



University of Idaho
College of Engineering

3S SINGLE AXLE TRAILER SUSPENSION

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SINGLE OBJECTIVE



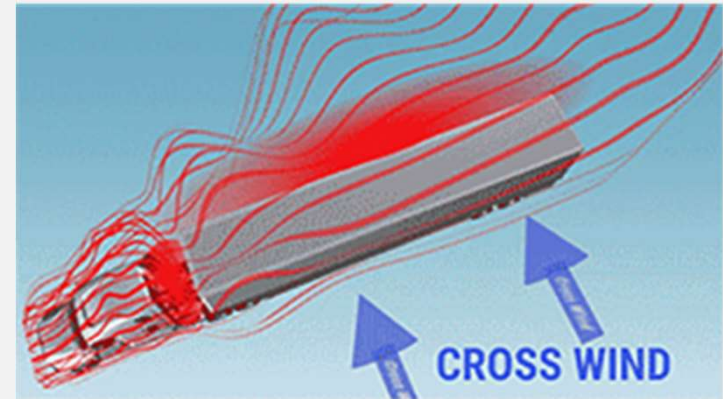
- Suspension Innovation
- Utilizes First-Class Lever
- Dependent & Independent

Deliverables:

- Production ready designs, drawings and load calculations
- 1:8 Scale Prototype Trailer

VALUE PROPOSITION

- Existing vs. Our Independent Suspension
- Reduces Sway and Increases Stability
- 3D Models, Drawings, and BOMs For 3 Capacities
- Negotiate a Partnership with Trailer Manufacturers



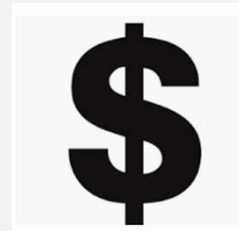
BACKGROUND

- First-Class lever
- Load Stability
- Increase Safety and Capabilities
- Rough Terrain/High Crosswinds
- Commercial suspension



CUSTOMER/PRODUCT REQUIREMENTS

- User Installation Time < 8 hours
- Dependent to Independent < 1 minute
- Static Rated load Capacity (2000lb, 3500lb, 6000lb)
- Dynamic Load per Tire/Spring - No less than FOS of 3
- Durability/Reliability Requirements – 10k-20k hours, Target 90%
- Cost Requirements – 250\$ for prototype



CONCEPT DEVELOPMENT PROCESS



Primary lever design was difficult to manufacture,
➤ Needed gussets to relieve stress concentrations.

Axle pin was originally multiple small welded pieces,
➤ Design was changed for ease of manufacturability.

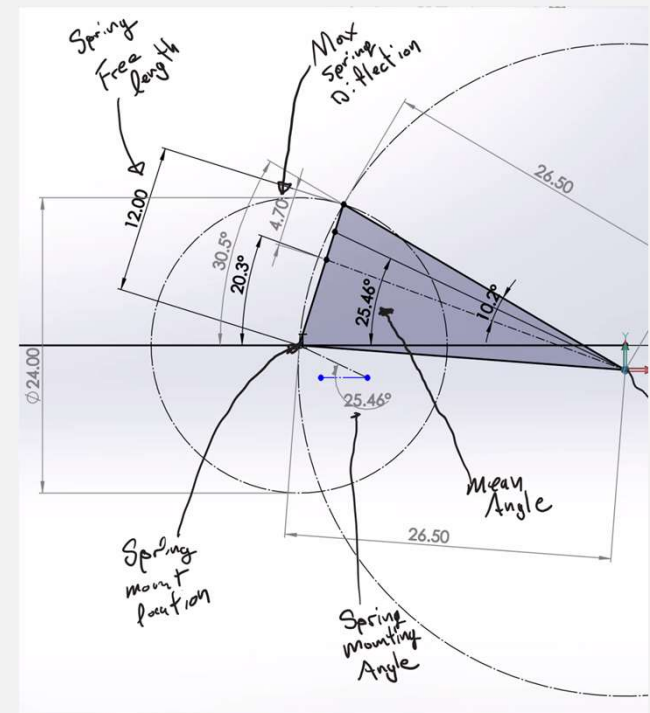
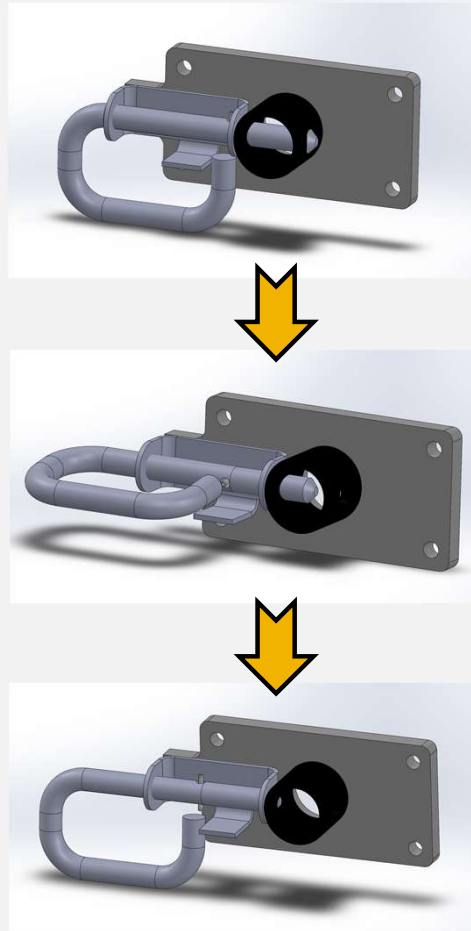
Bottom spring mount went through numerous iterations,
➤ Returned to a fixed support welded at an optimal angle to remain normal to top mount.

