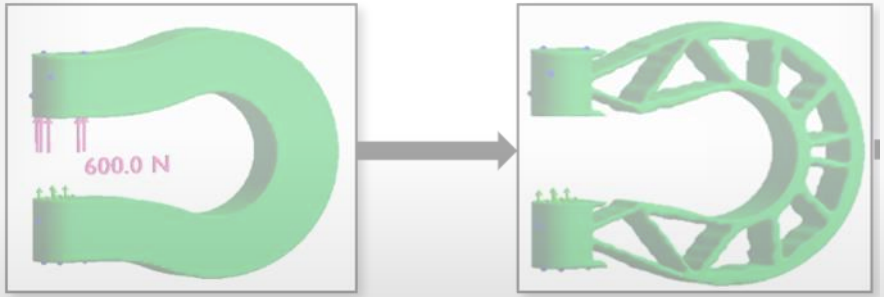
IDETC -CIE

International Design Engineering Technical Conferences & Computers and Information in Engineering Conference

Hilton Anaheim, Anaheim, CA

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

Tutorial 1
Learning Topology Optimization Through Examples and Case Studies

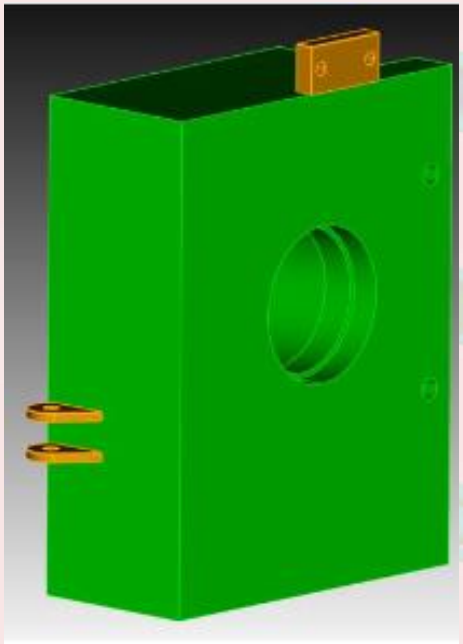


Initial Design TO Model

August 18, 2019

Problem 3: Upright Optimization

Design a lightest possible FSAE Race Car Suspension Upright



1. Maximum von-Mises Stress less than 250 MPa
2. Maximum Deflection less than 0.12 mm
3. Resonant Frequency greater than 75 Hz

Challenge Problem
2019 USACM Thematic Conference
Topology Optimization Roundtable

Requirements

- **Materials**

Material	Aluminum Alloy	
Young's Modulus	lbf/in^2	9993100
Yield Strength	lfb/in^2	40030.4
Density	lbm/in^3	0.0975437

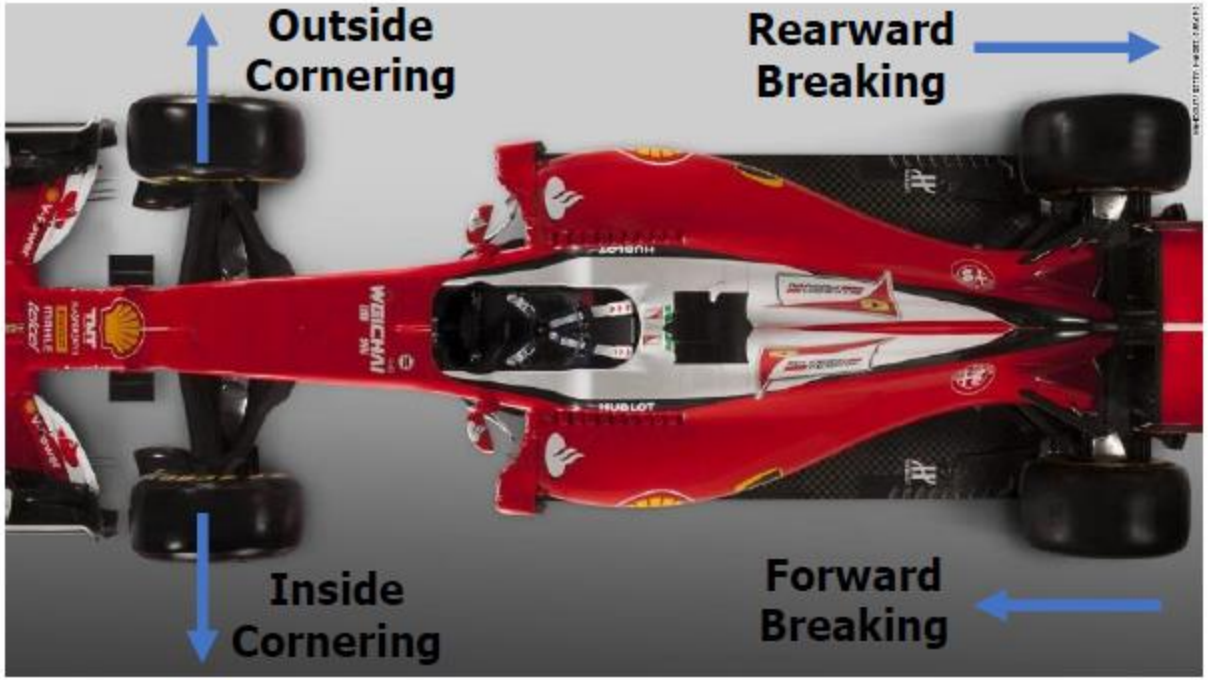
Material	Titanium Alloy	
Young's Modulus	lbf/in^2	16505295
Yield Strength	lfb/in^2	127633
Density	lbm/in^3	0.1564312

