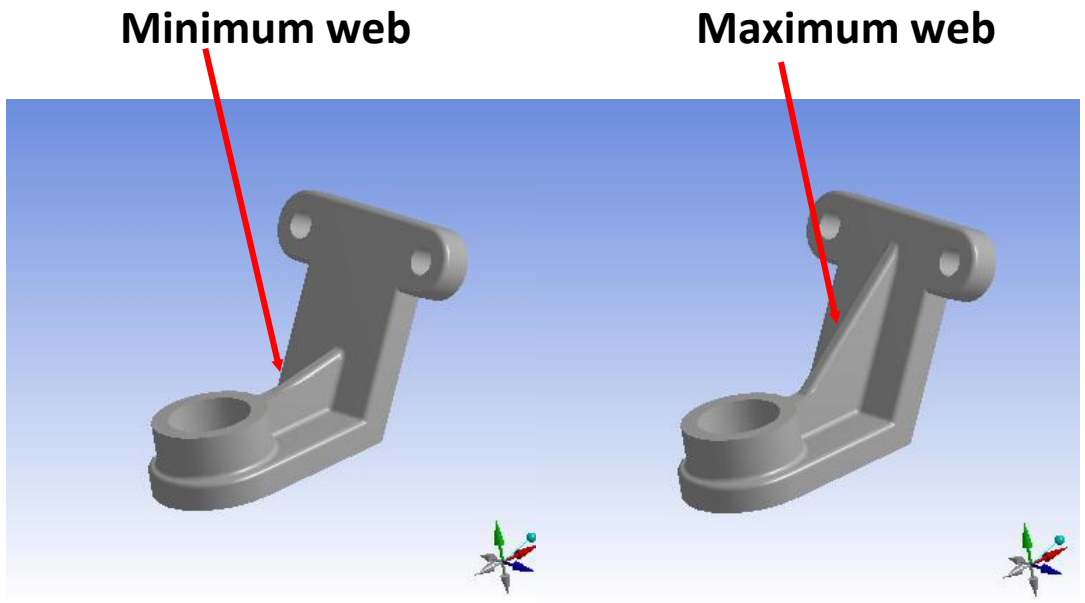
Optimum Design Course
Fall 2016

Ansys Tutorial 6

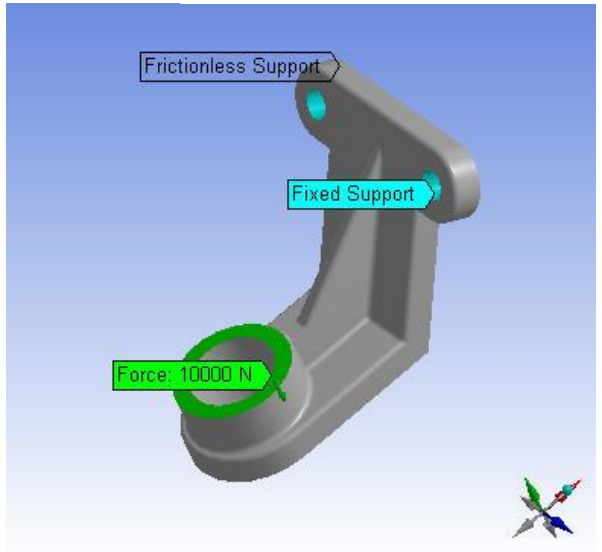
Support Bracket

Overview

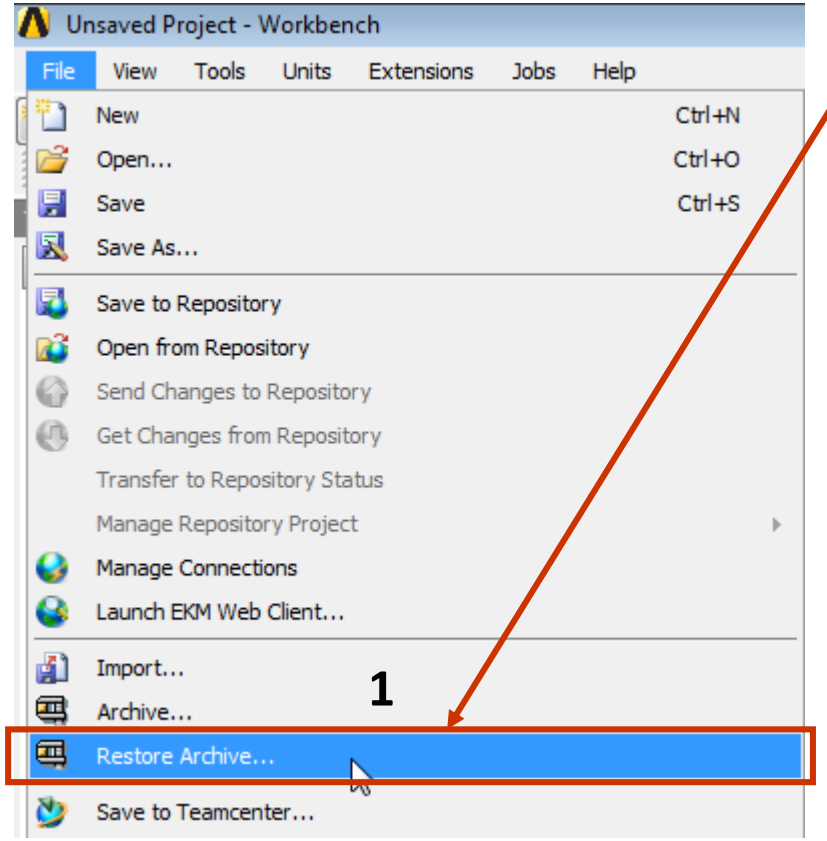
- **Goal**
  - Investigate the deflection and mass for model shown here as the load and the geometry are varied
  - The goal is to minimize mass and deflection with mass as the most important consideration



- **Model Description**
  - Constraints and Load are shown on the picture

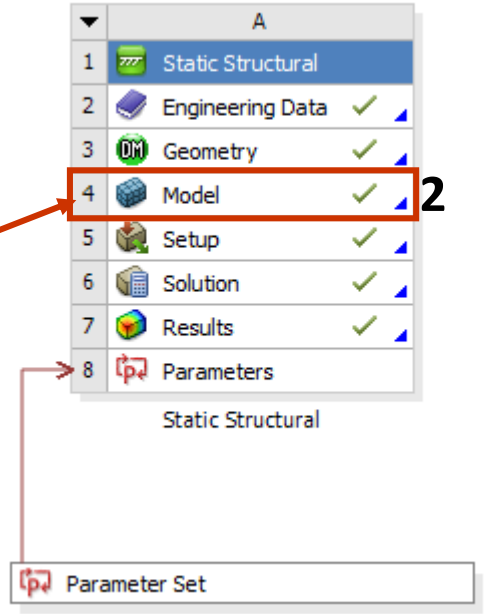


Project Startup



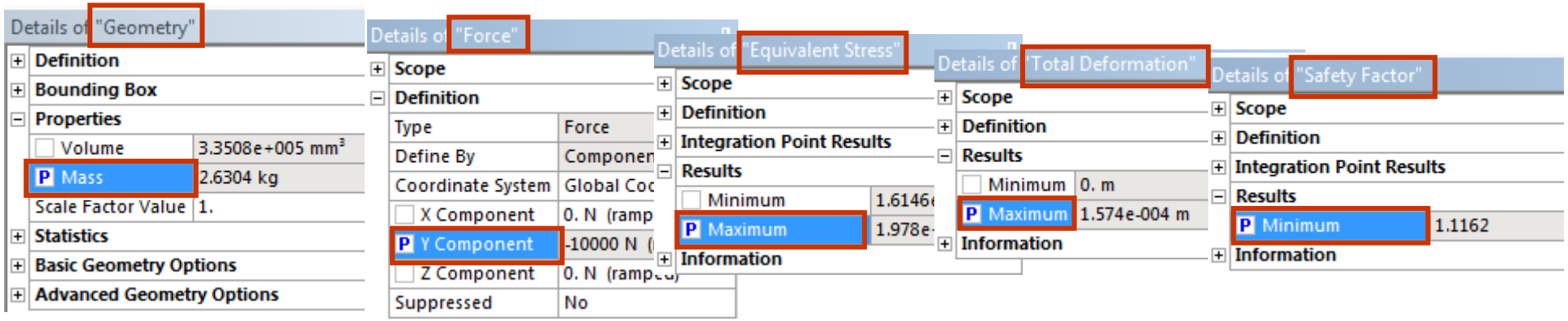
1. Restore Archive – file:
Support Bracket.wbpz