Mounts from axle to frame were changed to triangular shape,
➤ This will allow more area for fillet welds.



KEY ATTRIBUTES OF DESIGN

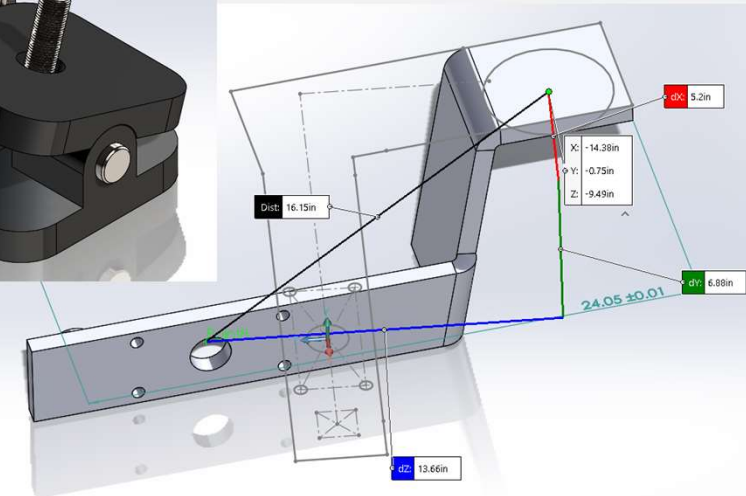
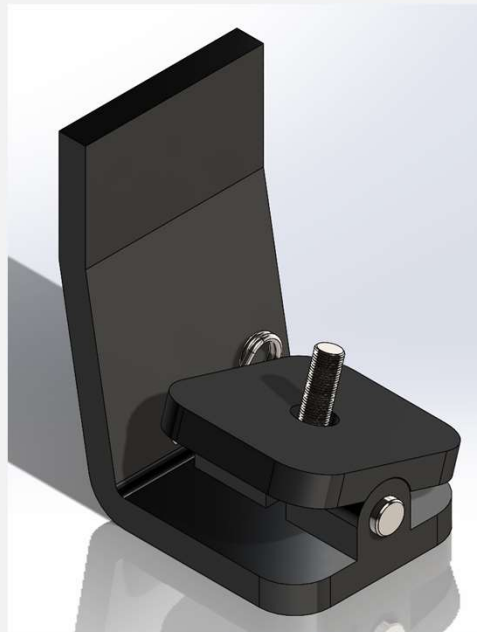
- Switching from dependent to independent suspension is made possible by quickly removing the spring-loaded axle pin.
- An optimum angle has been calculated for the where the bottom spring mount is welded to the frame.
 - This accounts for the rocker arm's entire range of motion.
 - Reduces buckling as much as possible without adding moving parts.
- Designed such that nearly any trailer could be converted.
- FEA of all structural components meets F.S. of 3.





