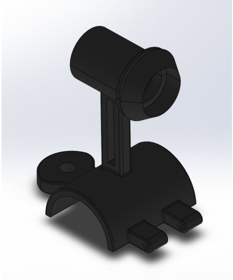
CAMPBELL DOWNS

Engineering Design Portfolio

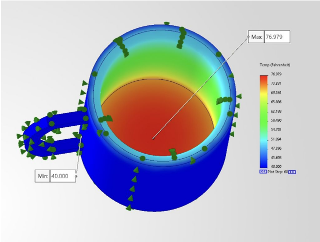
CAD • FEA • Design Optimization • Thermal Analysis

Purdue University | Aerospace Engineering

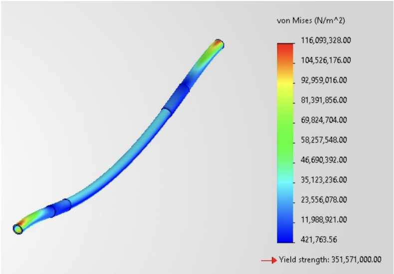
Multi-station fitness rack



Optimized bracket



Thermal study



Static FEA

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01

Profile & Core Skills

Summary from current resume and selected portfolio projects

Aerospace Engineering student focused on design, simulation, and manufacturable mechanical systems.

This portfolio highlights four projects that demonstrate a complete engineering workflow: defining requirements, building CAD models, running simulations, identifying weaknesses, and iterating toward validated designs.

2029
Expected graduation

PLM
Minor

3.36
GPA

CAD / PLM

- Siemens NX
- SolidWorks
- Teamcenter / PDM
- Parametric modeling

Analysis

- Static FEA
- Fatigue analysis
- Thermal simulation
- Design optimization

Programming

- C
- Python
- C#
- HTML / JavaScript

Engineering

- ECO workflows
- MATLAB plots
- Excel analysis
- 3D printing exposure

02

Selected Projects

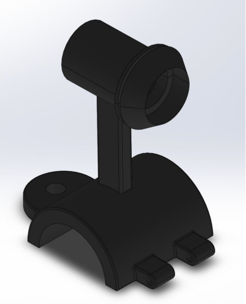
Four CAD and analysis projects drawn from submitted engineering reports

01

Multi-Station Fitness Rack

Assembly design, requirements definition, multi-case static FEA, fatigue verification

CAD + Analysis

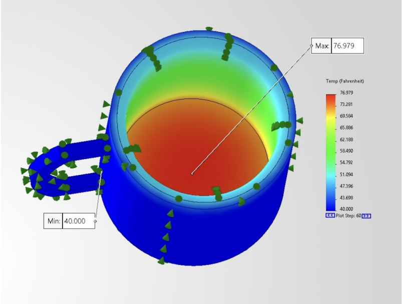


02

Bike Horn Mount Optimization

Parametric study, topology optimization, mass reduction, Nylon 6/10 part design

CAD + Analysis

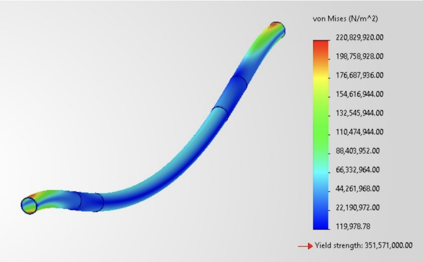


03

Double-Wall Mug Thermal Analysis

Transient thermal simulation, nonlinear stress, design iteration for thermal durability