2. Double click on model

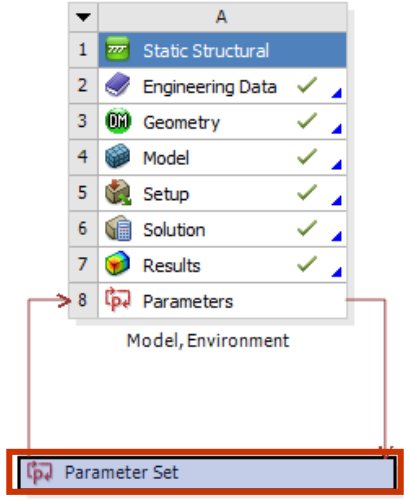


Parameterize Project

3. Parameterize the following parameters by checking the boxes beside them



4. Double click on parameter set

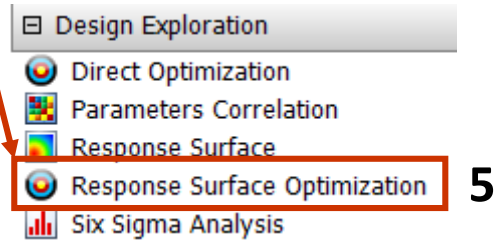


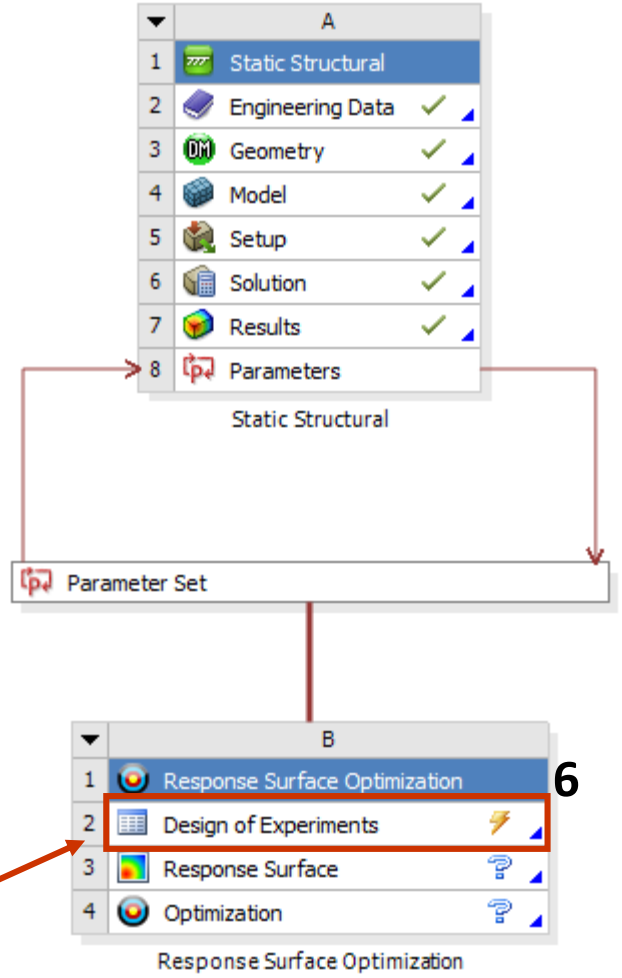
The parameters have been created

ID	Parameter Name	Value	Unit
Input Parameters			
Static Structural (A1)			
P1	ds_web	70	
P3	Force Y Component	-10000	N
New input parameter	New name	New expression	
Output Parameters			
Static Structural (A1)			
P2	Geometry Mass	2.6304	kg
P4	Equivalent Stress Maximum	2.2398E+08	Pa
P5	Total Deformation Maximum	0.00016951	m
P6	Safety Factor Minimum	1.1162	
New output parameter		New expression	
Charts			

Enter the Response Surface

5. Double click on Response Surface Optimization in the toolbox

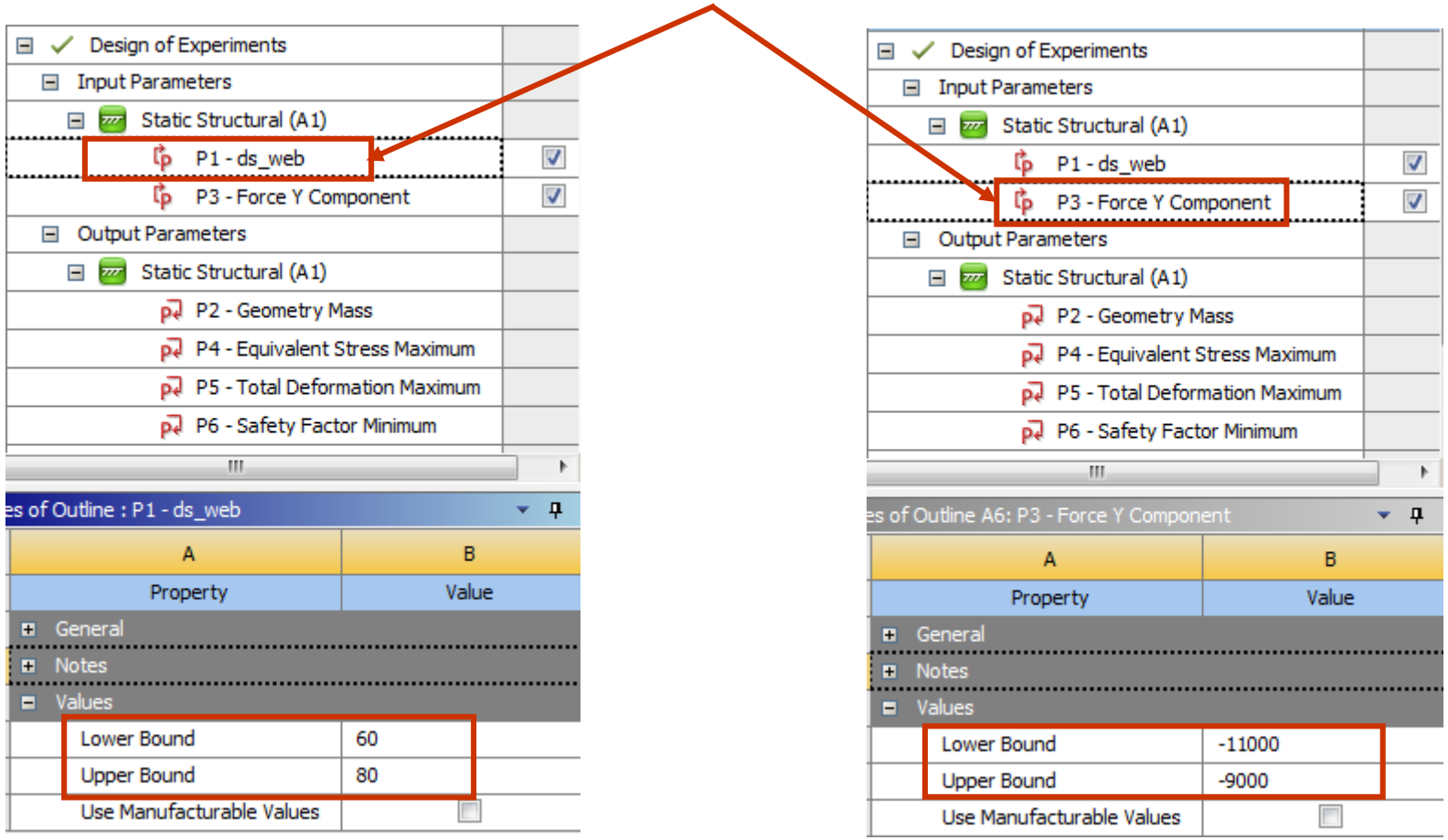




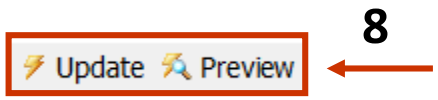
6. Right click on Design of Experiments and select Edit

Conduct a DOE study

7. Highlight parameters P1 then P3 in the outline of design of experiments, and set up lower and upper bounds as shown in the properties of outline



Conduct a DOE study



8. Preview and Update Design of Experiments

Progress

	A	B	C
1	Status	Details	Progress
2	Updating the Design of Experiments component in Response Surface Optimization	Updating the Model component in Static Structural for design point 3	

A total of 9 automatic design points are created

Table of Schematic B2: Design of Experiments (Central Composite Design : Auto Defined)

