

# Project II: Ansys Design Optimization

Joseph D. Galloway II

November 17th, 2021

## 1 Analysis Models

The following are the results from the Static Structural, Modal, and Transient Thermal tests using the initial design:

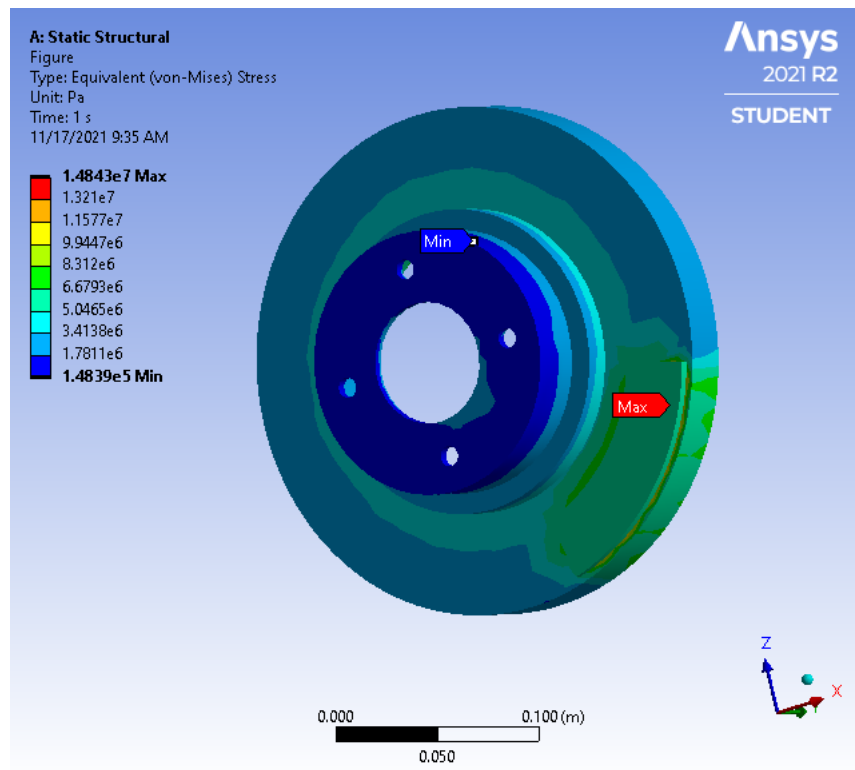


Figure 1: Static Structural Results - Front View

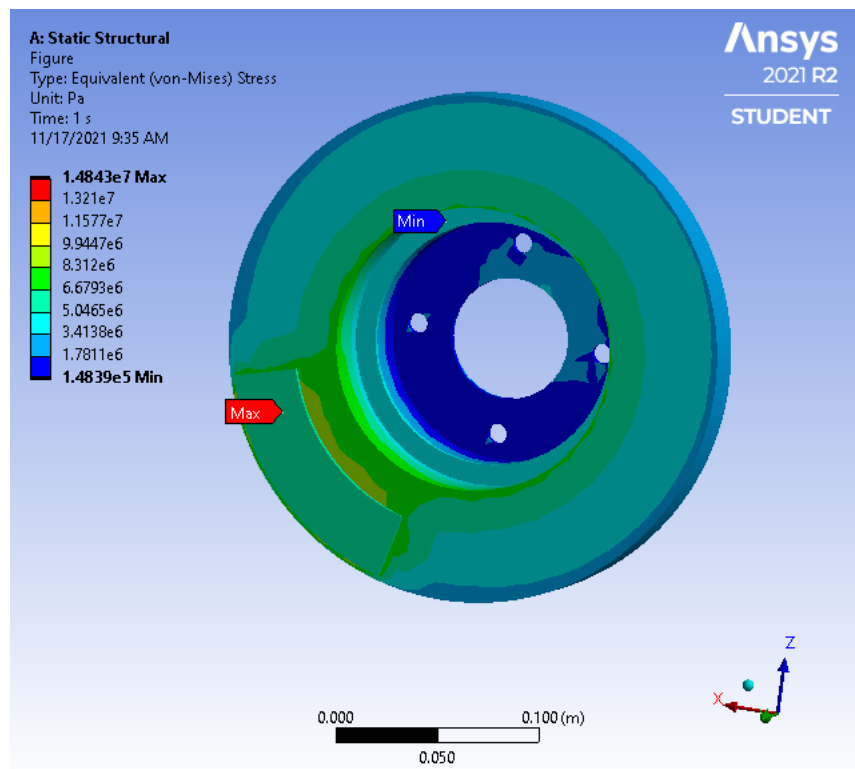


Figure 2: Static Structural Results - Back View

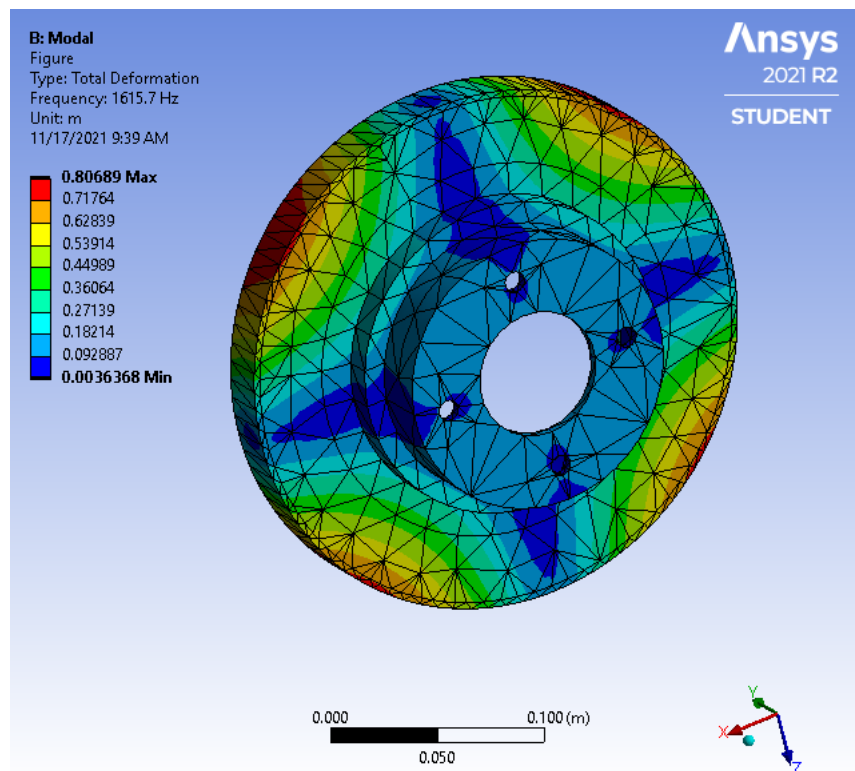


