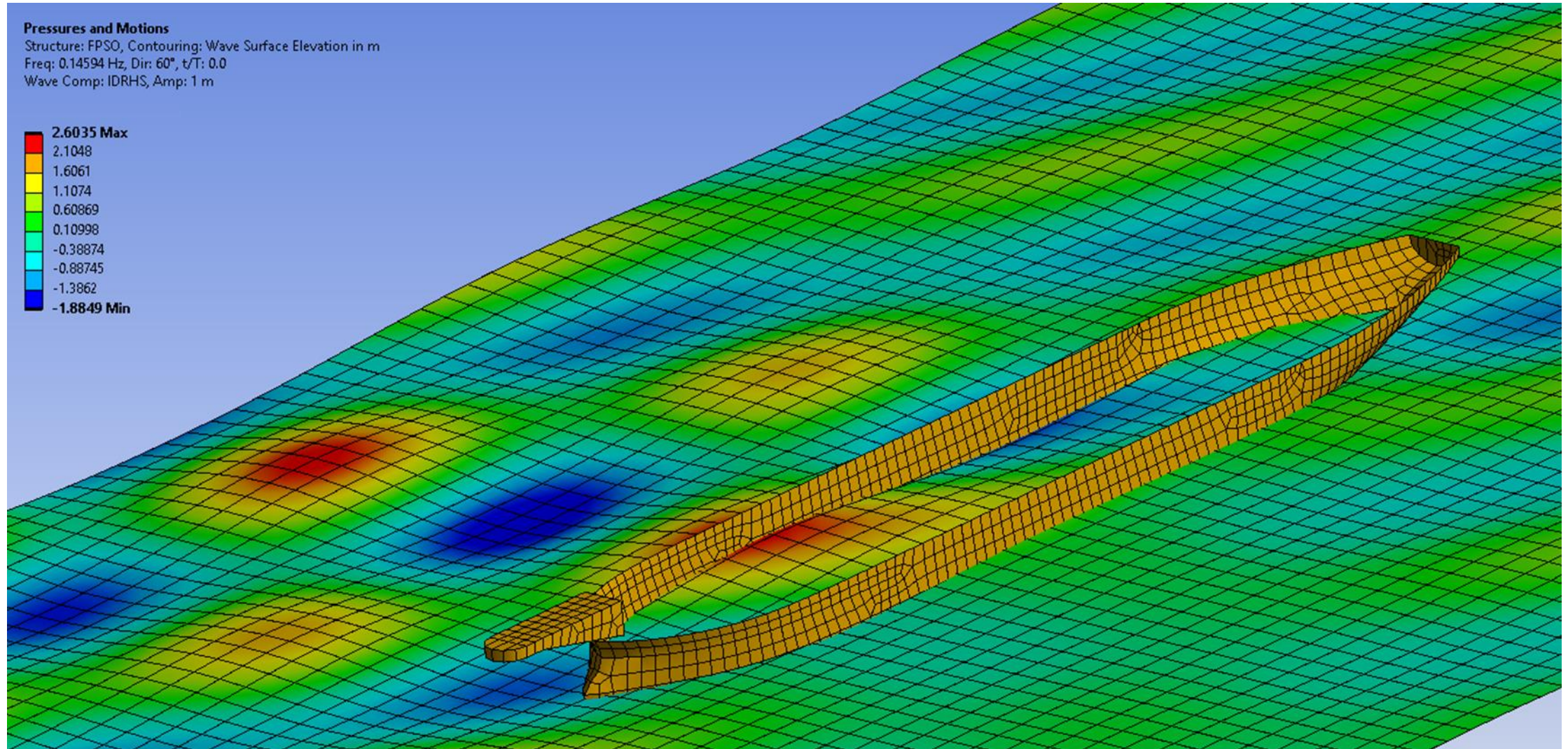


Geometry Properties Graph Report Preview

Tabulated Results Data

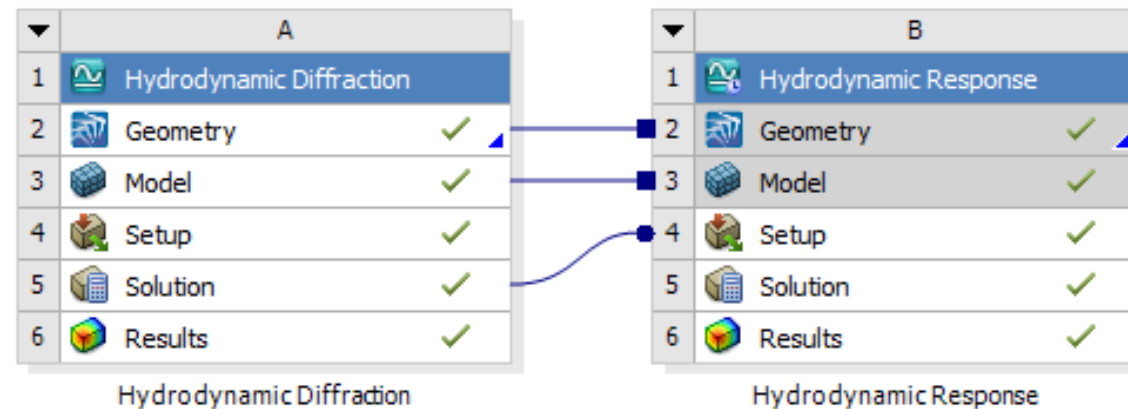
Wave Frequency (Hz)	Line A (m/m)	Line B (m/m)
0.01592	1.52039	0.99727
0.03449	0.96873	0.97344
0.05307	0.82319	0.85679
0.07164	0.54906	0.55408
0.09022	0.17193	0.19718
0.10879	0.05171	0.26396
0.12737	0.03314	0.16249
0.14594	0.03502	0.07336
0.16452	0.02518	0.02589
0.18309	0.01581	0.0128
0.20167	0.01048	4.22311e-3
0.22024	6.80733e-3	2.83984e-3
0.23882	3.97374e-3	1.32575e-3
0.25739	2.56115e-3	8.3235e-4
0.27597	1.64725e-3	3.45101e-4