CAD + Analysis



04

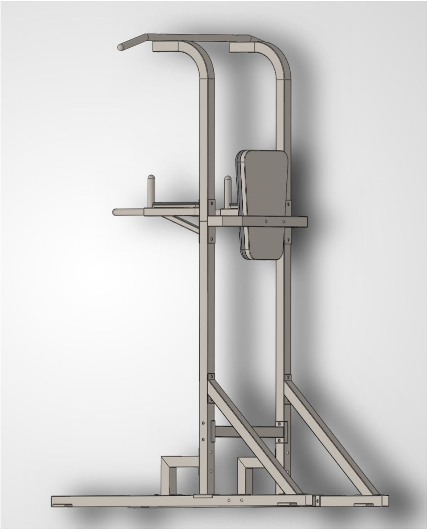
Pull-Up Bar Fatigue Optimization

Static analysis, fatigue life, material substitution, geometry optimization

CAD + Analysis

Project 01 | Multi-Station Fitness Rack

Structural design for a compact residential gym rack



Designed a consumer-grade rack integrating pull-up, dip, and leg raise stations into a compact home footprint.

Design Targets

- Support a 250 lb user load
- Global FOS target of 1.5
- Critical structural FOS target of 2.0
- Minimum 78,000 loading cycles

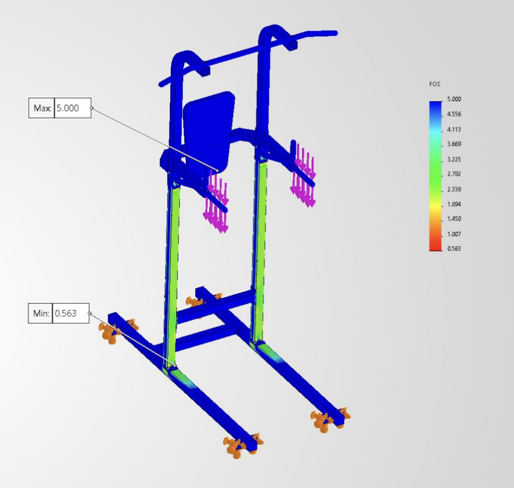
Load Cases

- Balanced pull-up
- Single-arm pull-up
- Dip station loading
- Leg raise station loading

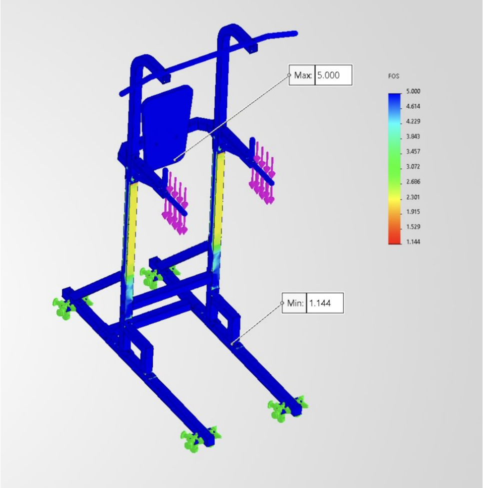
86 in	45 in	60 in	A36
Overall height	Width	Depth	Steel frame

Fitness Rack | FEA-Driven Iteration

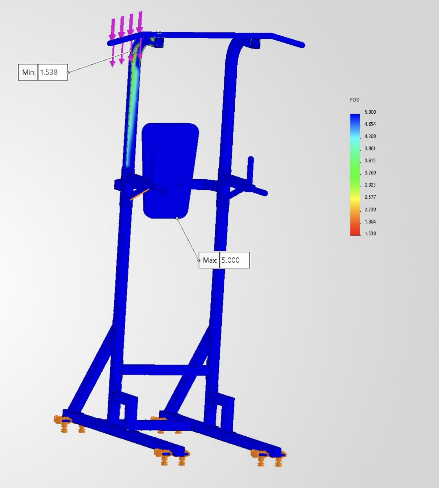
The portfolio story: failure mode → redesign → validated result



Initial dip-load FOS: below target near supports



Updated dip-load FOS after structural reinforcement



Asymmetric pull-up identified upper-arm weakness

Design Response

Added rear bracing and a front support/step to distribute load into the lower frame. The upper arm material thickness was then doubled to resolve the single-arm pull-up case.