	A	B	C	D	E	F	G
1	Name	P1 - ds_web	P3 - Force Y Component (N)	P6 - Safety Factor Minimum	P5 - Total Deformation Maximum (m)	P4 - Equivalent Stress Maximum (Pa)	P2 - Geometry Mass (kg)
2	1 DP 0	70	-10000	1.1162	0.00016951	2.2398E+08	2.6304
3	2	60	-10000	1.2329	0.00018051	2.0278E+08	2.6112
4	3	80	-10000	1.0906	0.00016337	2.2924E+08	2.6483
5	4	70	-11000	1.0147	0.00018646	2.4638E+08	2.6304
6	5	70	-9000	1.2402	0.00015256	2.0158E+08	2.6304
7	6	60	-11000	1.1208	0.00019856	2.2305E+08	2.6112
8	7	80	-11000	0.99141	0.00017971	2.5217E+08	2.6483
9	8	60	-9000	1.3699	0.00016246	1.825E+08	2.6112
10	9	80	-9000	1.2117	0.00014704	2.0632E+08	2.6483

Conduct a DOE study

9. Select DOE

Outline of Schematic B2: Design of Experiments

	A	B
1		Enabled
2	Design of Experiments	
3	Input Parameters	
4	Static Structural (A1)	
5	P1 - ds_web	☑
6	P3 - Force Y Component	☑
7	Output Parameters	
8	Static Structural (A1)	
9	P2 - Solid Mass	
10	P4 - Equivalent Stress Maximum	
11	P5 - Total Deformation Maximum	
12	P6 - Safety Factor Minimum	
13	P7 - Geometry Mass	
14	Charts	
15	Parameters Parallel	
16	Design Points vs Parameter	

9

Properties of Schematic B2: Design of Experiments

	A	B
1	Property	Value
2	Design Points	
3	Preserve Design Points After DX Run	☐
4	Failed Design Points Management	
5	Number of Retries	0
6	Design of Experiments	
7	Design of Experiments Type	Central Composit...
8	Design Type	Face-Centered
9	Template Type	Enhanced

10

10. Change design type to Face Centered

Template type: Enhanced

Conduct a DOE study

11

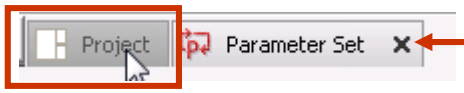
11. Preview and Updated DOE

A total of 17 automatic design points are created

Table of Schematic B2: Design of Experiments (Central Composite Design : Face-Centered : Enhanced)

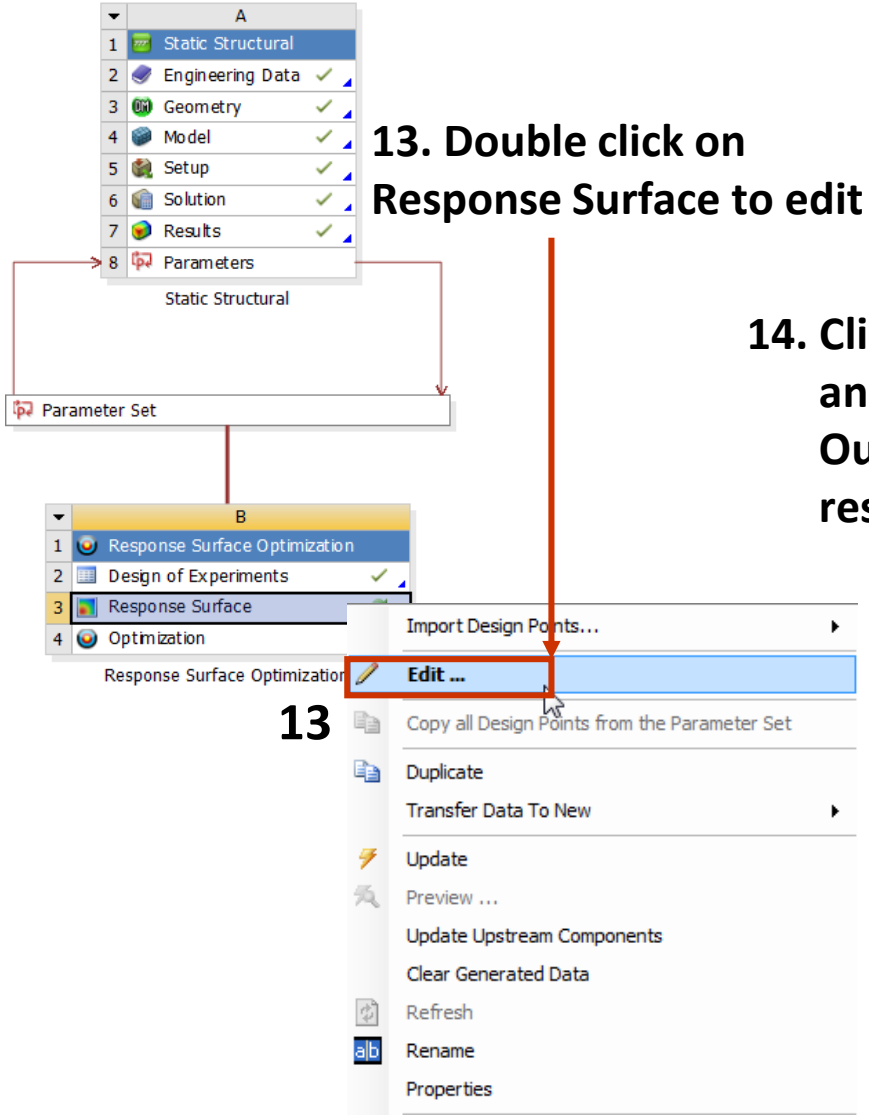
	A	B	C	D	E	F	G
1	Name	P1 - ds_web	P3 - Force Y Component (N)	P6 - Safety Factor Minimum	P5 - Total Deformation Maximum (m)	P4 - Equivalent Stress Maximum (Pa)	P2 - Geometry Mass (kg)
2	1 DP 0	70	-10000	1.1162	0.00016951	2.2398E+08	2.6304
3	2	60	-10000	1.2329	0.00018051	2.0278E+08	2.6112
4	3	65	-10000	1.1187	0.00017413	2.2347E+08	2.621
5	4	80	-10000	1.0906	0.00016337	2.2924E+08	2.6483
6	5	75	-10000	1.1433	0.00016601	2.1866E+08	2.6395
7	6	70	-11000	1.0147	0.00018646	2.4638E+08	2.6304
8	7	70	-10500	1.063	0.00017798	2.3518E+08	2.6304
9	8	70	-9000	1.2402	0.00015256	2.0158E+08	2.6304
10	9	70	-9500	1.1749	0.00016103	2.1278E+08	2.6304
11	10	60	-11000	1.1208	0.00019856	2.2305E+08	2.6112
12	11	65	-10500	1.0654	0.00018284	2.3465E+08	2.621
13	12	80	-11000	0.99141	0.00017971	2.5217E+08	2.6483
14	13	75	-10500	1.0889	0.00017431	2.2959E+08	2.6395
15	14	60	-9000	1.3699	0.00016246	1.825E+08	2.6112
16	15	65	-9500	1.1776	0.00016543	2.123E+08	2.621
17	16	80	-9000	1.2117	0.00014704	2.0632E+08	2.6483
18	17	75	-9500	1.2035	0.00015771	2.0772E+08	2.6395

