FORMULA SAE®

Suspension

Tires, wheels, hubs, uprights, control arms, steering linkage, springs, dampers, anti-roll bars, geometry, kinematics, vehicle dynamics. Selection and use of materials.

Suspension Overview

Goals:

- Reliability: the vehicle must consistently complete the 22 km endurance event
  - minimum FOS of 2 for all parts
- reduce design complexity, ensure serviceability

General:

- Hoosier 16-7.5x10, R25B tires with 10” Keizer aluminum rims
- track width/wheelbase: 46.9”, 60.2”
- 50 % FLLTD

front left suspension assembly

rear left suspension assembly

Kinematics

Static Front Parameters:

FVSA Length	53.7”
FVSA Angle	2.96°
Roll Center height	1.21”
Scrub Radius:	0.22”
Mechanical trail:	0.87”
Camber:	-2°
Caster:	8.7°
KPI:	2.82°
Toe:	0.0°

Static Rear Parameters:

FVSA Length	146.56”
FVSA Angle	1.56°
Roll Center height	0.638”
Scrub Radius:	0.620”
Mechanical trail:	0”
Camber:	-2°
KPI:	11.0°
Toe:	0.0°

Suspension/Steering Linkages

- Short long arm (SLA) double wishbone suspension setup
- 4130 Steel Tubes, 0.058" Wall Thickness, 5/8" OD
  - Min FOS 2, Pacejka tire curves used to find forces
- Welding Cups used for rear suspension A-Arms
- Double Shear Joints for all suspension chassis attachment points
- Threaded rod-ends w/ jam nuts used for ease of adjusting lengths
- Serviceability and Accessibility
  - Maximum 4 washers per bolt
  - Access to bolt heads and nuts

Forces Experienced by Suspension Arms (N)			
	Left Hand Corner at 1.5g	Accelerate at 1g	5g Bump
Lower A-Arm Fore	507.990	707.887	3800.592
Lower A-Arm Aft	8007.604	1607.887	3268.360
Upper A-Arm Fore	422.256	664.079	1337.469
Upper A-Arm Aft	6282.909	2497.043	656.867
Tierod	38.812	686.475	241.701
Pushrod	1289.109	4661.308	965.303

Left Rear Suspension Assembly

Left Front Suspension Assembly

Rockers

Rear rocker loads:

- Pushrod Force: 2265 N bearing load
- Shock Absorber Force: 400 N bearing load

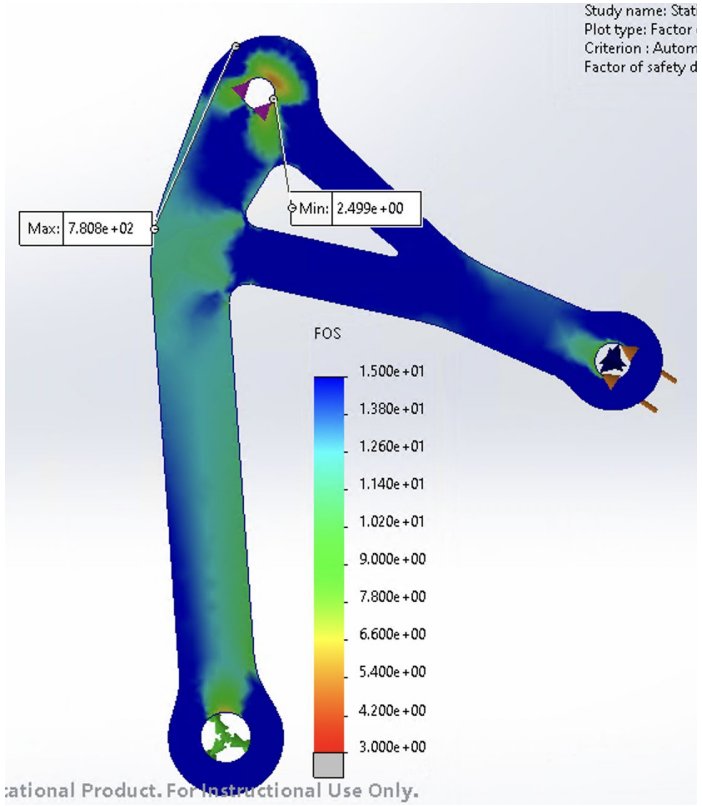
Material:

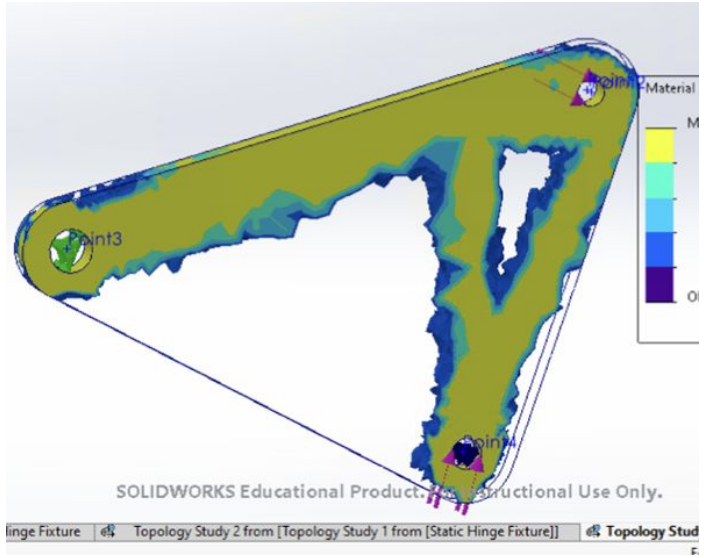
- Aluminum 6061 T6
- Yield Strength: 2.4 x 10^8 N/m^2

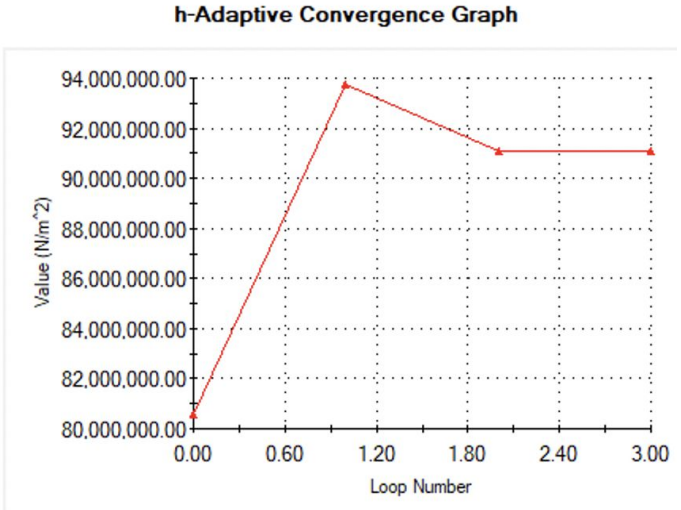
Final design min FOS: 2.5

	Front	Rear
Roll Center Height (in)	1.212	0.638
Ride Rate (lb/in)	155.84	159.25
Motion Ratio*	1.1442	0.8985

*Motion ratio is defined as wheel displacement/spring displacement

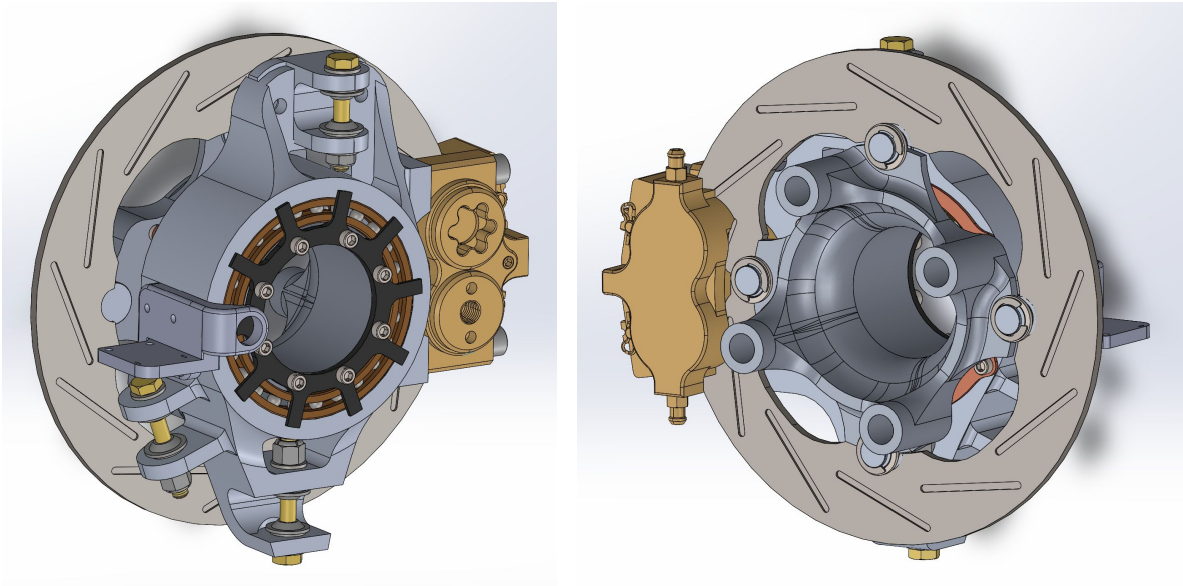






Hubs & Uprights

- 7075-T6 was selected for hubs and uprights due to its high strength-to-weight ratio
- Uprights allow for camber adjustment with addition of shims
- Minimum factor of safety: 2
- Rims attach to the hubs with lug bolts
- Double bearing arrangement, a bearing press-fit and further secured with retainers on each side of the hub to mitigate cantilever effect
- Deep groove non-contact sealed bearings