FEA

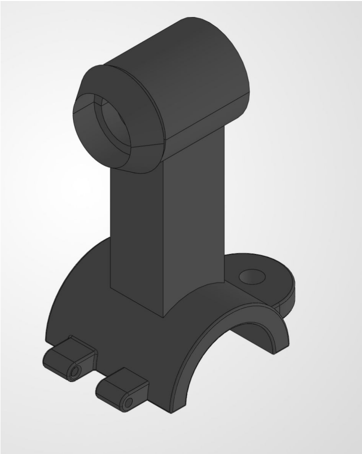
Design iteration

Fatigue validation

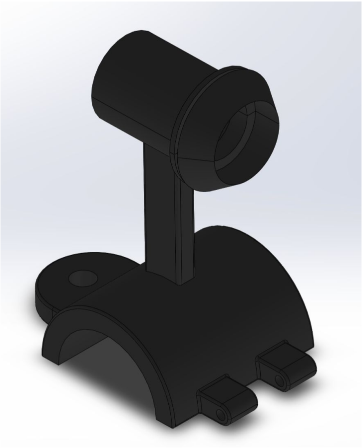
Project 02 | Bike Horn Mount Optimization

Parametric modeling and optimization of a lightweight Nylon 6/10 accessory bracket

Rebuilt a non-robust baseline model into a simplified, optimization-ready mount, then evaluated geometry changes against mass and minimum factor of safety.



Baseline design



Selected parametric design

Variables Studied

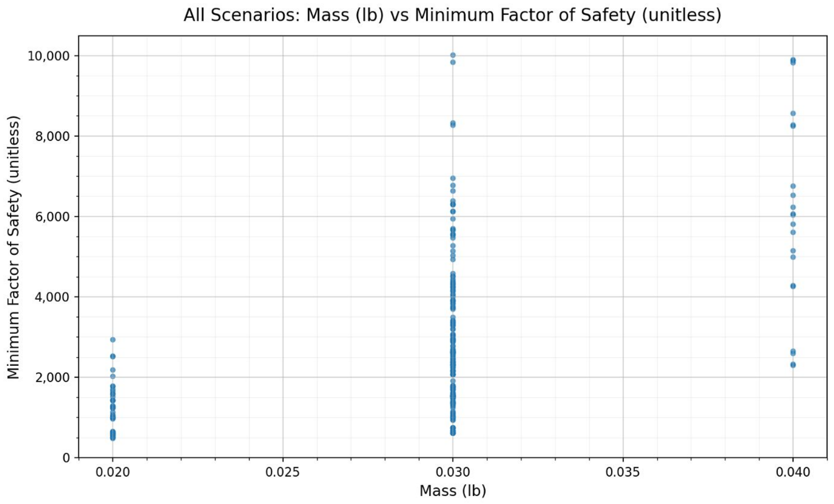
- Bridge width and length
- Bridge fillet radius
- 270 design scenarios