12



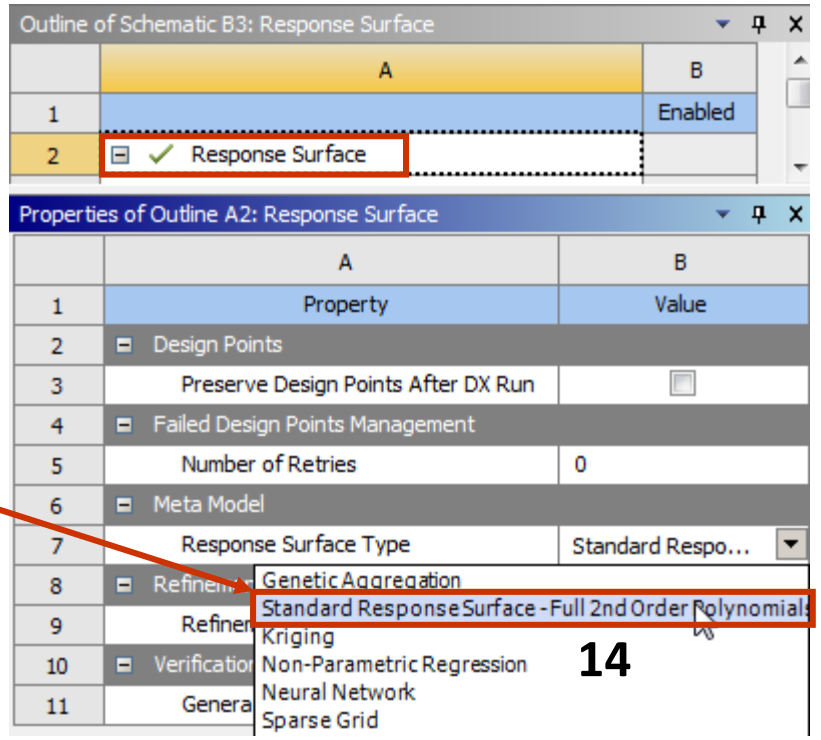
12. Return to Project

Conduct a Response Surface study



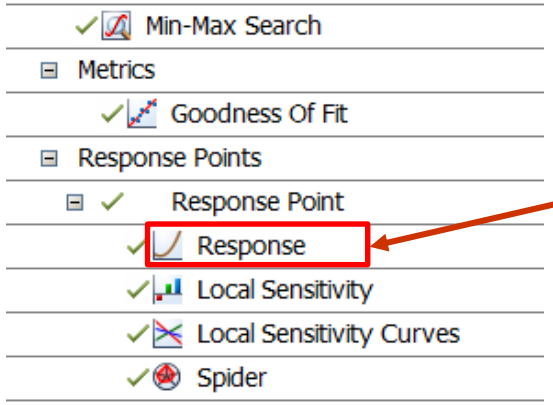
13. Double click on Response Surface to edit it

14. Click on Response surface and in the Properties of Outline change to standard response surface



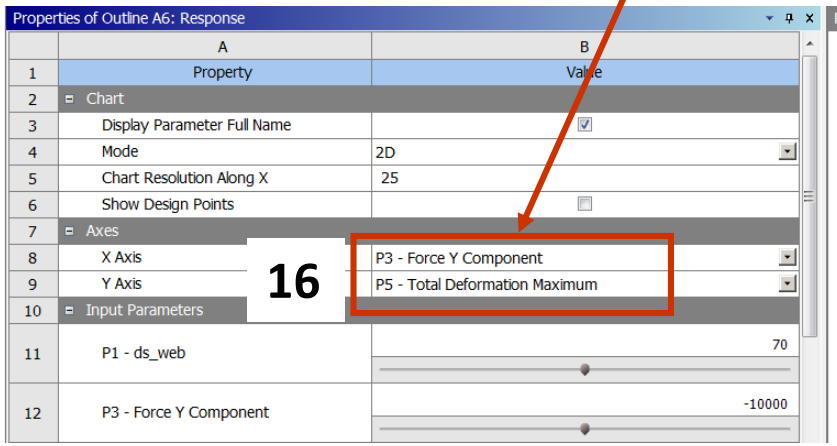
15. Update the Response Surface

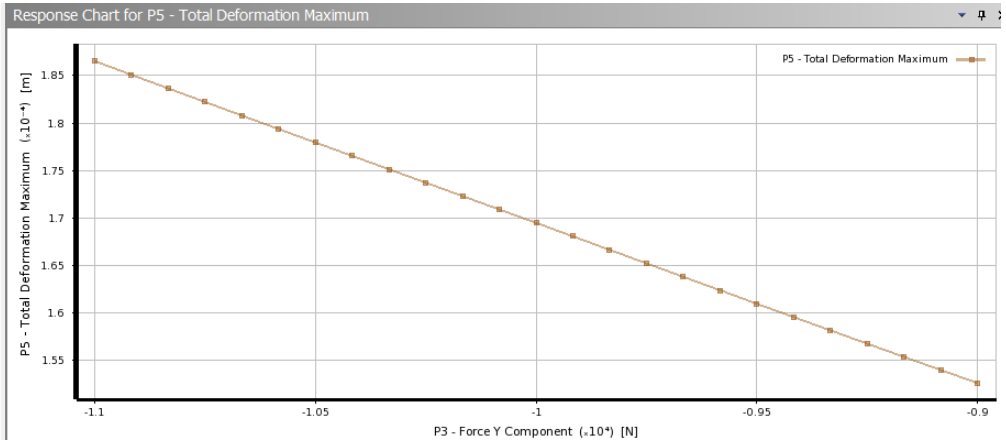
Conduct a Response Surface study



Click Response

16.In the Properties frame, select Force Y Component and Total Deformation Maximum as the x and y axis, respectively





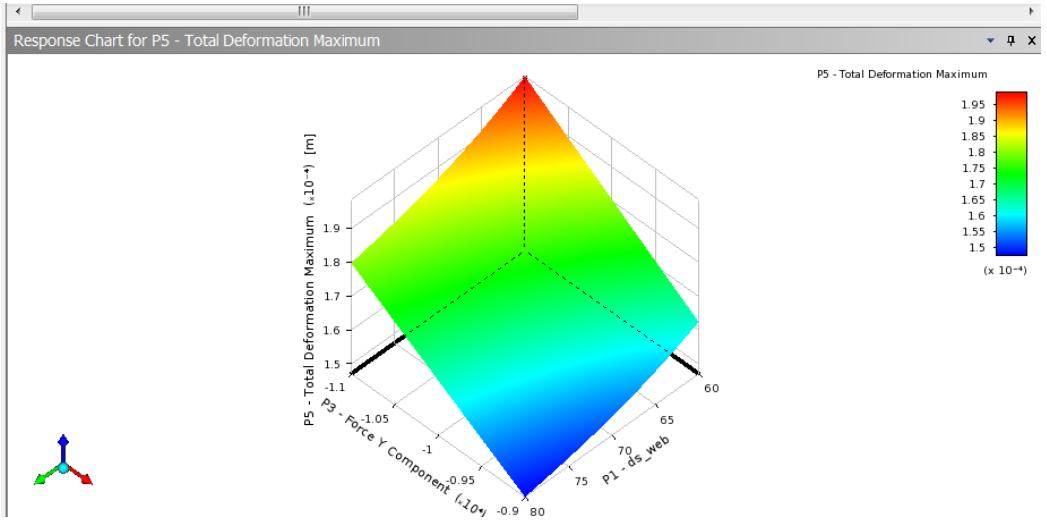
Conduct a Response Surface study

17. Set Mode to 3D

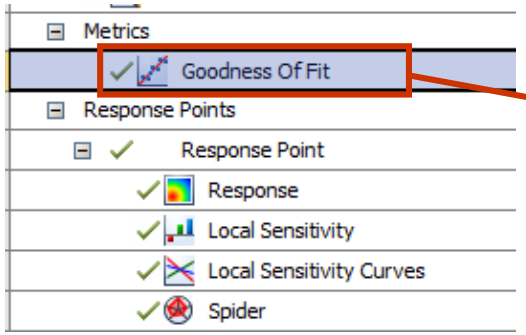
Properties of Outline A6: Response

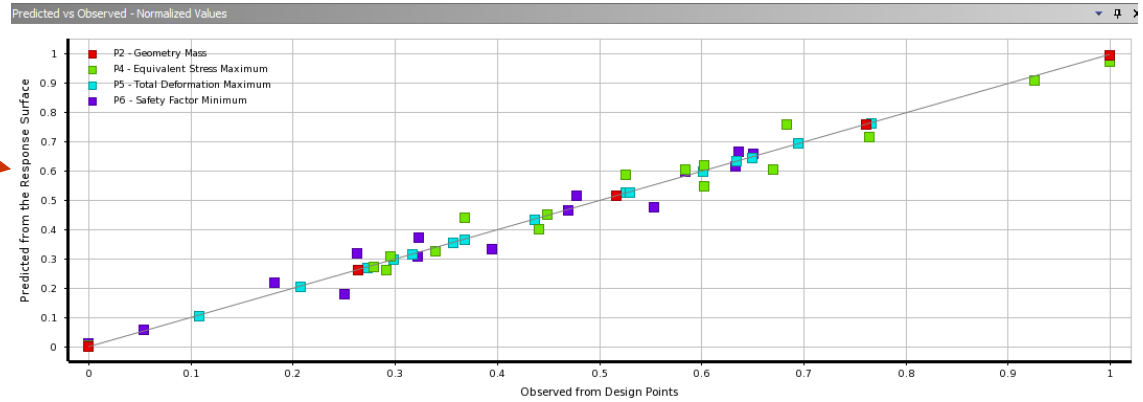
	A	B
1	Property	Value
2	Chart	
3	Display Parameter Full Name	☑
4	Mode	3D
5	Chart Resolution Along X	25
6	Chart Resolution Along Y	25
7	Show Design Points	☐
8	Axes	
9	X Axis	P3 - Force Y Component
10	Y Axis	P1 - ds_web
11	Z Axis	P5 - Total Deformation Maximum
12	Input Parameters	
13	P1 - ds_web	70
14	P3 - Force Y Component	-10000