Hydrodynamic Pressures and Motions



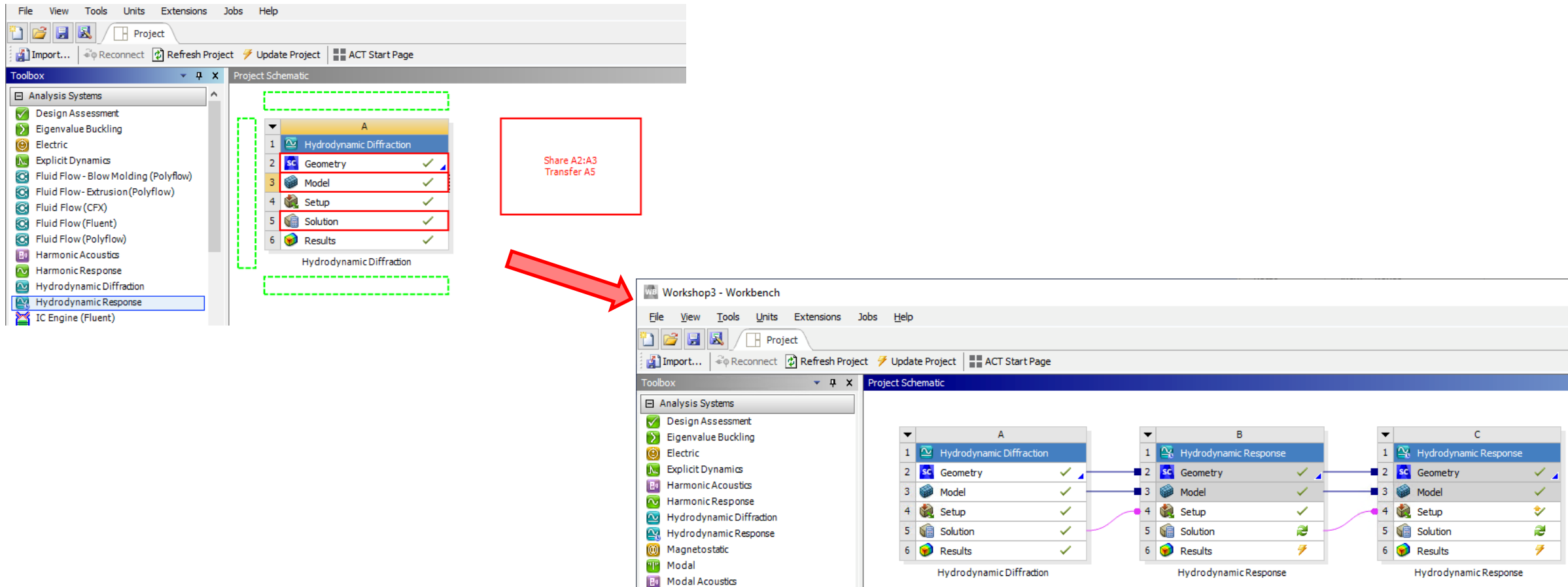
/ A Note on Connections

- In this example the mooring lines and articulation have been defined before the Hydrodynamic Diffraction system has been Solved. However, it must be noted that the effects of these connections will **not** be seen in the Hydrodynamic Diffraction results.
- It is possible to enter a 6x6 Connection Stiffness matrix (under Connections), applied between one structure and the ground or between two structures, which **is** accounted for in the HD system. However, in many cases the stiffness matrix can only be approximated.
- To fully assess the effects of the mooring lines and articulation on the system the user must view the results of a Hydrodynamic Response analysis. This is covered next.



Stability Analysis and Time Domain Simulation

- Add two HR systems by dragging and dropping on to the Workbench Project Schematic page



Define the Environment

- Right-click on **Hydrodynamic Response (B4)**, Insert > Irregular Wave > Pierson-Moskowitz
- Set Direction of Spectrum to 170°
- Set Significant Wave Height to 4m
- Set Zero Crossing Period to 8s
- Right-click on **Hydrodynamic Response (B4)**, Insert > Current > Constant Velocity
- Set a 1 m/s current at 175°. Note that since we have not defined any hull drag coefficients for the FPSO there will be no current loading on that vessel. The Turret, however, will be loaded since it is modelled in part by a tubular Morison element.
- Right-click and Propagate each of Irregular Wave 1 and Current 1 into the time domain analysis, Hydrodynamic Response (C4)

Details	
[-] Details of Irregular Wave 1	
Name	Irregular Wave 1
Visibility	Visible
Activity	Not Suppressed
Wave Range Defined By	Frequency
[-] Wave Spectrum Details	
Wave Type	Pierson-Moskowitz
<input type="checkbox"/> Direction of Spectrum	170°
Wave Spreading	None (Long-Crested Waves)
Spectrum Presentation Method	1D Graph
Seed Definition	Program Controlled
Number of Spectral Lines Definiti...	Program Controlled
Omit Calculation of Drift Forces	No
Start and Finish Frequency Defi...	Program Controlled
Start Frequency	0.05127 Hz
Finish Frequency	0.45167 Hz
<input type="checkbox"/> Significant Wave Height	4 m
<input type="checkbox"/> Zero Crossing Period	8 s
Export CSV File	Select CSV File...
[-] Cross Swell Details	
Wave Type	None

/Time Domain Analysis Settings

- In the time domain Analysis Settings of **Hydrodynamic Response (C4)**:
- Check that Analysis Type is set to Irregular Wave Response with Slow Drift
- Check that Time Step is set to 0.1 seconds
- Set Duration to 1000 seconds
- Check that Use Cable Dynamics is set to Yes