Figure 3: Modal Results - Front View

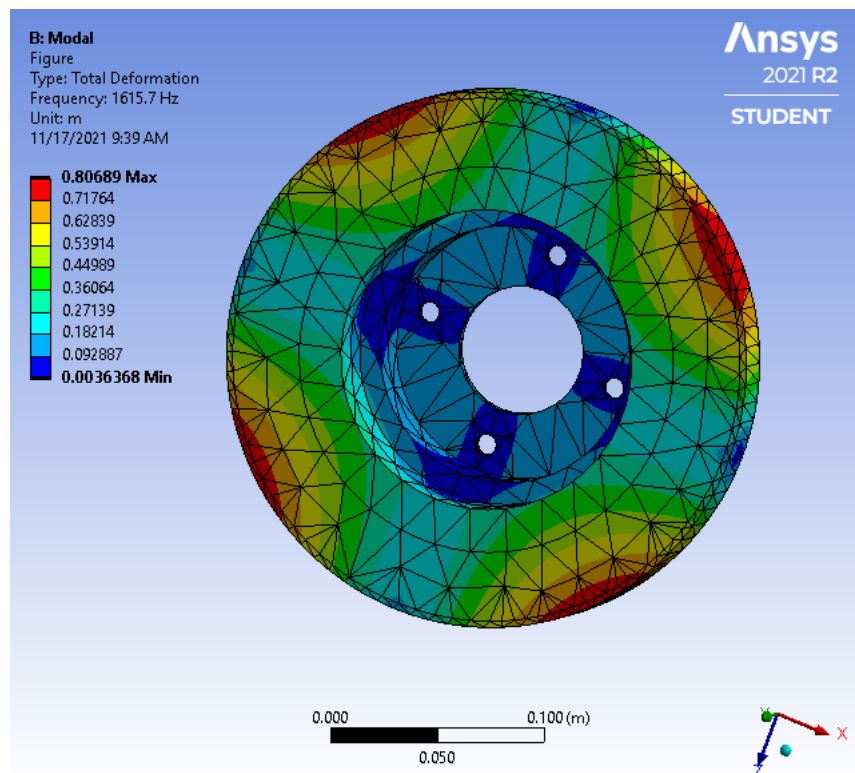


Figure 4: Modal Results - Back View

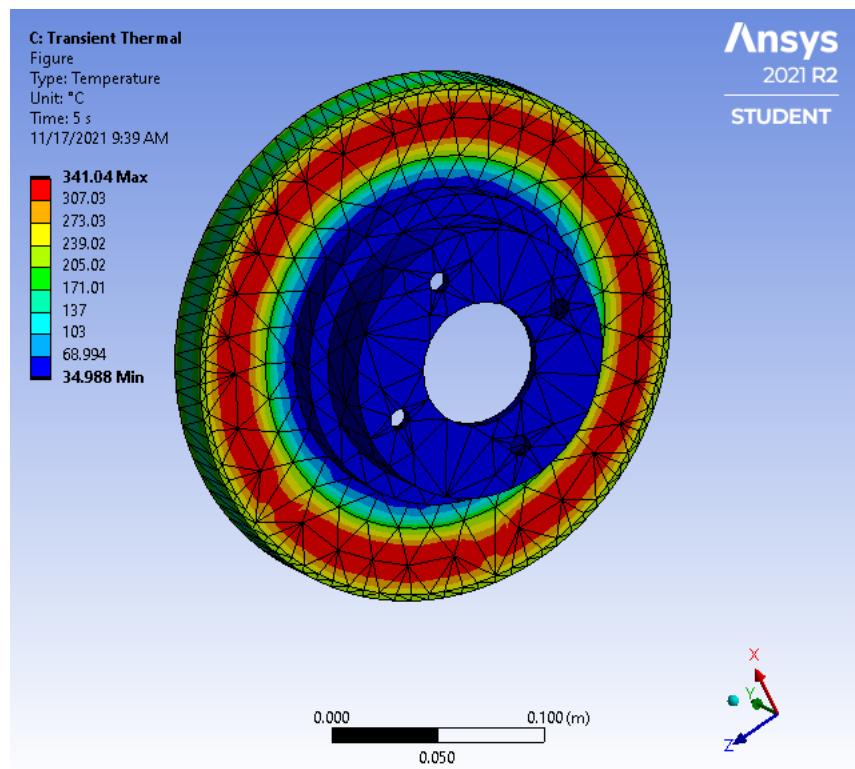


Figure 5: Transient Thermal Results - Front View

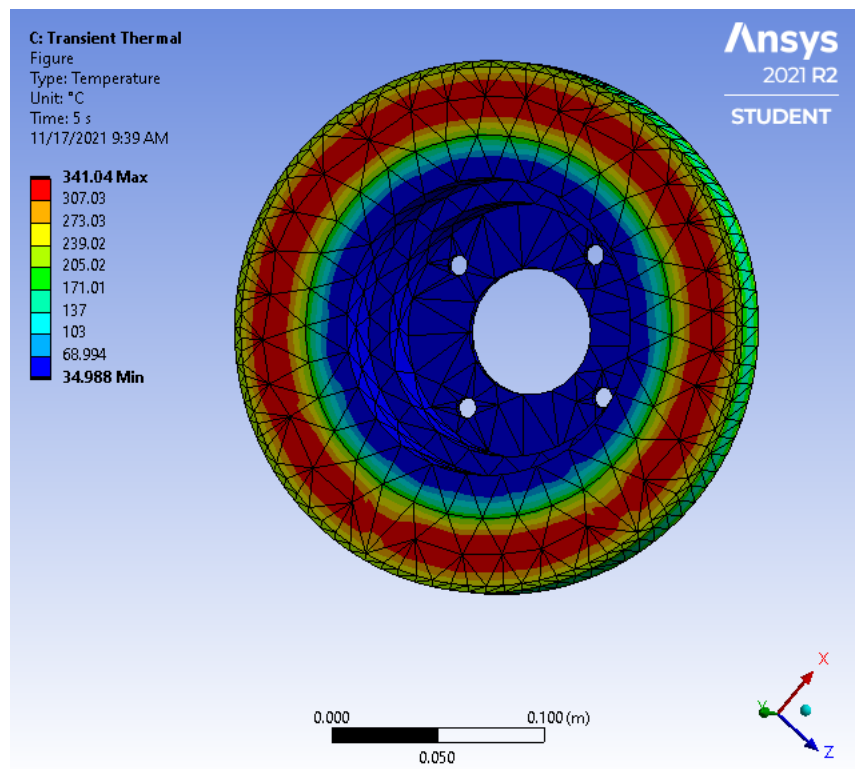


Figure 6: Transient Thermal Results - Back View

## 2 Design of Experiment

The type of Design of Experiment chosen was the Latin Hypercube Sampling Design with user-defined samples. The number of samples chosen was 40. The input parameters are the following:

1. Rotor Inner Diameter (mm)
  - (a) Lower Bound = 67.5
  - (b) Upper Bound = 90
2. Rotor Outer Diameter (mm)
  - (a) Lower Bound = 124
  - (b) Upper Bound = 150
3. Rotor Thickness (mm)
  - (a) Lower Bound = 20
  - (b) Upper Bound = 35

The response surface type chosen was the Standard Response Surface with twelve verification points. The results from the response surface are shown in the Sensitivity Analysis section.