17

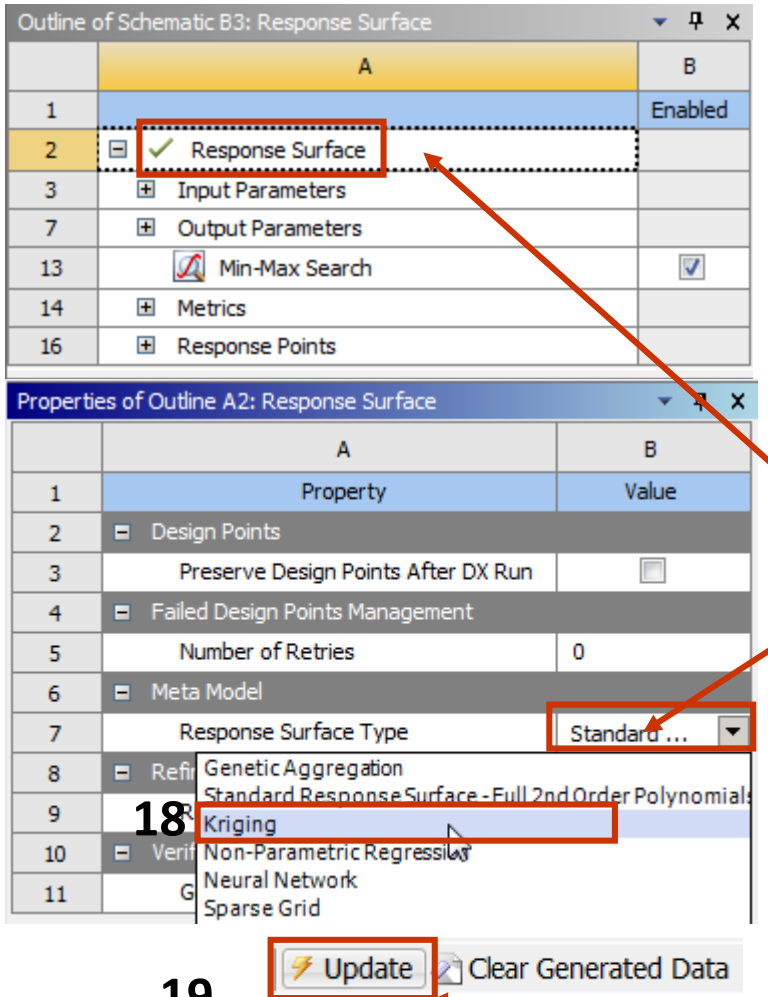


Check the Goodness of Fit





Conduct a Response Surface study



18. Click on Response surface and in the Properties of Outline change from standard response surface to Kriging

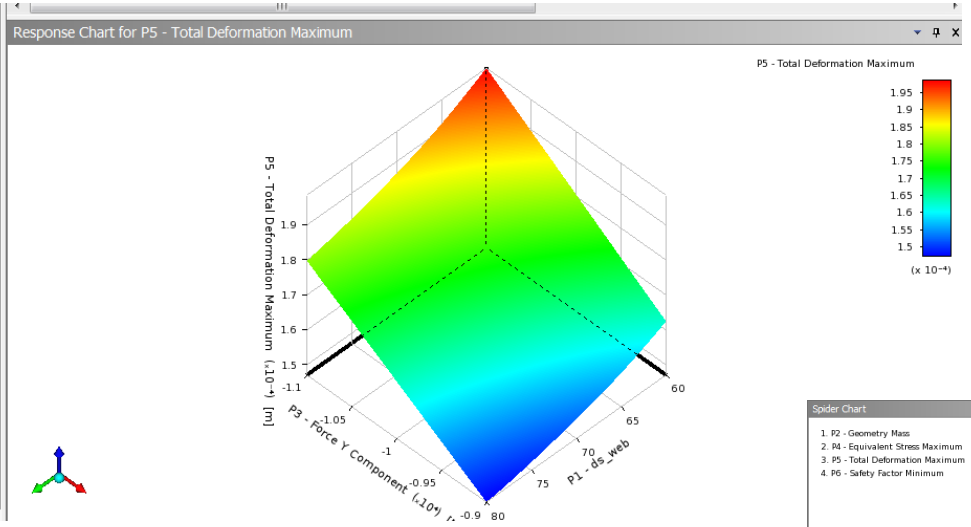
19. Update response surface

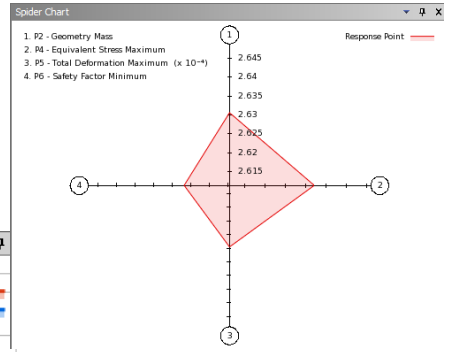
Conduct a Response Surface study

Plot Response surface > 3D (repeat step 17)

Properties of Outline A11: Response

	A	B
1	Property	Value
2	Chart	
3	Display Parameter Full Name	☑
4	Mode	3D
5	Chart Resolution Along X	25
6	Chart Resolution Along Y	25
7	Show Design Points	☐
8	Axes	
9	X Axis	P3 - Force Y Component
10	Y Axis	P1 - ds_web
11	Z Axis	P5 - Total Deformation Maximum
12	Input Parameters	
13	P1 - ds_web	70
14	P3 - Force Y Component	-10000
15	Output Parameters	

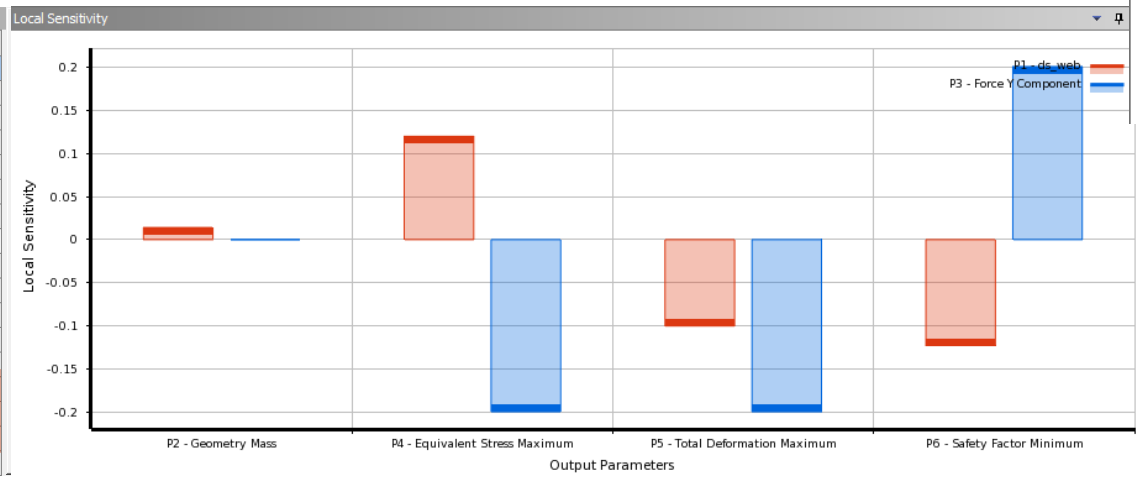




Plot local sensitivities and spider chart

Outline of Schematic B3: Response Surface

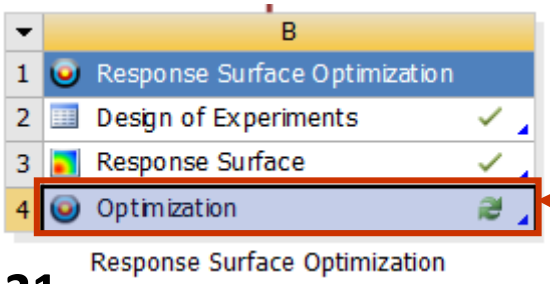
	A	B
1		Enabled
2	Response Surface	
3	Input Parameters	
4	Static Structural (A1)	
5	P1 - ds_web	☑
6	P3 - Force Y Component	☑
7	Output Parameters	
14	Min-Max Search	☑
15	Metrics	
16	Goodness Of Fit	
17	Response Points	
18	Response Point	
19	Response	
20	Local Sensitivity	
21	Local Sensitivity Curves	
22	Spider	
*	New Response Point	