Details	
[-] Details of Analysis Settings	
Name	Analysis Settings
Computation Type	Time Response Analysis
External Operation before Solving	None
External Operation after Solving	None
Parallel Processing	Program Controlled
Use Cable Dynamics	Yes
[-] Time Response Specific Options	
Analysis Type	Irregular Wave Response with Slow Drift
<input type="checkbox"/> Start Time	0.0 s
<input type="checkbox"/> Time Step	0.1 s
Output Step	0.1 s
<input type="checkbox"/> Duration	1000 s
Number of Steps	10001
Finish Time	1000 s
Starting Position	Program Controlled

/ Check Solution

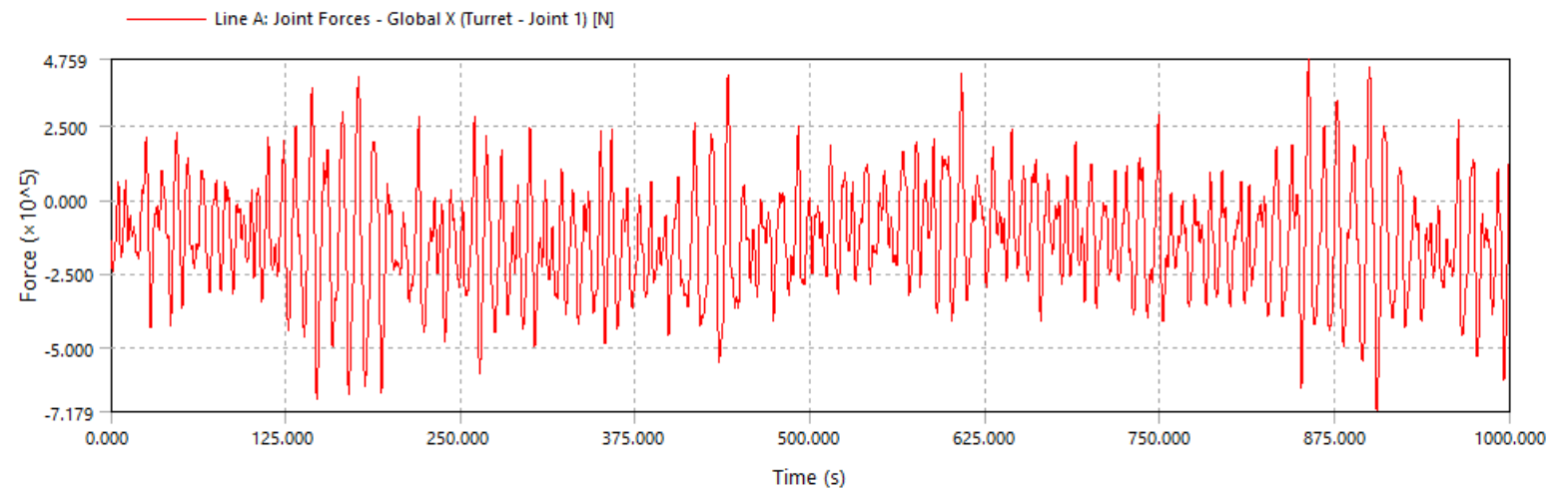
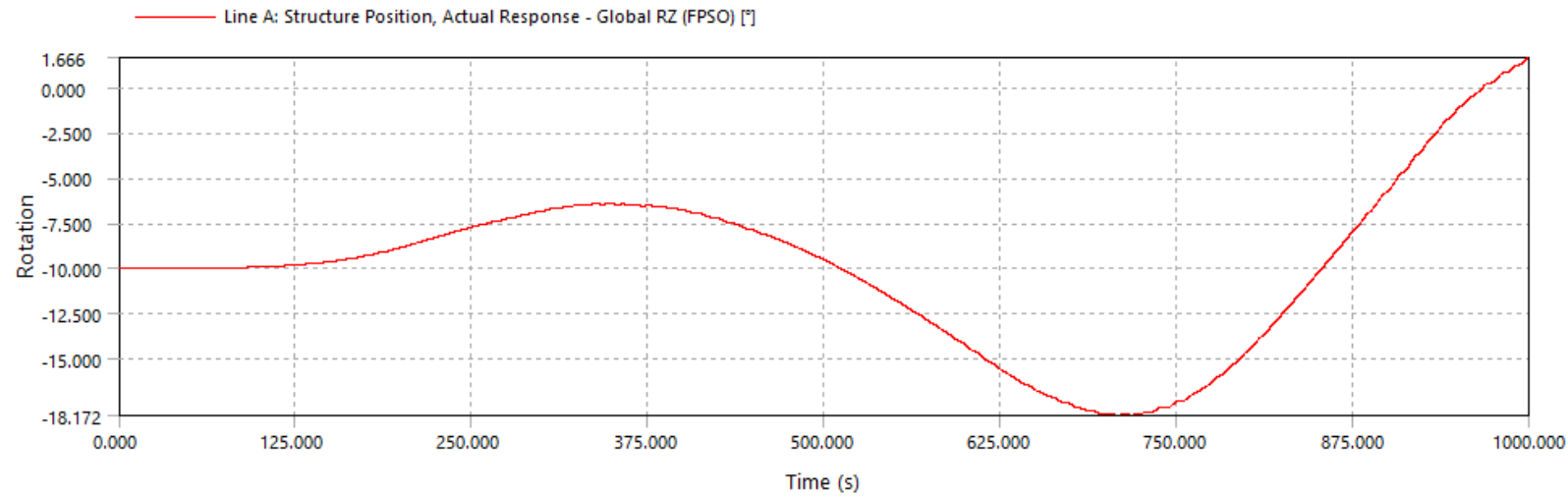
- Right-click on the time domain Hydrodynamic Response Solution (C5) to Insert Result > Structure Position > Actual Response
- Select FPSO for the Structure and Global RZ as the Component of motion
- Obtain forces on the turret joint connection - Insert Result > Joint Forces