Front Right Hubright Assembly

Roll Rates and Dampers

	Front	Rear
Roll Stiffness (lb-ft/deg)	249.17	254.63
Spring Stiffness (lb/in)	150	250

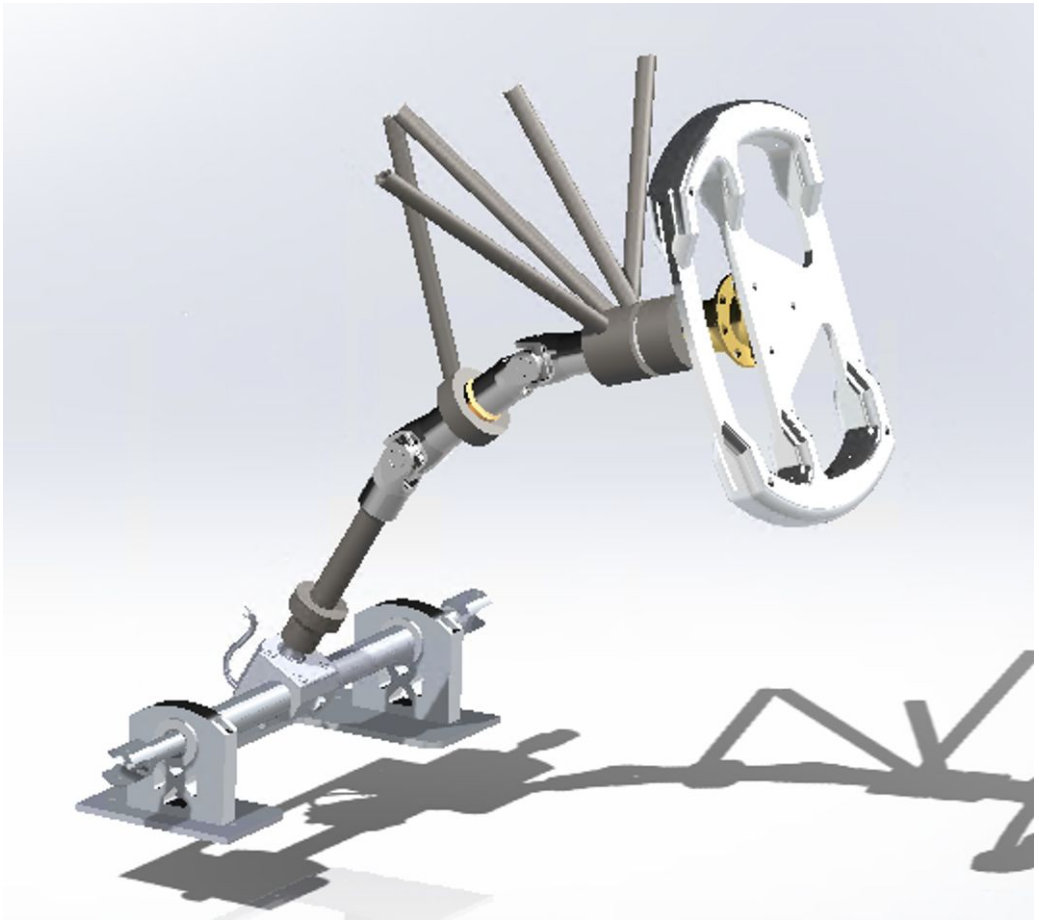
- TTX25 MkII Öhlins dampers
- Roll gradient: 1.0 deg/g

Steering

Goal: reduce compliance, maintain consistent driver feel/control

- Steering ratio: 4.79
- Two u-joint design in column
  - 20° operating angle for each
  - constant linear velocity
- two supports with oiled bushing/double bearing arrangement
- splined column connections
- unibody mounting system
- minimum FOS of 3

- tuneable bump steer/ackermann



Data Acquisition/Testing and Validation

Instrumentation:

- Linear potentiometers for damper length, wheel speed sensors, 3 axis accelerometer, steering angle sensor

Future plans:

- Instron, strain gauge testing to validate expected forces
- Dynamic testing (to validate/correlate with our tire models)
  - tire temperature
    - understeer v.s. oversteer, camber angle in cornering
  - normal force experienced on tires
- Steer steer test (to check for steering hysteresis