Conduct a Response Surface Optimization

20

20. Return to project



21

21. Double click on optimization

22. Click on optimization and set Optimization Method > Screening

Number of Samples = 1000

Outline of Schematic B4: Optimization

	A	B	C
1		Enabled	Monitoring
2	Optimization		
3	Objectives and Constraints		
4	Domain		
5	Static Structural (A1)		
6	P1 - ds_web	☑	
7	P3 - Force Y Component	☑	
8	Results		

Properties of Schematic B4: Optimization

	A	B
1	Property	Value
2	Design Points	
3	Preserve Design Points After DX Run	☐
4	Failed Design Points Management	
5	Number of Retries	0
6	Optimization	
7	Optimization Method	Screening
8	Number of Samples	1000
9	Maximum Number of Candidates	3
10	Verify Candidate Points	☐
11	Optimization Status	
12	Number of Evaluations	0
13	Number of Failures	0
14	Size of Generated Sample Set	0
15	Number of Candidates	0

22

Conduct a Response Surface Optimization

23. Set the goals as shown in optimization table

Note: Note that P might have a different suffix in your WB

Outline of Schematic B4: Optimization

	A
1	
2	Optimization
3	Objectives and Constraints
4	Minimize P2
5	Minimize P5

Table of Schematic B4: Optimization

	A	B	C	D	E	F	G
1	Name	Parameter	Objective		Constraint		
2			Type	Target	Type	Lower Bound	Upper Bound
3	Minimize P2	P2 - Geometry Mass	Minimize		No Constraint		
4	Minimize P5	P5 - Total Deformation Maximum	Minimize		No Constraint		
*		Select a Parameter					

24. Update Optimization

Update | Clear Generated Data

Table of candidate designs based on the goals

Table of Schematic B4: Optimization

	A	B	C	D	E
1	Optimization Study				
2	Minimize P5	Goal, Minimize P5 (Default importance)			
3	Minimize P2	Goal, Minimize P2 (Default importance)			
4	Optimization Method				
5	Screening	The Screening optimization method uses a simple approach based on sampling and sorting. It supports multiple objectives and constraints as well as all types of input parameters. Usually it is used for preliminary design, which may lead you to apply other methods for more refined optimization results.			
6	Configuration	Generate 1000 samples and find 3 candidates.			
7	Status	Converged after 1000 evaluations.			
8	Candidate Points				
9		Candidate Point 1	Candidate Point 1 (verified)	Candidate Point 2	Candidate Point 3
10	P1 - ds_web	60		60.15	60.07
11	P3 - Force Y Component (N)	-9000		-9249	-9499
12	P2 - Geometry Mass (kg)	2.6112	2.6112	2.6115	2.6113
13	P5 - Total Deformation Maximum (m)	0.00016239	0.00016239	0.00016669	0.0001713

Conduct a Response Surface Optimization

25. Select Tradeoff and Samples to get tradeoff and samples chart. Also set Number of Pareto Fronts to 16

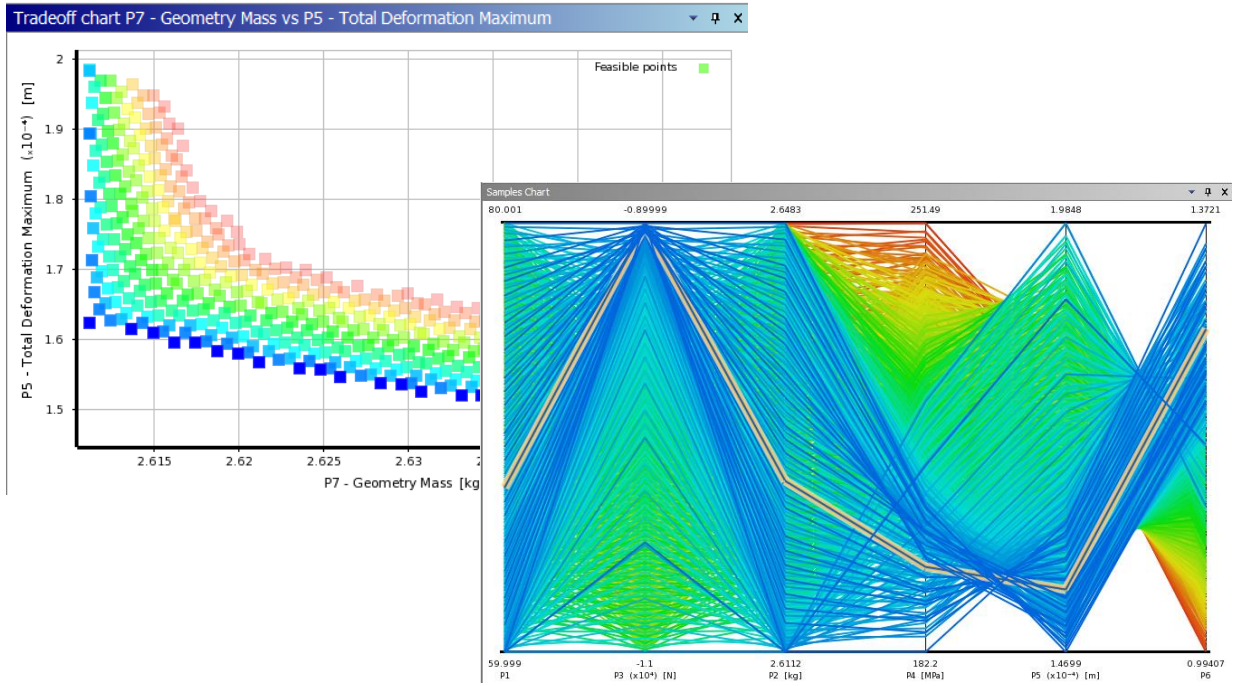
Outline of Schematic B4: Optimization

	A	B	C
1		Enabled	Monitoring
2	Optimization		
3	Objectives and Constraints		
4	Minimize P7		
5	Minimize P5		
6	Domain		
7	Static Structural (A1)		
8	P1 - ds_web	☑	
9	P3 - Force Y Component	☑	
10	Results		
11	Candidate Points		
12	Tradeoff		
13	Samples		
14	Sensitivities		

Properties of Outline A11: Tradeoff

25

	A	B
1	Property	Value
2	Chart	
3	Display Parameter Full Name	☑
4	Mode	2D
5	Number of Pareto Fronts to Show	16
6	Axes	
7	X Axis	P7 - Geometry Mass
8	Y Axis	P5 - Total Deformat...