Material	Steel	
Young's Modulus	lbf/in^2	29010000
Yield Strength	lfb/in^2	31183.1
Density	lbm/in^3	0.289018

Goal

- **Design lightest possible FSAE race car suspension upright**

Loads


Outside Cornering
Inside Cornering
Rearward Breaking
Forward Breaking

Requirements

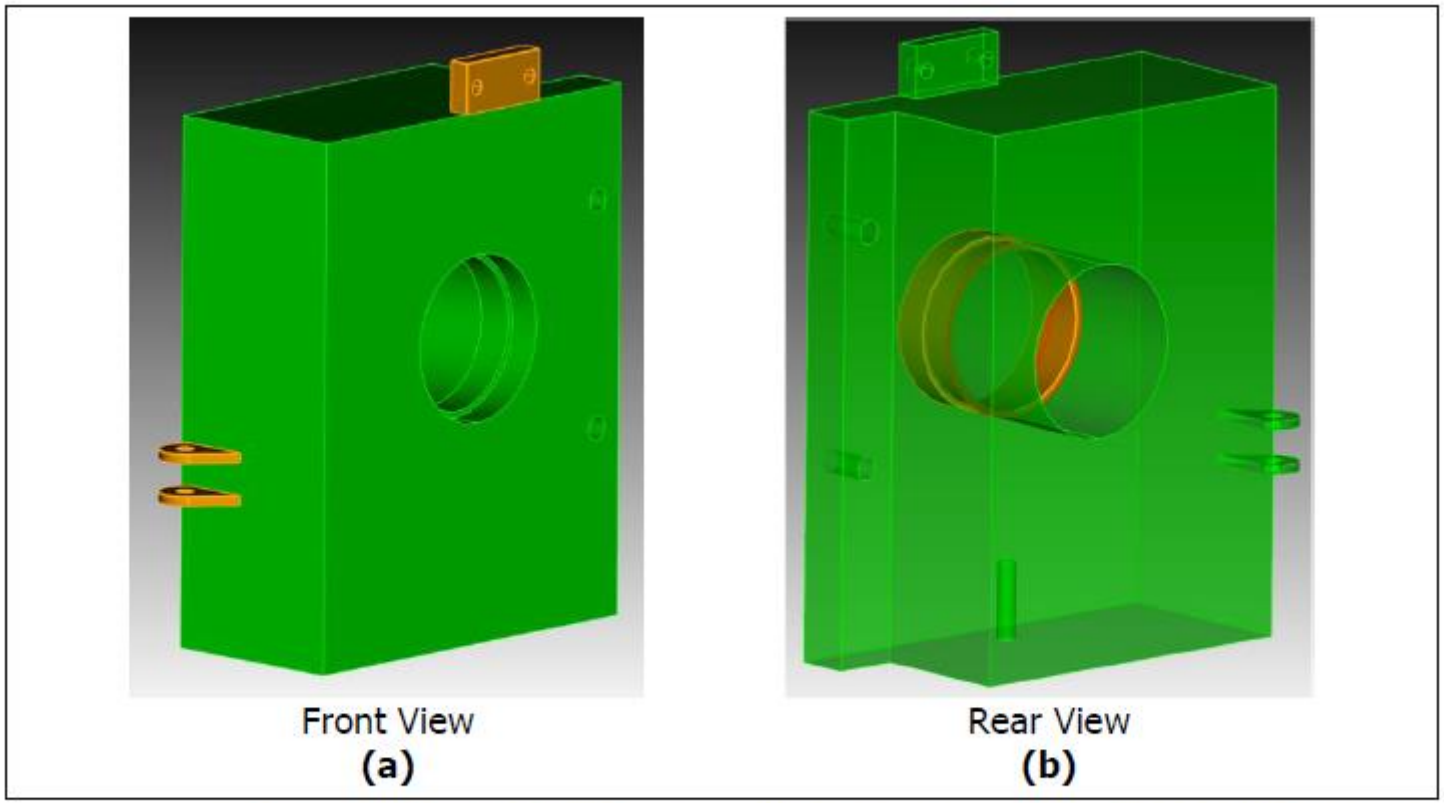
Inside Cornering (Load Case 0)		X (lbf)	Y(lbf)	Z(lbf)
Up Fore AA Force (Normal to two top holes	C1	0	11	0
Up Aft AA Force-Shear Force on top two holes	C2	24	24	0
Pull rod Force-Shear force on two top holes	C3	0	-60	60
Load on Two Top Holes		24	-25	60
Lower Fore AA Force-Force Normal to two Attach bores	C4	0	-10	0
Low AFT AA Force_Force normal to two attach bore	C5	0	-39	0
Load on the lower bore		0	-49	0
Tie rod Force-Force normal to attach hole	C6	0	19	0
Load on the Side holes for TieRod		0	19	0