MANUFACTURING PROCESS – CHALLENGES THAT WE FACED

- Initial spring base bracket hinge was too costly and difficult to manufacture within the scope of this project.
- Many preliminary ideas required bending thick steel plating.
- The 3 different load capacities each required varying material thicknesses
 - Every structural piece needed to be tested by FEA to find the smallest allowable thickness.
- Our calculated angles spring mounts were incorrect and needed to be redone.
 - After multiple different calculation methods, SolidWorks was used for optimization
- Testing weldments in SolidWorks



RECOMMENDATIONS & FUTURE DEVELOPMENT

- Design a manufacturable, cost effective hinge-supported mount for the bottom of the spring that can withstand load requirements.
- Try to buy things not manufacture due to cost
- Laser cut rocker arms out of acrylic – sturdy prototype
- What we would change about our design



PROTOTYPE MANUFACTURING PROCESS



Calibrate 3D printer and print test piece

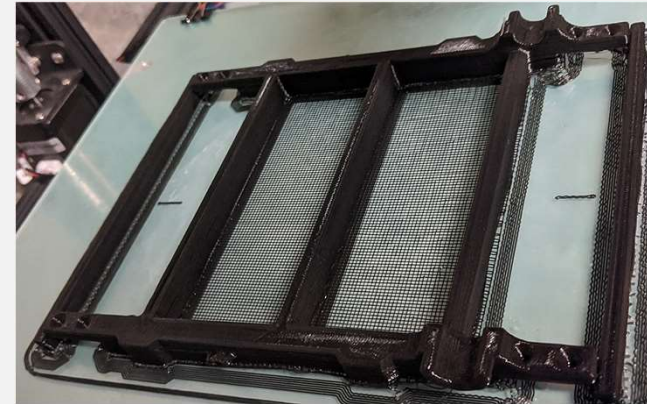
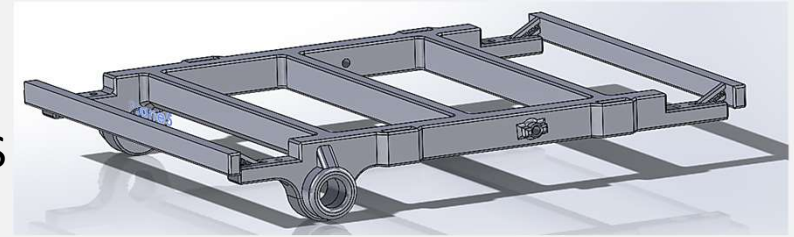
- 3D printed components: 3x bed pieces, LHS & RHS rocker arm, 2x bottom spring mount, 4x spring retainer, 2x axle caps.

Levers printed axially outwards, to maximize laminar strength.

Warping effects significant; utilized unenclosed 3d printer by flattening benign layers.

Added supports to perimeter features of center piece, that could easily be snapped off.

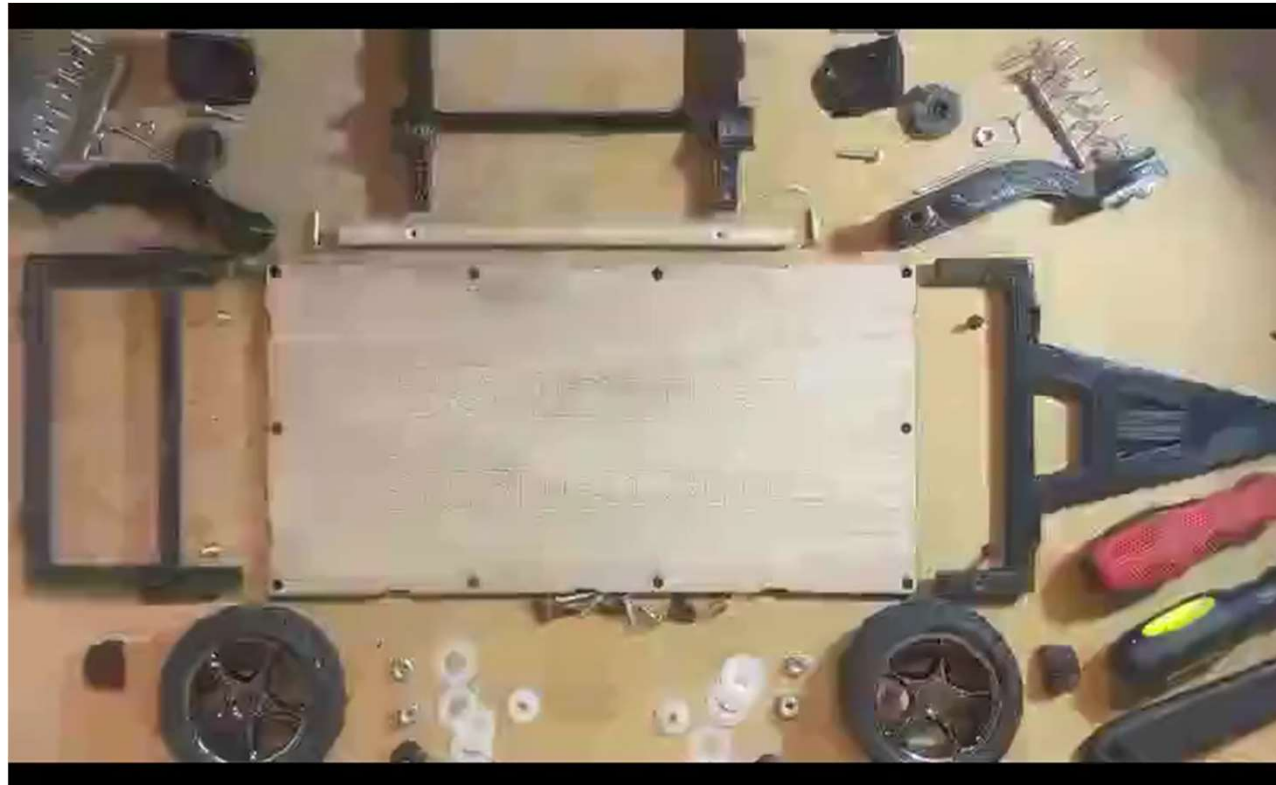
All printed parts had to be sanded down and filed considerably due to the raft adhering to the surface.