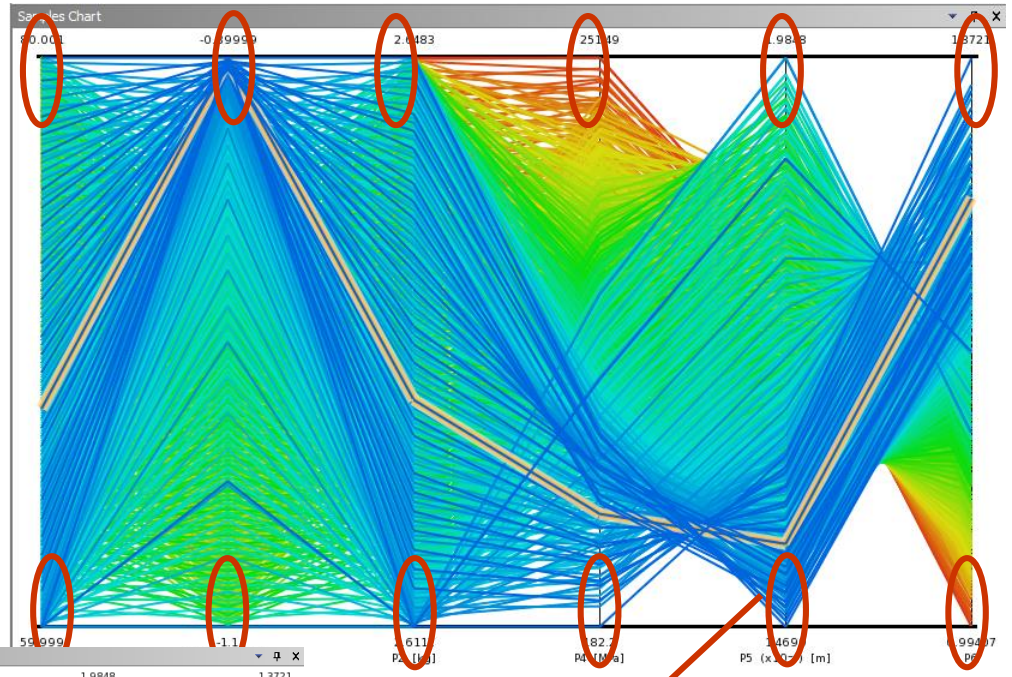


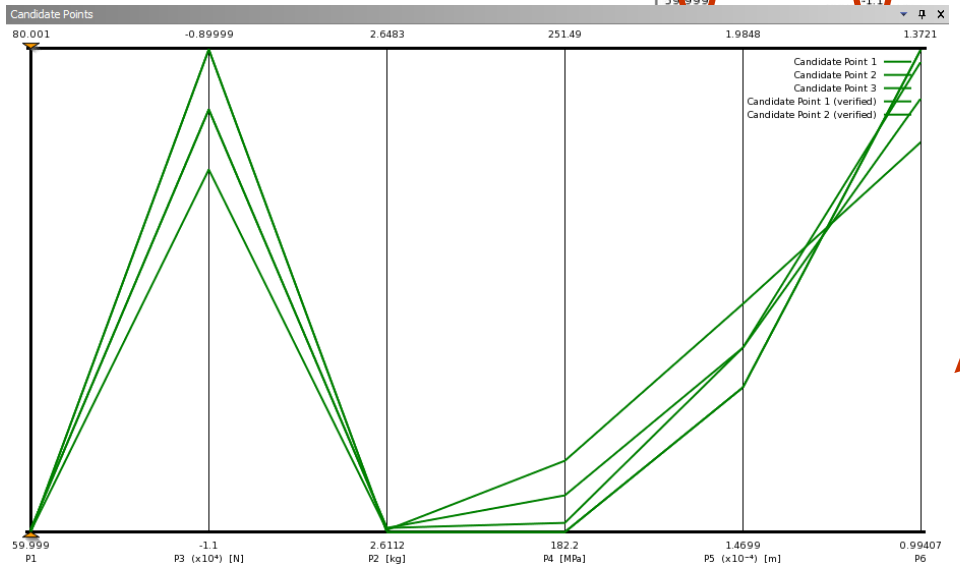
In this case we have optimized goals that are counter to one another (min deformation and min mass)

Reducing the mass means Increasing the deformation and vice versa

Conduct a Response Surface Optimization

Try holding your mouse over these locations and drag the orange handles that appear up or down

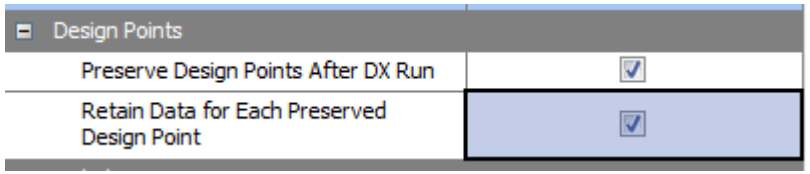


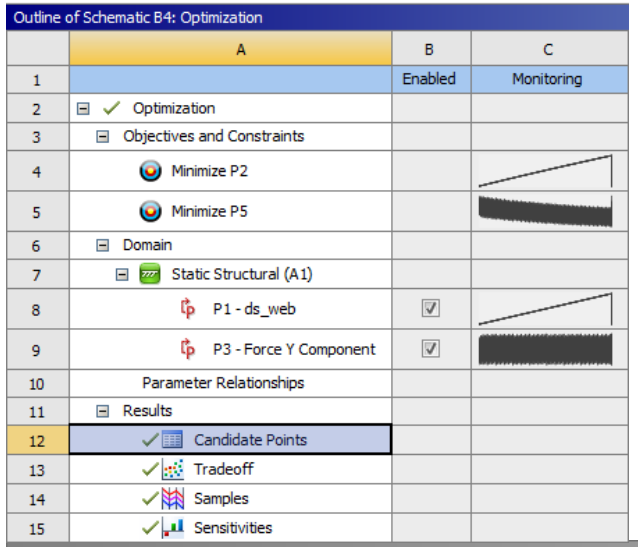


This can help you narrow in on samples with parameters in the ranges you are interested in

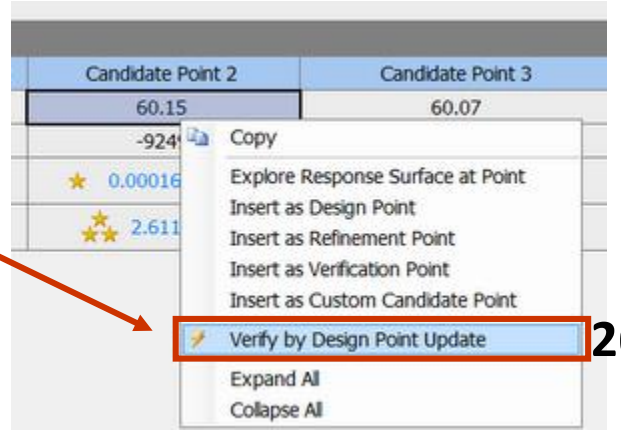
Conduct a Response Surface Optimization

26. Under Optimization, enable the options to “Preserve” and “Retain” the Design Points





27. Under Candidate Points, select candidate 2, RMB, and click Verify by Design Point Update



26

Here we can see how the results of the optimization compare to a full simulation for Candidate 2

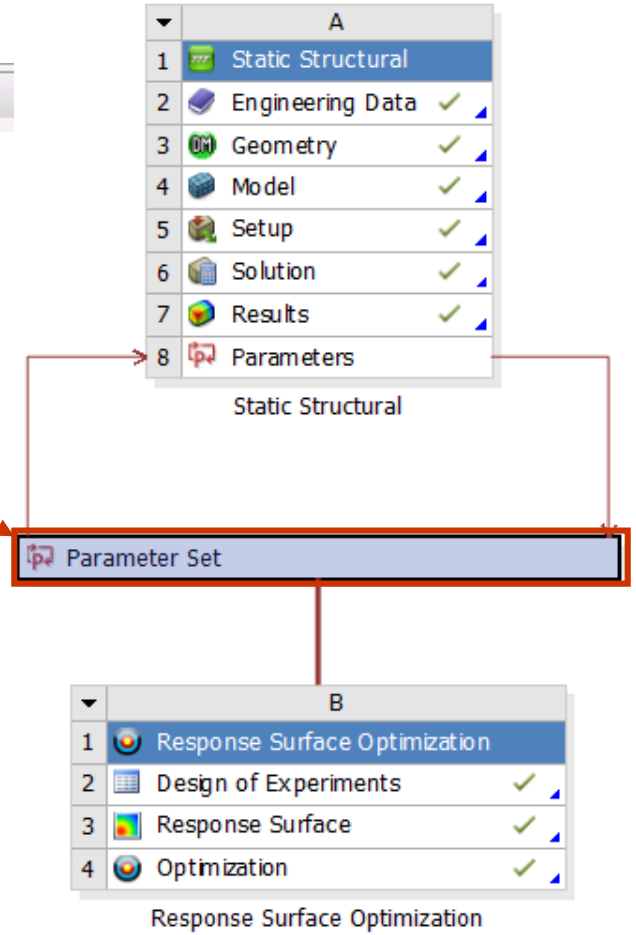
Table of Schematic B4: Optimization , Candidate Points

	A	B	C	D	E	F	G	H	I	J
1	Reference	Name	P1 - ds_web	P3 - Force Y Component (N)	P2 - Geometry Mass (kg)		P4 - Equivalent Stress Maximum (MPa)	P5 - Total Deformation Maximum (m)		P6 - Safety Factor Minimum
2					Parameter Value	Variation from Reference		Parameter Value	Variation from Reference	
3		Candidate Point 1	60	-9000	2.6112	-0.01 %	182.2	0.00016239	-5.20 %	1.3721
4		Candidate Point 1 (verified)			2.6112	-0.01 %	182.2	0.00016239	-5.20 %	1.3721
5		Candidate Point 2	60.15	-9249	2.6115	0.01 %	187.56	0.00016669	-2.69 %	1.3336
6		Candidate Point 2 (verified) DP 1			2.6115	0.01 %	183.52	0.00016668	-2.70 %	1.3623
7		Candidate Point 3	60.07	-9499	2.6113	0.00 %	192.46	0.0001713	0.00 %	1.2996
*		*New Custom Candidate Point*	*70*	*-10000*						