0.2055 N

Horn load

Nylon

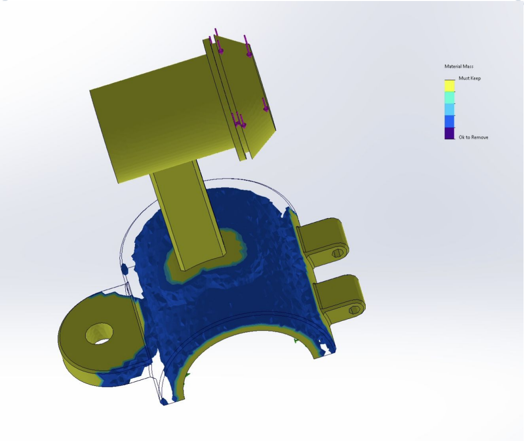
6/10 material



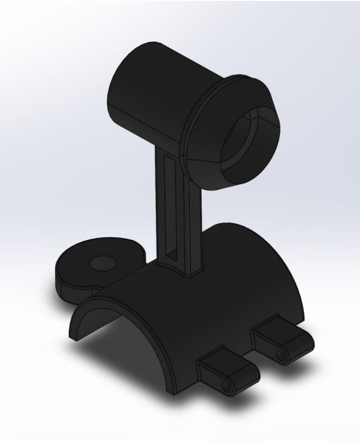
Mass vs FOS plot

Bike Horn Mount | Topology-Informed Redesign

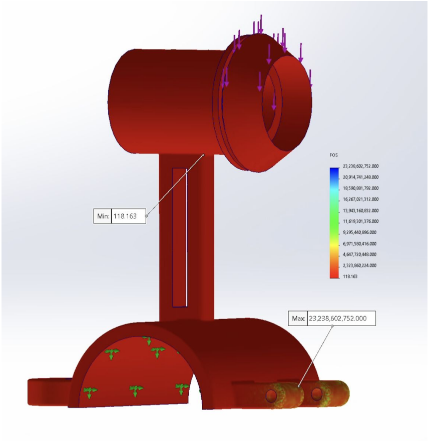
Moving from parametric optimization to targeted material removal



Topology result: low-stress removal regions



Final optimized geometry



Final static study

Result

≈30%

mass reduction from the selected parametric design

FOS > 100

Engineering Takeaway

The project demonstrates a practical optimization workflow: simplify an unstable CAD model, define meaningful parameters, evaluate design-space tradeoffs, then use topology results to guide final geometry.

Parametric CAD

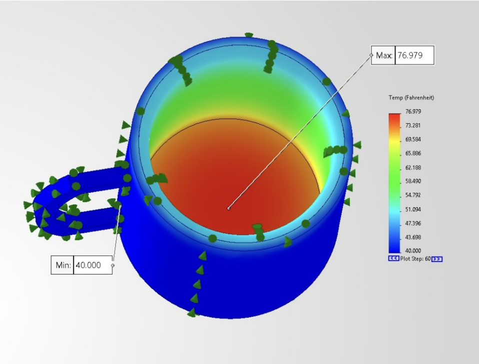
Topology

Mass reduction

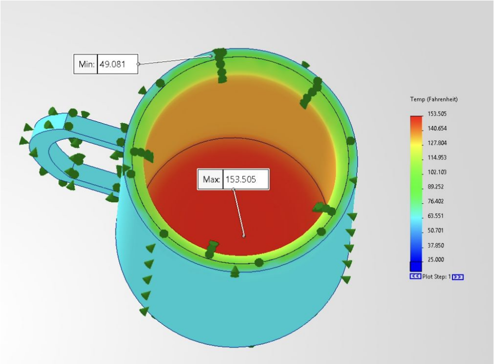
Project 03 | Double-Wall Mug Thermal Analysis

Transient thermal and nonlinear stress simulation for a double-wall insulated mug

Modeled a two-layer mug with a ceramic outer shell, stainless steel inner liner, and insulating air gap. Simulations evaluated cooling and thermal stress under diff



Case A: 40°F air convection



Case B: 50°F water convection

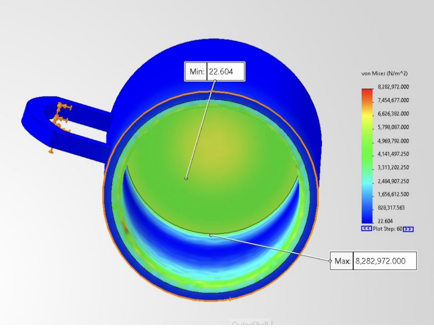
Simulation Setup

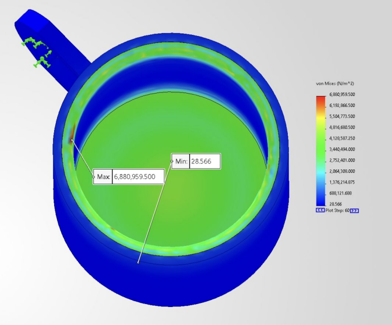
- Initial mug temperature: 175°F
- 300-second transient thermal study
- 5-second nonlinear stress time step
- Outer surfaces exposed to convection