Outside Cornering (Load Case 1)		X (lbf)	Y(lbf)	Z(lbf)
Up Fore AA Force (Normal to two top holes	C1	0	-31	0
Up Aft AA Force-Shear Force on top two holes	C2	-103	-103	0
Pull rod Force-Shear force on two top holes	C3	0	-305	305
Load on Two Top Holes		-103	-439	305
Lower Fore AA Force-Force Normal to two Attach bores	C4	0	393	0
Low AFT AA Force_Force normal to two attach bore	C5	0	894	0
Load on the lower bore		0	1287	0
Tie rod Force-Force normal to attach hole	C6	0	-91	0
Load on the Side holes for TieRod		0	-91	0

Forward Braking (Load Case 4)		X (lbf)	Y(lbf)	Z(lbf)
Up Fore AA Force (Normal to two top holes	B1	562	0	0
Up Aft AA Force-Shear Force on top two holes	B2	-270	-270	0
Pull rod Force-Shear force on two top holes	B3	0	-343	343
Load on Two Top Holes		292	-614	343
Lower Fore AA Force-Force Normal to two Attach bores	B4	0	90243	0
Low AFT AA Force_Force normal to two attach bore	B5	0	1461	0
Load on the lower bore		0	91705	0
Tie rod Force-Force normal to attach hole	B6	0	-488	0
Load on the Side holes for TieRod		0	-488	0
Brake Calliper Torque-Torque load applied normal to two mounting holes	B7	0	0	4541
Load on the Brake mountings holes		0	0	4541

Rearward Braking (Load Case 5)		X (lbf)	Y(lbf)	Z(lbf)
Up Fore AA Force (Normal to two top holes	B1	562	0	0
Up Aft AA Force-Shear Force on top two holes	B2	-270	-270	0
Pull rod Force-Shear force on two top holes	B3	0	-343	343
Load on Two Top Holes		292	-614	343
Lower Fore AA Force-Force Normal to two Attach bores	B4	-95921	0	0
Low AFT AA Force_Force normal to two attach bore	B5	0	1461	0
Load on the lower bore		-95921	1461	0
Tie rod Force-Force normal to attach hole	B6	0	-488	0
Load on the Side holes for TieRod		0	-488	0
Brake Calliper Torque-Torque load applied normal to two mounting holes	B7	0	0	4541
Load on the Brake mountings holes		0	0	4541