## 3 Sensitivity Analysis

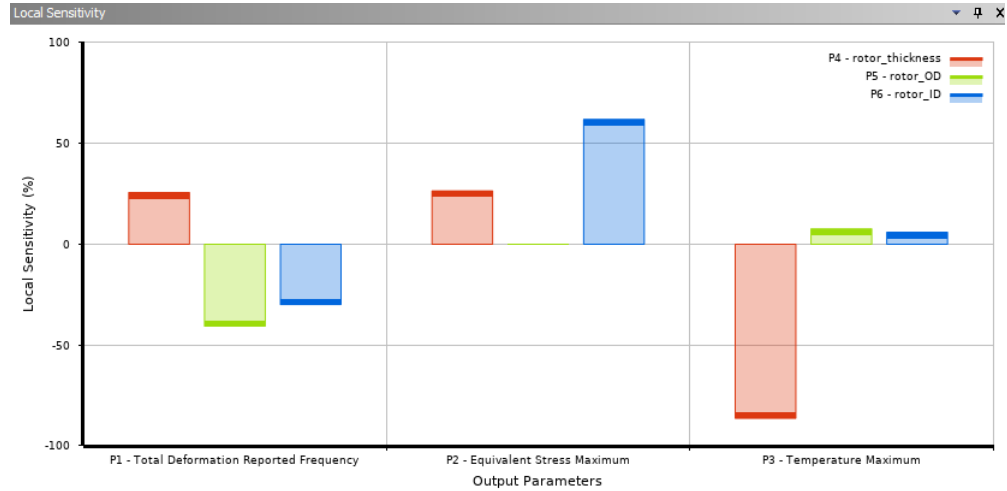


Figure 7: Local Sensitivity

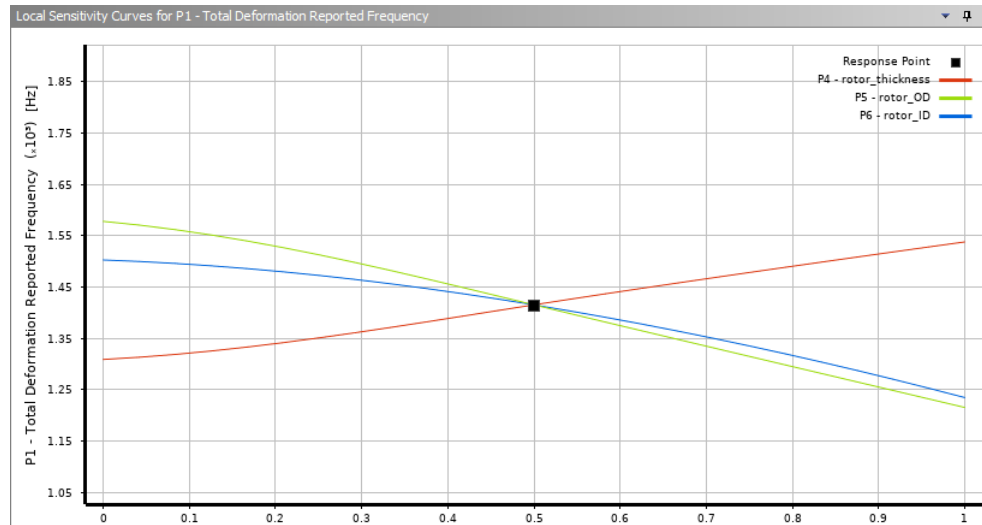


Figure 8: Total Deformation Reported Frequency

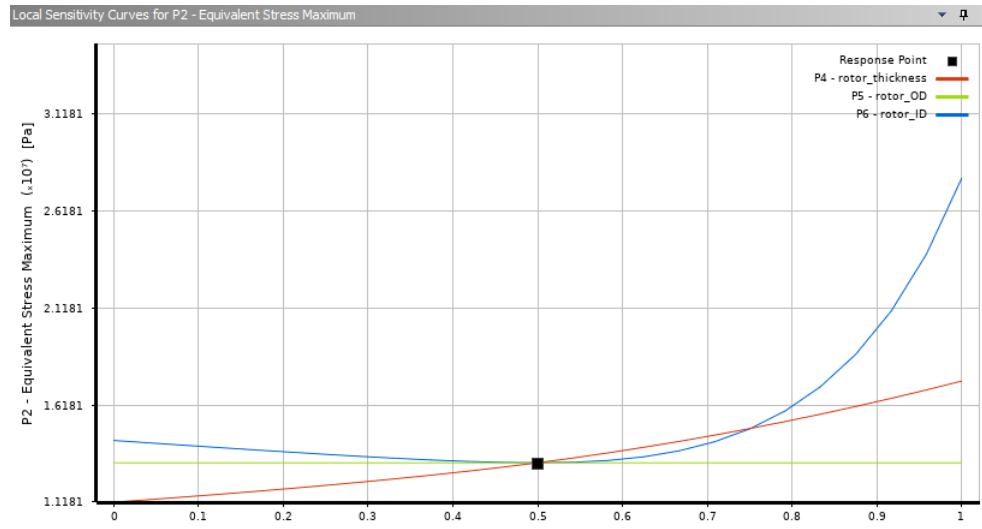


Figure 9: Equivalent Stress Maximum



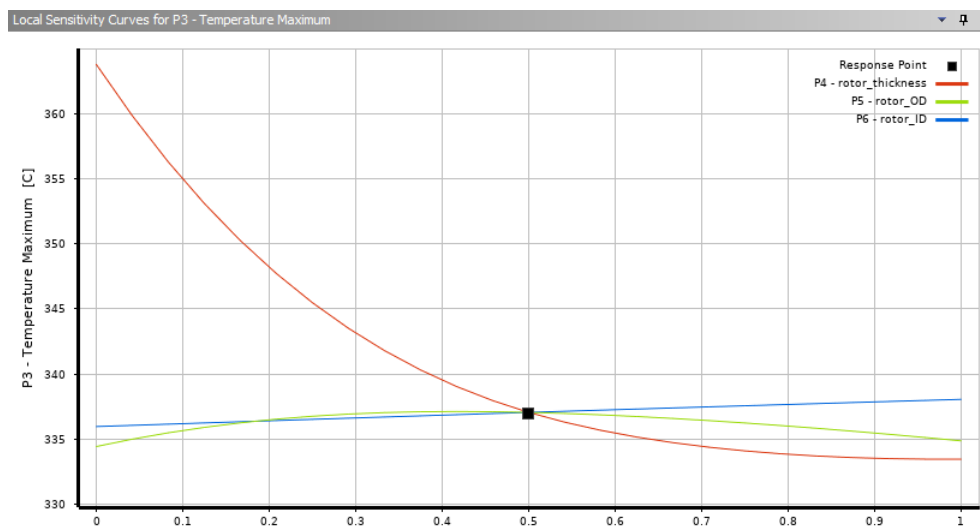


Figure 10: Temperature Maximum

## 4 Optimization

The optimization algorithm chosen was the Multi-objective Genetic Algorithm (MOGA). The following are the parameters chosen for the optimization section:

Properties of Outline A2: Optimization		
	A	B
1	Property	Value
6	Optimization	
7	Method Selection	Auto
8	Estimated Number of Evaluations	14400
9	Method Name	MOGA
10	Tolerance Settings	<input checked="" type="checkbox"/>
11	Verify Candidate Points	<input type="checkbox"/>
12	Number of Initial Samples	3000

Figure 11: Optimization Parameters

Properties of Outline A2: Optimization		
	A	B
1	Property	Value
12	Number of Initial Samples	3000
13	Number of Samples Per Iteration	600
14	Maximum Allowable Pareto Percentage	70
15	Convergence Stability Percentage	2
16	Maximum Number of Iterations	20
17	Maximum Number of Candidates	3

Figure 12: Additional Optimization Parameters

The parameters for the rotor thickness, the rotor outer diameter, and the rotor inner diameter were kept the same as the values in the Design of Experiment. The three parameters chosen were the Total Deformation Reported Frequency, the Equivalent Stress Maximum, and the Temperature Maximum. The objective for each parameter was set to minimize them all to zero with no constraints. The following are the three candidates Ansys provided:

Name	P4 - rotor_thickness (mm)	P5 - rotor_OD (mm)	P6 - rotor_ID (mm)	P1 - Total Deformation Reported Frequency (Hz)		P2 - Equivalent Stress Maximum (Pa)		P3 - Temperature Maximum (C)	
				Parameter Value	Variation from Reference	Parameter Value	Variation from Reference	Parameter Value	Variation from Reference
Candidate Point 1	21.356	149.89	79.201	⇒ 1119.2	0.00%	★ 1.1476E+07	0.00%	✗✗✗ 353.52	0.00%
Candidate Point 1 (verified)				✗ 1120.5	0.12%	★ 1.2747E+07	11.08%	✗✗✗ 356.62	0.88%
Candidate Point 2	21.356	149.89	78.792	✗ 1120.8	0.15%	★ 1.1471E+07	-0.05%	✗✗✗ 353.48	-0.01%
Candidate Point 2 (verified)				✗ 1124	0.43%	★ 1.268E+07	10.49%	✗✗✗ 355.96	0.69%
Candidate Point 3	21.593	149.91	78.525	✗ 1124.1	0.44%	★ 1.1529E+07	0.43%	✗✗✗ 352.23	-0.36%
Candidate Point 3 (verified)				✗ 1125.7	0.58%	★ 1.2761E+07	11.20%	✗✗✗ 355.15	0.46%

Figure 13: Candidate Points

After this run, it was determined that the first candidate point with the following parameters was the best option:

1. Rotor Inner Diameter = 79.201 mm
2. Rotor Outer Diameter = 149.89 mm
3. Rotor Thickness = 21.356 mm

With these parameters, the following were the predicted results:

1. Total Deformation Reported Frequency = 1119.2 Hz
2. Equivalent Stress Maximum =  $1.1476 \times 10^7$  Pa
3. Temperature Maximum = 353.52 C

The new geometry parameters were used in the for the following model analysis results:

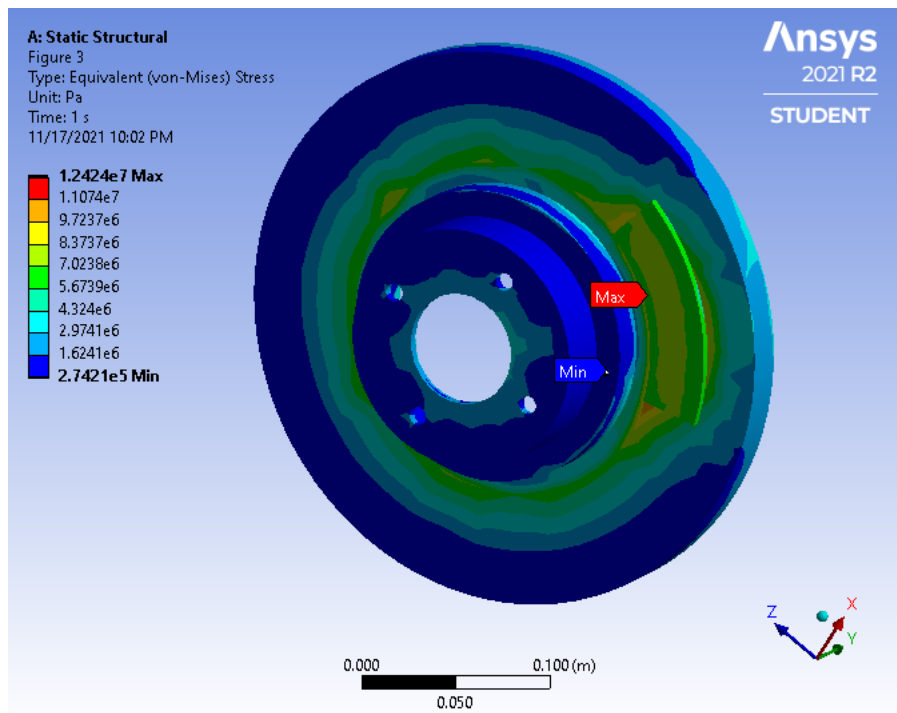


Figure 14: Static Structural Results - Front View

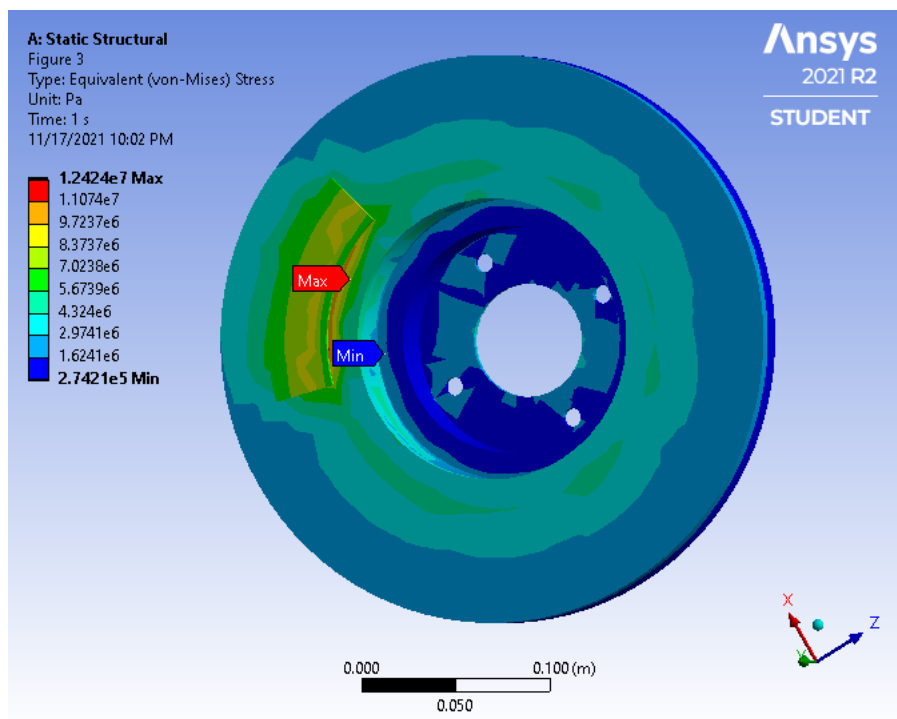


Figure 15: Static Structural Results - Back View

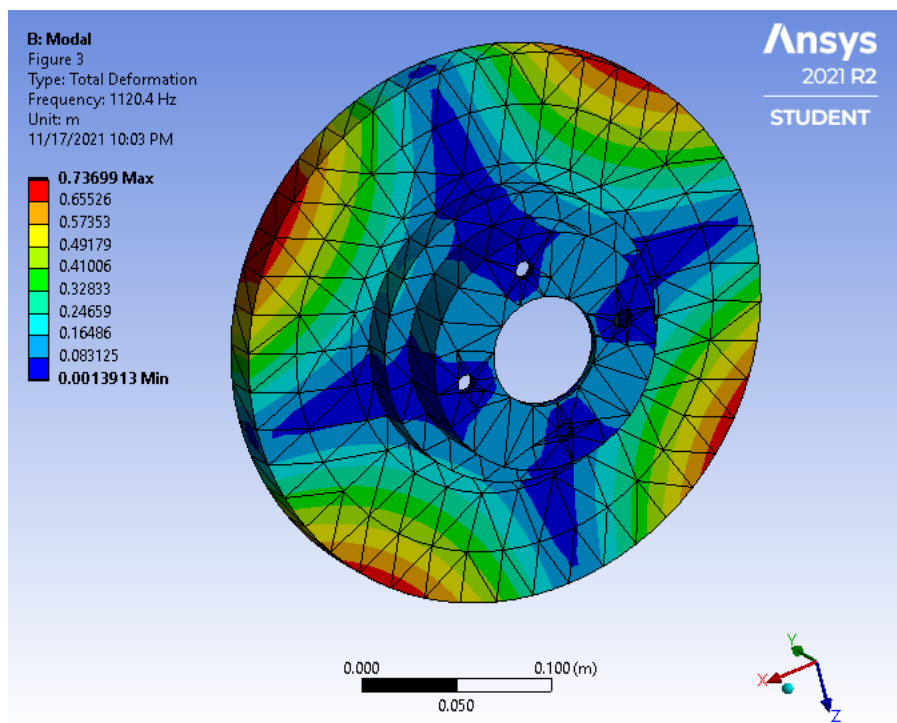


Figure 16: Modal Results - Front View

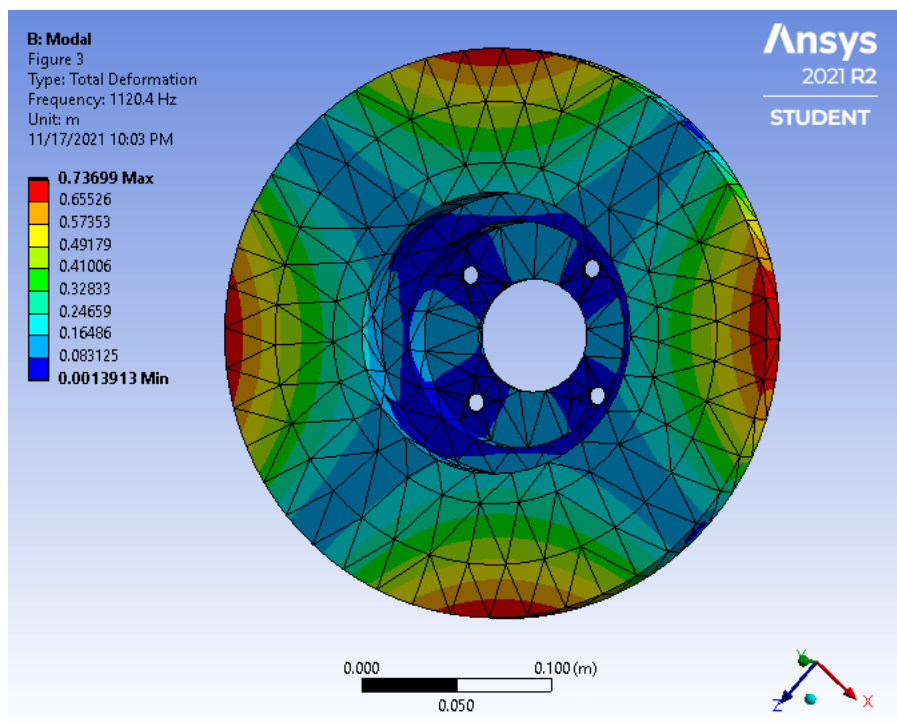


Figure 17: Modal Results - Back View

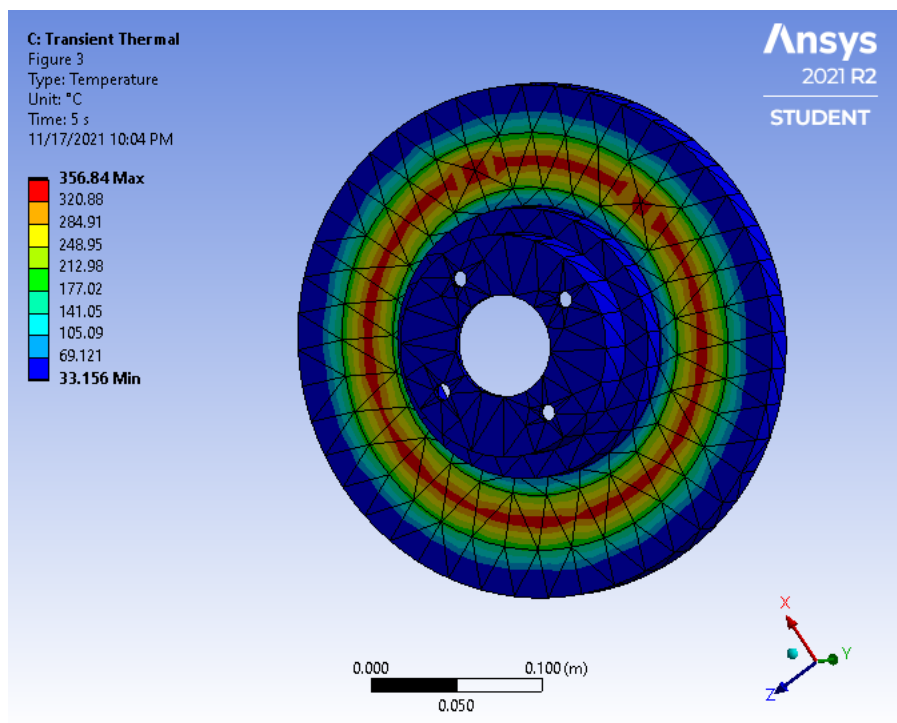