Details	
[-] Details of Structure Position, Actual Response	
Name	Structure Position, Actual Response
Presentation Method	Line
Axes Selection	Distance/Rotation vs Time
[-] Line A	
Structure	FPSO
Type	Structure Position
SubType	Actual Response
Component	Global RZ

Details	
[-] Details of Joint Forces	
Name	Joint Forces
Presentation Method	Line
Axes Selection	Force/Moment vs Time
[-] Line A	
Structure	Turret
Type	Joint Forces
Component	Global X
Connection	Joint 1

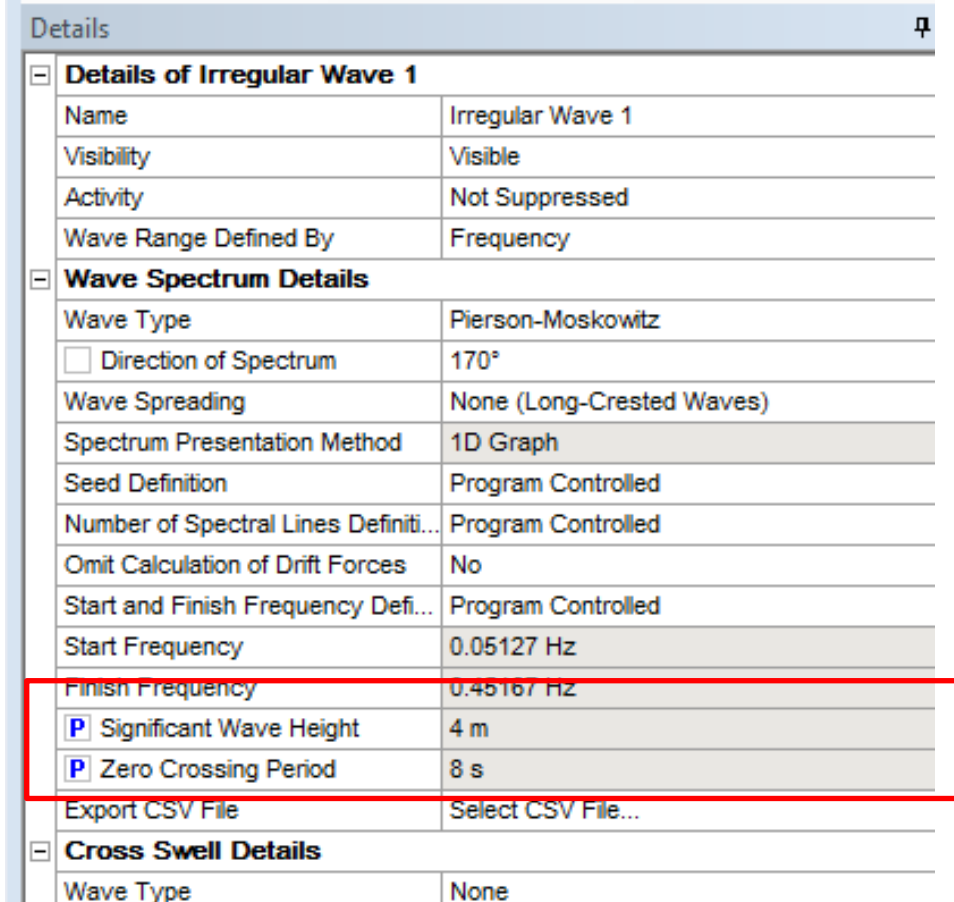
- Hit **Solve** on time domain Hydrodynamic Response (C4). Notice that the Stability Analysis (system B) is automatically updated first.

Typical Results



/ Setting Up Parameters

- For design studies, several input parameters can be set as variable (such as environmental parameters)
- Click the check box on the left hand side of the Significant Wave Height in the Irregular Wave Details
- The letter **P** will indicate that this value is a variable parameter and the value input box will be locked.
- Repeat for the Zero Crossing Period



Details	
Details of Irregular Wave 1	
Name	Irregular Wave 1
Visibility	Visible
Activity	Not Suppressed
Wave Range Defined By	Frequency
Wave Spectrum Details	
Wave Type	Pierson-Moskowitz
<input type="checkbox"/> Direction of Spectrum	170°
Wave Spreading	None (Long-Crested Waves)
Spectrum Presentation Method	1D Graph
Seed Definition	Program Controlled
Number of Spectral Lines Definiti...	Program Controlled
Omit Calculation of Drift Forces	No
Start and Finish Frequency Defi...	Program Controlled
Start Frequency	0.05127 Hz
Finish Frequency	0.45167 Hz
P Significant Wave Height	4 m
P Zero Crossing Period	8 s
Export CSV File	Select CSV File...
Cross Swell Details	
Wave Type	None

Setting Up Output Parameters

- In the Solution, set as output parameter the Joint Forces Minimum and Maximum Value.

Details4

[-] Details of Joint Forces

Name	Joint Forces
Presentation Method	Line
Axes Selection	Force/Moment vs Time
Export CSV File	Select CSV File...