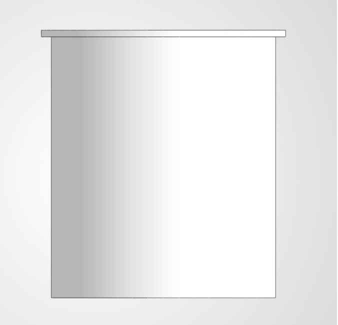
23	**350**	**300 s**	**304 SS**	**Ceramic**
W/m²K air convection	W/m²K water convection	Study duration	Inner liner	Outer shell

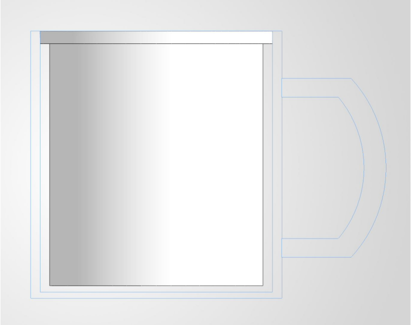
Double-Wall Mug | Stress Concentration Reduction

Geometry changes were used to reduce thermally induced stress peaks


Baseline stress, Case A


Baseline stress, Case B


Initial liner

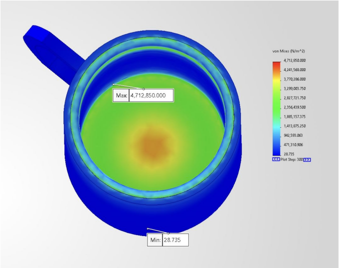

Updated liner

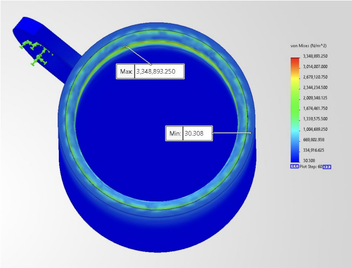
Design Changes

Doubled the inner-liner lip thickness and added fillets at the liner base to reduce sharp stress concentration locations.

Thermal FEA

Fillets

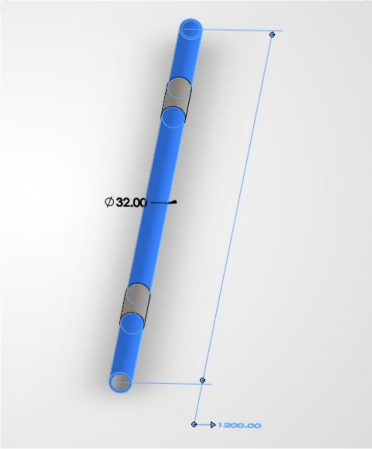

Updated stress, Case A


Updated stress, Case B

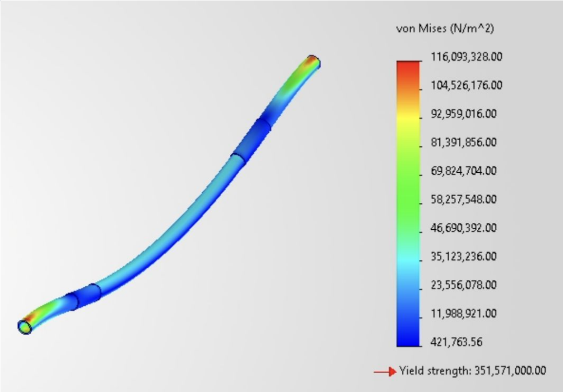
Project 04 | Pull-Up Bar Fatigue Optimization

Static and fatigue analysis of a cyclically loaded consumer fitness component

Evaluated a pull-up bar under a 250 lb user load, then modified geometry and material selection to reduce cost and material usage while preserving long-term durability.