Figure 18: Transient Thermal Results - Front View



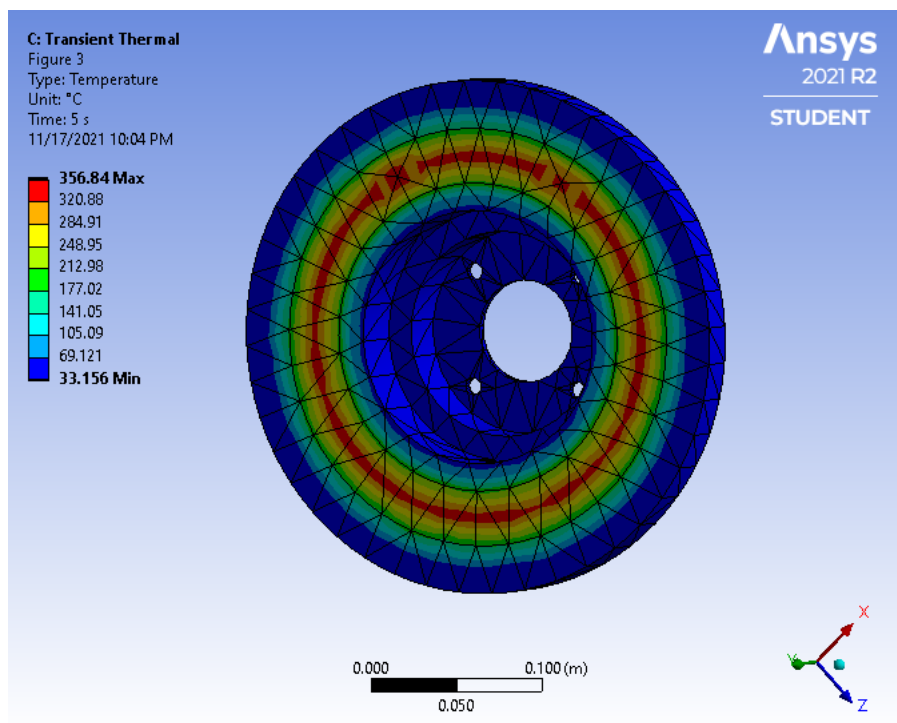


Figure 19: Transient Thermal Results - Back View

The results from the Static Structural and Modal tests show that the design improved. However, the results from the Transient Thermal test shows the design suffers from a higher maximum temperature. The results from each test are similar to the predicted results from the optimization algorithm.