[-] Line A

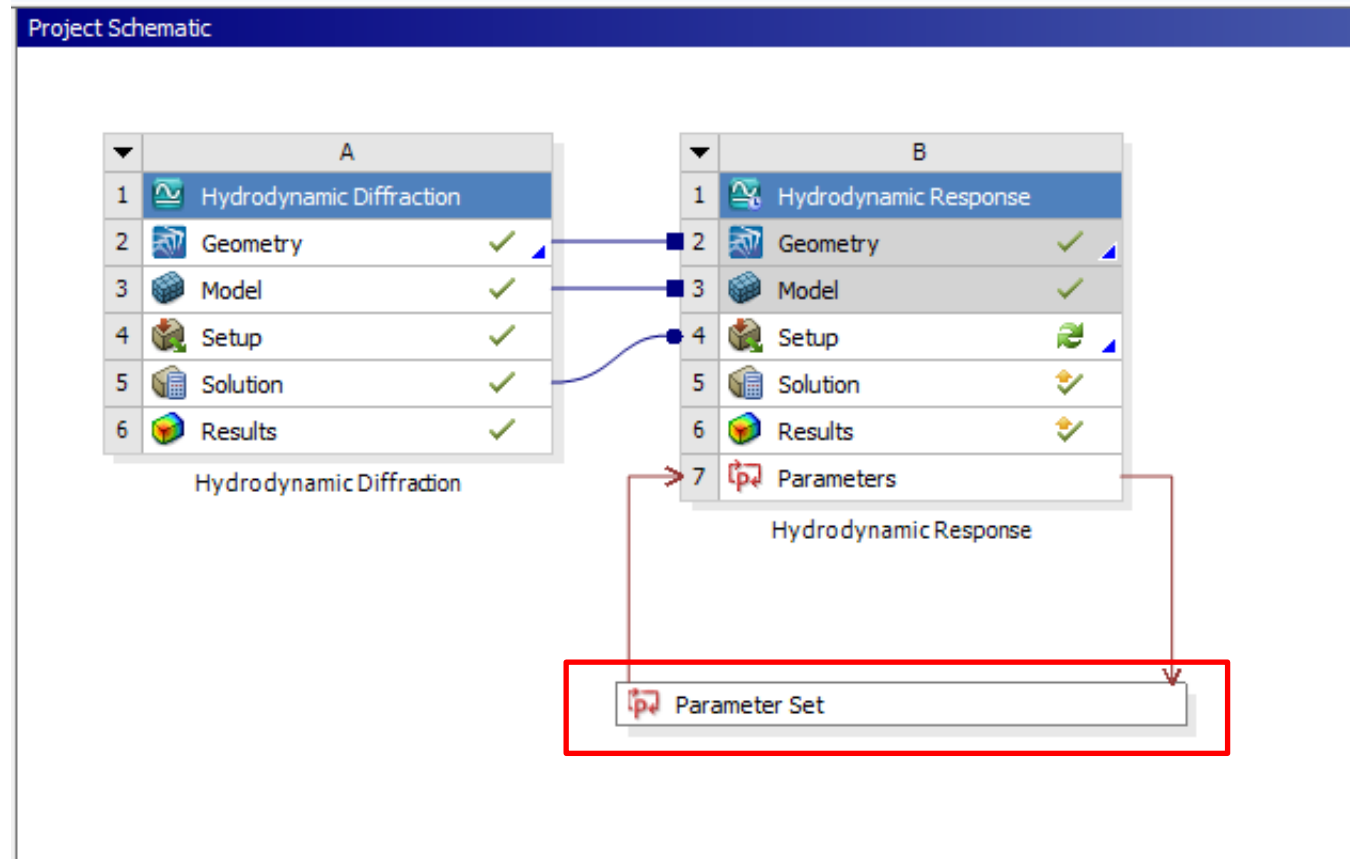
Structure	Turret
Type	Joint Forces
Connection	Joint 1
Component	Global X
<input type="checkbox"/> Abscissa Position of Minimum	904.9 s
<input type="checkbox"/> Abscissa Position of Maximum	856.1 s
<input checked="" type="checkbox"/> Minimum Value	-717925.75 N
<input checked="" type="checkbox"/> Maximum Value	475902.438 N

[-] Line B

Structure	Undefined...
-----------	--------------

Setting Up Parameters

- Go back to Project Schematic
- You will see that the Parameter Set box has appeared. Double-click on the Parameter Set box



Design Points View

•Design Points view in Workbench consists of several sub-views:

- Outline of all parameters
- Table of design points
- Properties
- Chart
- Parameters Chart Toolbox

The screenshot displays the Ansys Workbench Design Points view interface. The main window is titled 'Articulation - Workbench' and contains several sub-views:

- Toolbox:** Located on the left, it contains icons for 'Hydrodynamic Response (B1)', 'P1', 'P2', 'P3', and 'Charts'. A message states: 'No toolbox items are applicable for the current selection.'
- Outline of All Parameters:** A table listing parameters and their units.