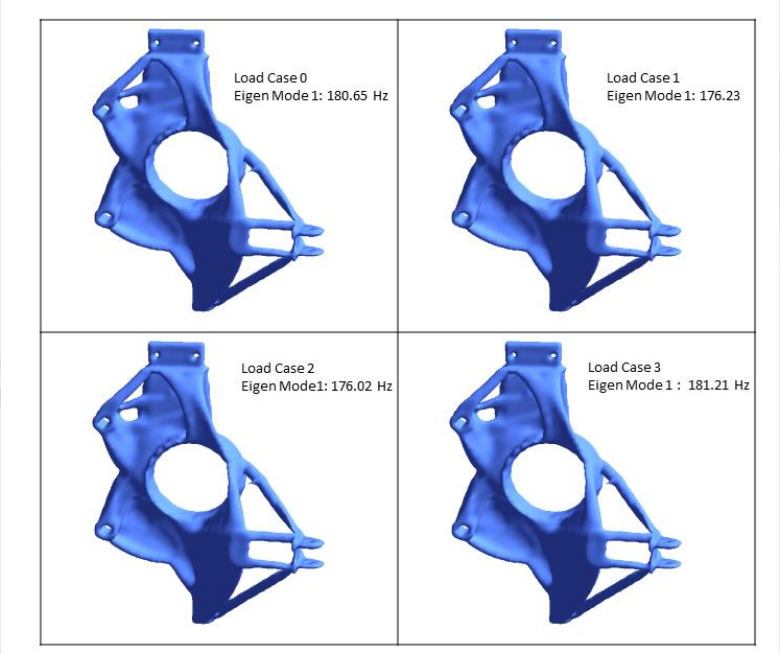
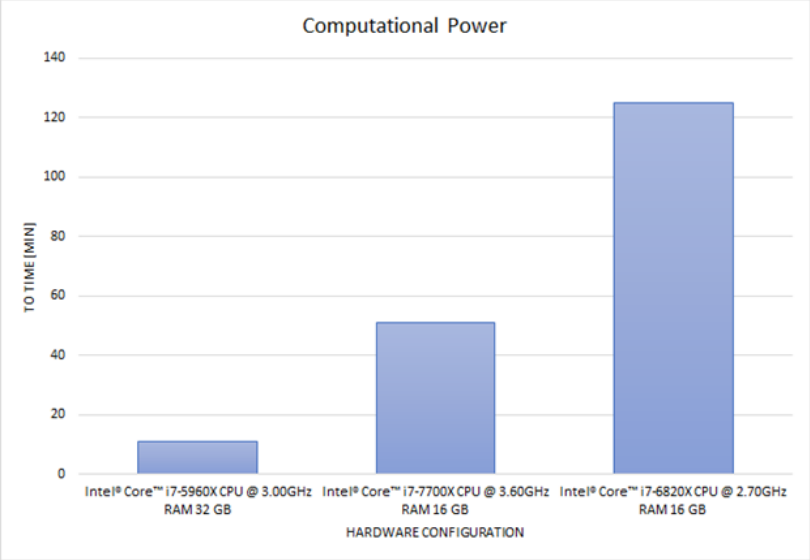
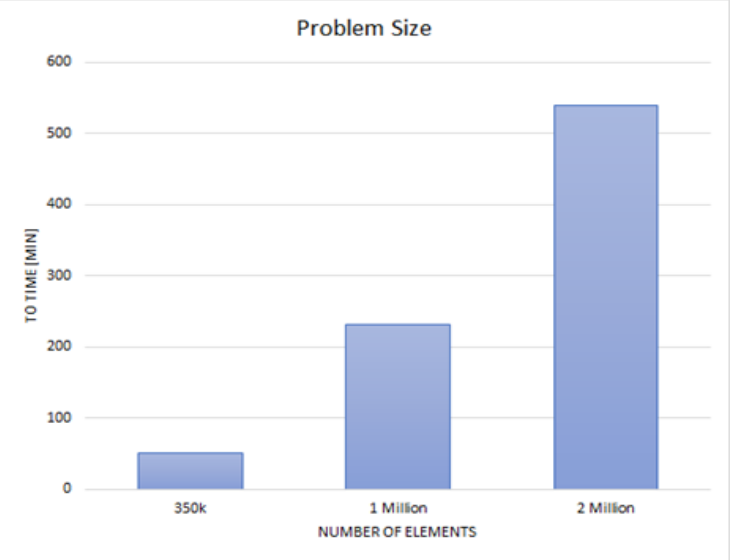
Requirements



Problem domain: (a) Front view with fixed regions, i.e., regions that do not participate in the optimization, highlighted in gold; (b) Rear view with dirichlet boundary conditions, i.e., regions with x, y, and z displacements set to zero, highlighted in gold.

Results_Pareto

Results_Eigen Values



Pareto Capabilities