Verify the Response Surface Optimization

28. Return to Project

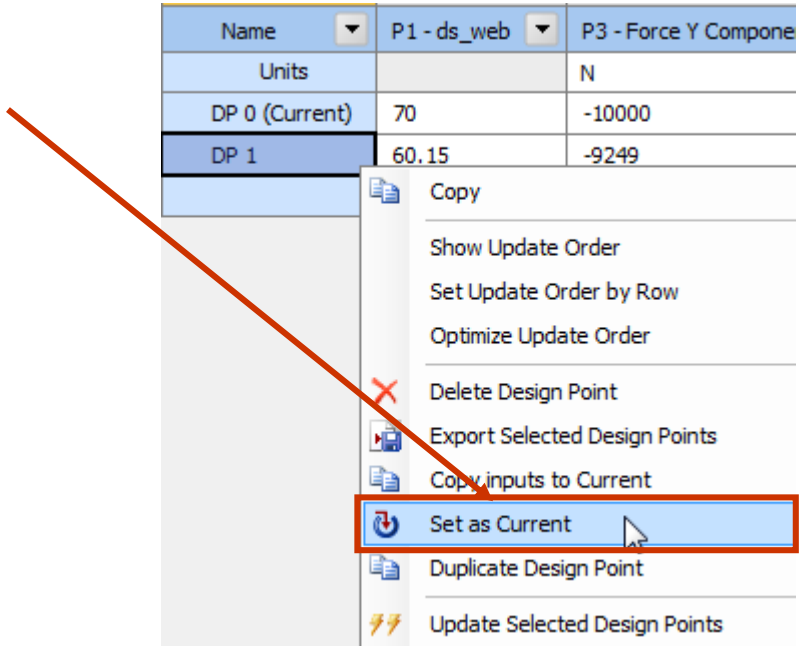
29. Double click on Parameter Set



Verify the Response Surface Optimization

30. RMB on DP 1 > Set as Current

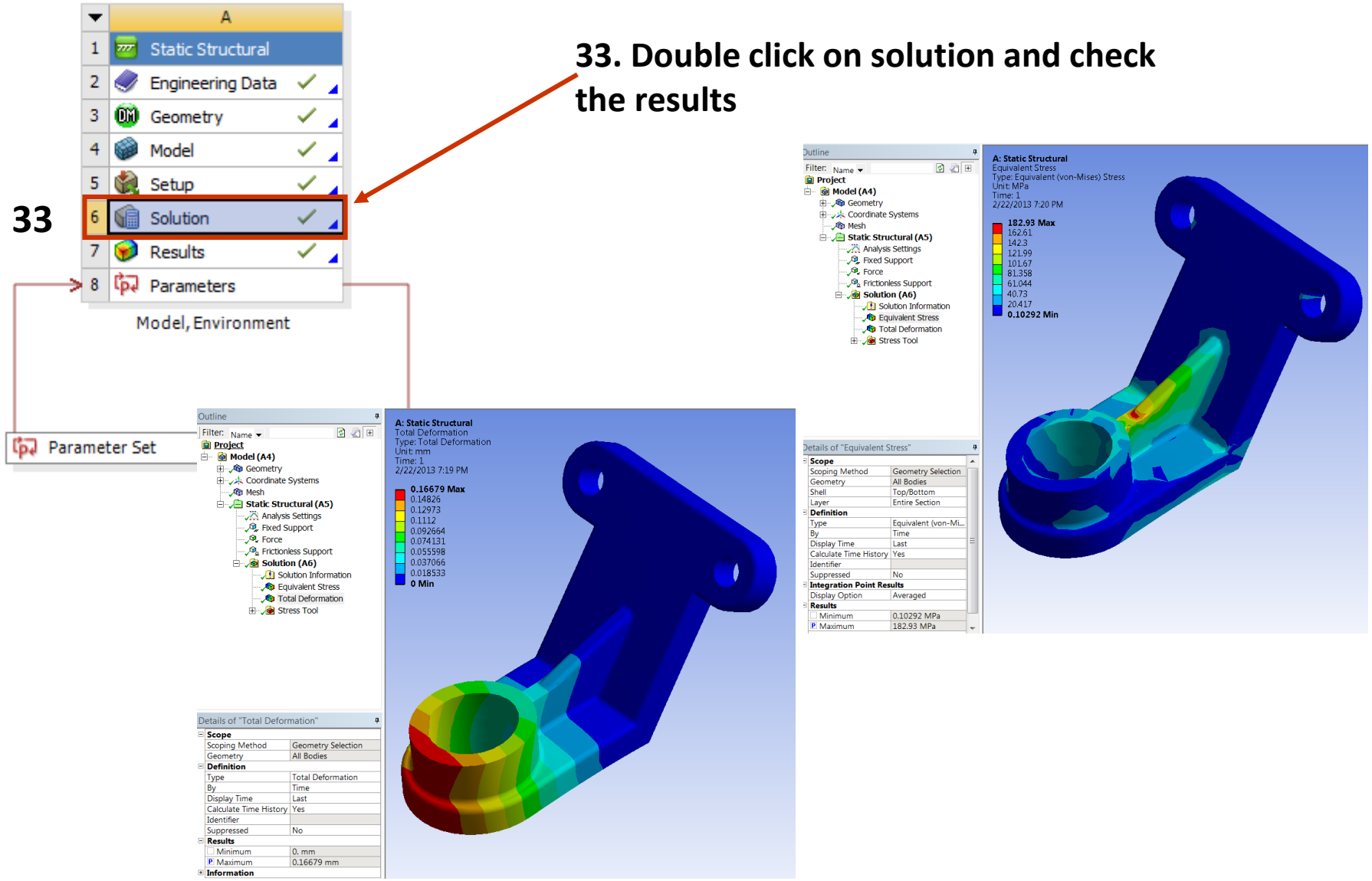
31. Switch to Project



Verify the Response Surface Optimization

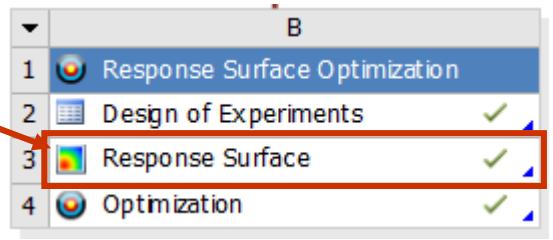
33. Double click on solution and check the results

33

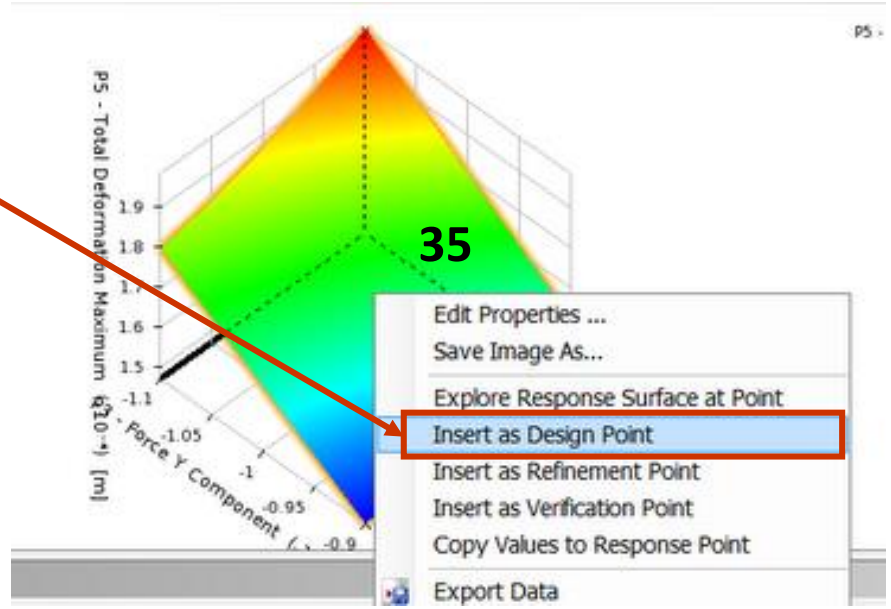


Verify the Response Surface Optimization

34. Double click on Response Surface



35. RMB on the Response Surface to insert the point in the response surface Design Point



Verify the Response Surface Optimization

36. Double click on Parameter Set

37. Retain DP 2 and Update Selected Design Point

38. You can see deformation and stress if you open Mechanical application