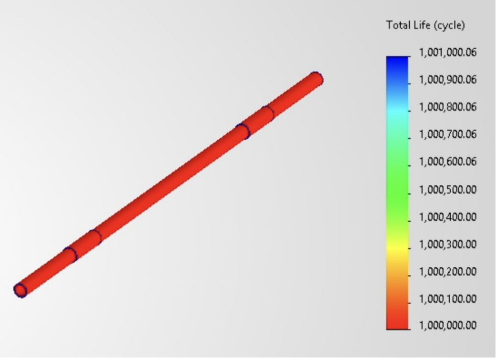
Original model



Original static stress

Load & Study Setup

- 1112 N downward load
- Both bar ends fixed
- Zero-based fatigue loading
- 208,572 cycle design target

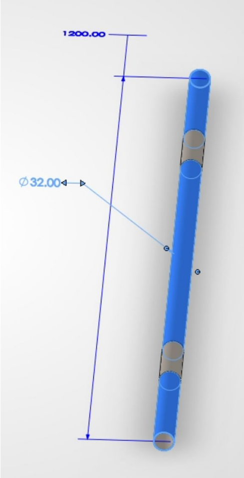


Original fatigue life plot

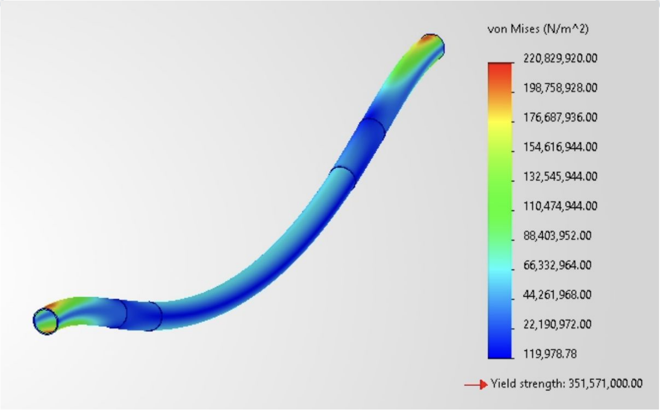
250 lb	10 yr	1M
User load	Use target	Original life cycles

Pull-Up Bar | Cost & Weight-Conscious Redesign

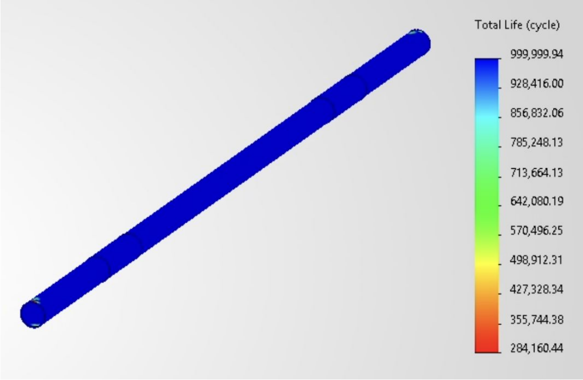
Original design was overbuilt, leaving room for material and cost reduction



Improved geometry



Improved static stress



Improved fatigue life

Final Result

284,160

minimum fatigue cycles after redesign

Above 10-year target

Optimization Choices

Increased inner diameter, reduced handle outer diameter, and changed material from AISI 1020 steel to A36 steel to improve manufacturability and reduce cost.

- Fatigue
- Material choice
- Cost focus

PORTFOLIO SUMMARY

Engineering workflow demonstrated across four projects

CAD Modeling

Assemblies, parametric geometry, design simplification, and product-focused part modeling.

Simulation

Static FEA, fatigue life, transient thermal studies, and nonlinear stress analysis.

Iteration

Design decisions driven by failure modes, stress concentrations, mass targets, and manufacturability.

Contact

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