## 5 Final Design

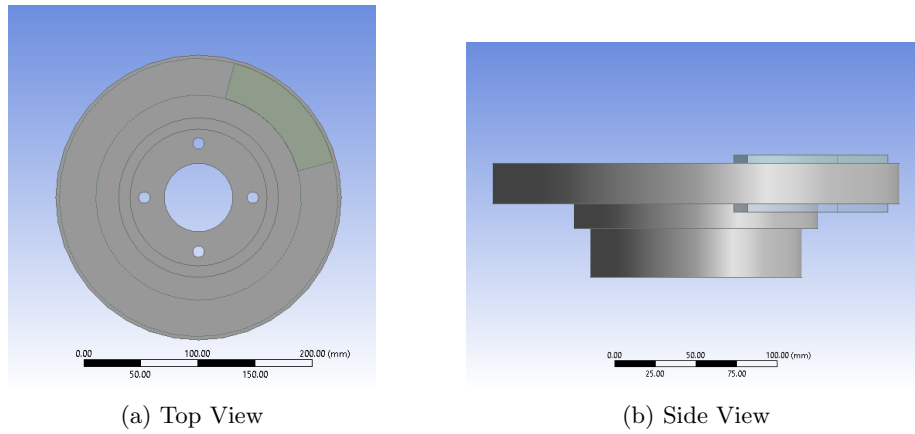


Figure 20: Initial Geometry

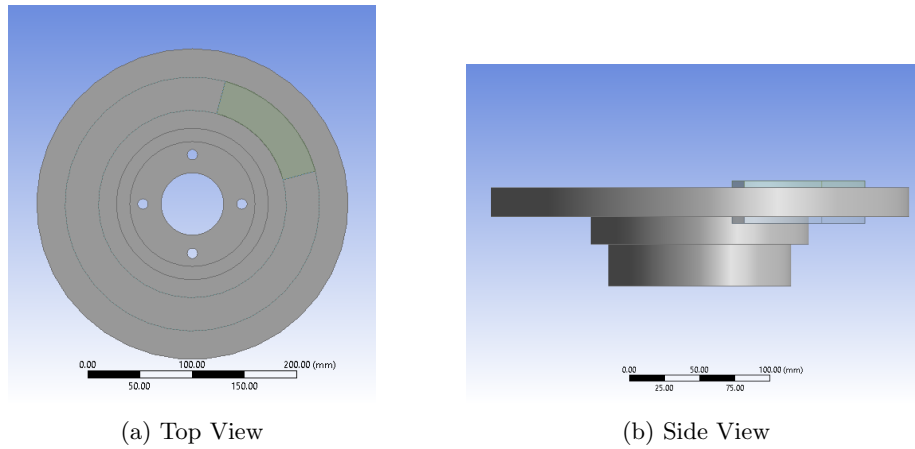


Figure 21: Final Geometry

# Appendices

## A Ansys Workbench

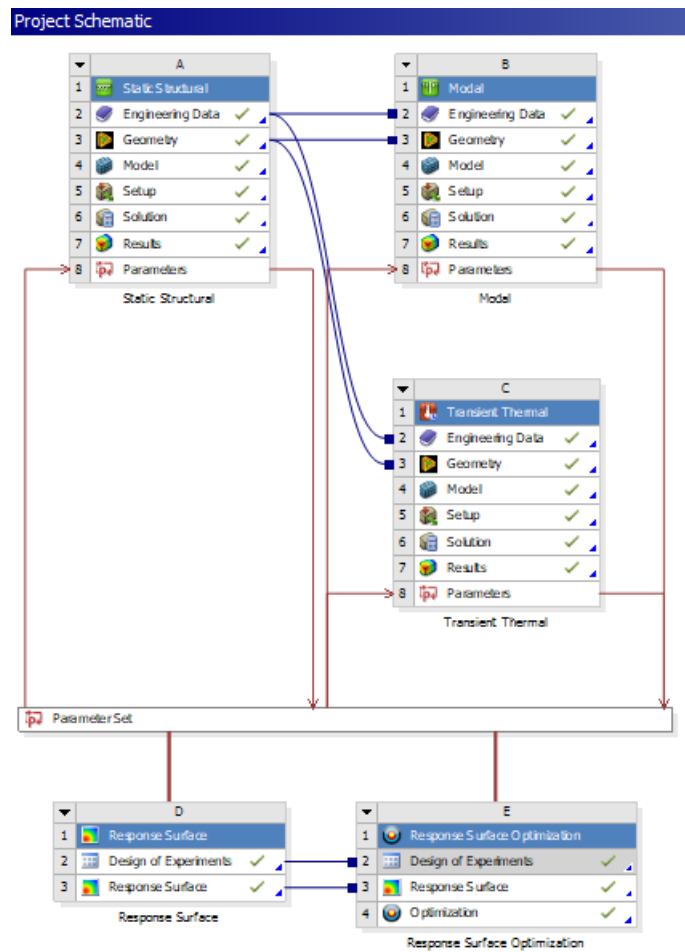


Figure 22: Ansys Workbench