ID	Parameter Name	Value	Unit
1	Input Parameters		
2	Hydrodynamic Response (B1)		
3	P1	Irregular Wave 1 Significant Wave Height	m
4	P4	Irregular Wave 1 Zero Crossing Period	s
5	New input parameter	New name	New expression
6	Output Parameters		
7	Hydrodynamic Response (B1)		
8	P2	Joint Forces Maximum Value (Joint 1)	N
9	P3	Joint Forces Minimum Value (Joint 1)	N
10	New output parameter	New expression	
11	Charts		
- Table of Design Points:** A table showing design point data.

A	B	C	D	E	F	G	H
Name	P1 - Irregular Wave 1 Significant Wave Height	P4 - Irregular Wave 1 Zero Crossing Period	P2 - Joint Forces Maximum Value (Joint 1)	P3 - Joint Forces Minimum Value (Joint 1)	Retain	Retained Data	Note
Units	m	s	N	N			
DP 0 (Current)	4	8	7.2239E+05	-1.0325E+06	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
- Properties of Design Points: Parameter Set:** A table showing properties for the design point set.

A	B
Property	Value
Design Point Report	
Report Image	None
- Chart:** A placeholder for a chart, currently showing 'No data'.

/ Setting Up Design Points

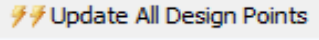
- Go to Table of Design Points and vary both the wave height and zero crossing period, as shown to define three additional design points. Save the Project
- Click 
- The solution will take several minutes, so be patient.
- Note the Retained Data column. If one or more of these boxes are checked then the complete solution for that particular design point(s) will be saved. Otherwise only the initial design point (marked as Current) is preserved.

Table of Design Points								
	A	B	C	D	E	F	G	H
1	Name ▾	P1 - Irregular Wave 1 Significant Wave Height ▾	P2 - Irregular Wave 1 Zero Crossing Period ▾	P3 - Joint Forces Minimum Value (Joint 1) ▾	P4 - Joint Forces Maximum Value (Joint 1) ▾	<input type="checkbox"/> Reta	Retained Data	Note ▾
2	Units	m	s	N	N			
3	DP 0 (Current)	4	8	-7.1793E+05	4.759E+05	<input checked="" type="checkbox"/>	✓	
4	DP 1	4	10	⚡	⚡	<input type="checkbox"/>		
5	DP 2	3	9	⚡	⚡	<input type="checkbox"/>		
6	DP 3	3	11	⚡	⚡	<input type="checkbox"/>		
*						<input type="checkbox"/>		

/ Design Points Results

- Review the results table for each design point

Table of Design Points								
	A	B	C	D	E	F	G	H
1	Name ▾	P1 - Irregular Wave 1 Significant Wave Height ▾	P2 - Irregular Wave 1 Zero Crossing Period ▾	P3 - Joint Forces Minimum Value (Joint 1) ▾	P4 - Joint Forces Maximum Value (Joint 1) ▾	<input type="checkbox"/> Retained	Retained Data	Note ▾
2	Units	m	s	N	N			
3	DP 0 (Current)	4	8	-7.1793E+05	4.759E+05	<input checked="" type="checkbox"/>	✓	
4	DP 1	4	10	-5.8844E+05	4.9245E+05	<input type="checkbox"/>		
5	DP 2	3	9	-4.6713E+05	3.4514E+05	<input type="checkbox"/>		
6	DP 3	3	11	-4.2083E+05	4.2942E+05	<input type="checkbox"/>		
*						<input type="checkbox"/>		

Results of Parameter Studies

- You can also plot them from the Parameter Charts Toolbox:
 - Select Outline Of All Parameters to see the Toolbox
 - Double-click on Parameters Chart
 - Select X axis and Y axis parameters from Properties of Outline
- The resulting plot appears in Parameter Chart window (Note that line properties may be modified by RMB on the line and select Edit Properties)