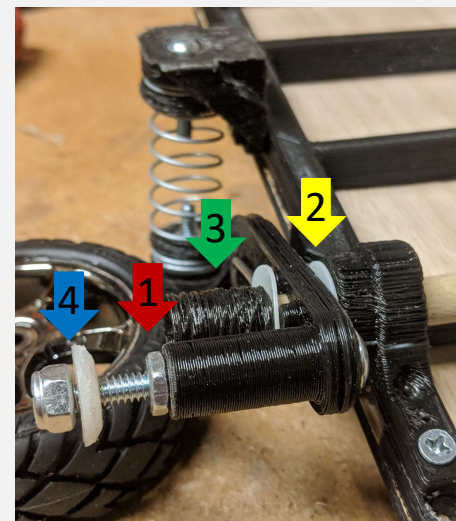


RAPID PROTOTYPING

- Main issue was adherence to print bed.
 - Large rafts wasted filament and came loose over time
 - Skirts would warp and get in way of printer.
 - Increasing brim width was crucial to reduce cupping/warping.



- Bed too large to fit on printer; had to be cut into 3 pieces.
- Originally planned to print mounting surface for tire
- 1** Instead chose pretensioned thru-bolts to reinforce most likely failure mode.
- 2** Added pairs of nylon bushings between lever faces, to reduce friction.
- 3** Added axle caps to secure rocker arm.
- 4** Added lock-nut and nylon bushing to properly secure wheel to armature.



FAILED PRINTS

First platform incorporated Lego-like connections

Extruded cylinders were too brittle and had no tensile strength.

Changed to screw connections due to small resolution.

- 1 → Axle mounts were enlarged and became a mating pair.
 - To reduce torsion loading, axle became fixed to bed.
- 2 → First bottom spring mount was too brittle due to sharp bend; delaminated near corner.
 - Triangle gussets added to both sides.
- 3 → First spring retainer design only compressed one side of spring at mount.
 - Matched swept cut to pitch of spring.



1:8 SCALE PROTOTYPE DEMONSTRATION

- Lever Ratio = 3.5
 - ~1" spring travel --> 0.28" at wheel
- Removable pin passes through center of axle
 - When removed, one side will flex more than other
- Total Cost = \$50

Invaluable as demonstrative tool to explain how lever mates and interacts with axle and trailer bed.



VALIDATION OF THE PROTOTYPE

Scope: *"Fabricate a small-scale prototype of a trailer frame and suspension system for demonstration purposes. This may be 3D printed or use fabrication techniques, or a combination of both."*

We wanted to keep all parts exact scale replicas of full-size model, but this was infeasible due to the tolerance of the printer.

- Because prototype is for demonstration purposes, 3D print was most realistic approach.
 - However it is inherently weak in the Z-direction.
- After discussion with client, chose to add braces throughout and increase thickness of parts.
 - Most parts oversized 3% to compensate for shrinking.
 - Mating surfaces changed to 1/16" tolerance gap.
- Completion of prototype validates interference and performance.
 - Final validation would be testing max loading capability before failure.

**THANK YOU FOR LISTENING
QUESTIONS?**

