Technion FSAE Racing

Suspension Team

Design of a New Project Course #034353/4
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Abstract

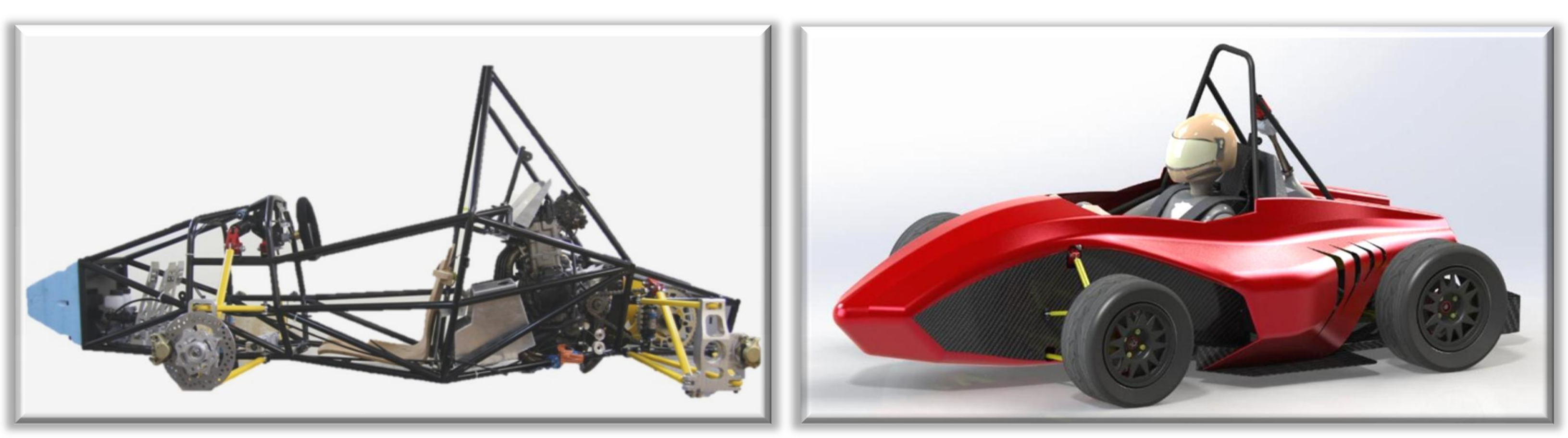
Formed in 1979, **Formula SAE** is a design and manufacture competition, held between students from universities all around the world. The challenges' main objective is to develop a Formula-style race car prototype, which will be evaluated for its potential as a production item. The competition takes place in track-weekends events, in different locations worldwide.
For the first-ever Technion Formula SAE challenger, this year **Suspension Team** had to conduct an extensive and thorough research in the fields of vehicle dynamics, suspension systems, solid bodies motion analysis, materials and manufacturing processes, with the aim to enable the production of an effective, simple, robust and reliable suspension system.

Project Objective and Requirements

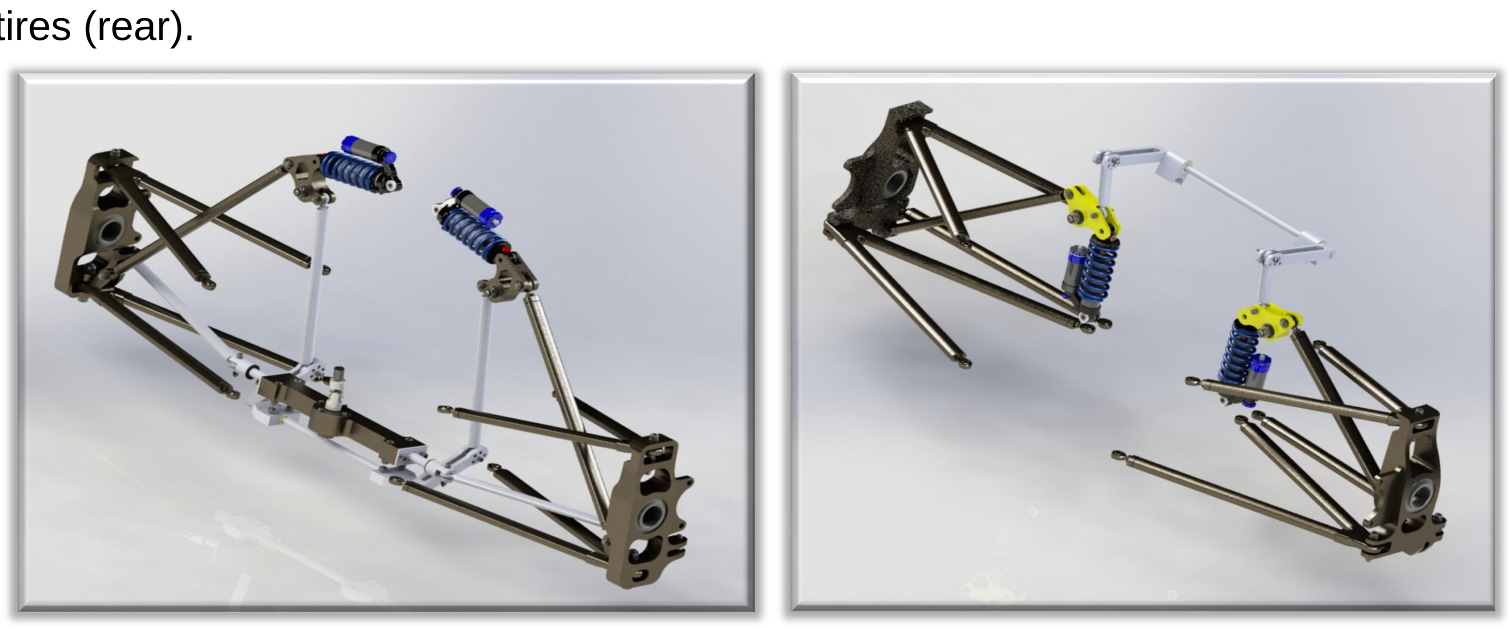
The **Technion Formula Teams'** main objective is to design, manufacture, market and race a vehicle, according to the Formula SAE guidelines.
Suspension Teams' aim is to design and manufacture optimal suspension, damping and weight-transfer mechanism, that will work seamlessly, deliver maximum tire grip at any condition, control body movement, enhance track performance and integrate with all the vehicle components.

Product Description

Functionality
Suspension system main task is linking the vehicles' sprung mass to its tires, and help control that mass' movement and inertia. In order to achieve this goal, the team designed components which are described in the following sections.



Geometry & Kinematics
- Unparalleled and unequalled A–arms double wishbones, thoroughly designed to supply optimal tire grip through entire wheel travel range, while supporting longitudinal loads.
- 10% Ackermann steering geometry was set, for optimal fit to tight turns circuits.
- Tie-rods were designed to supply steering moment (front), and resist transverse loads from the tires (rear).



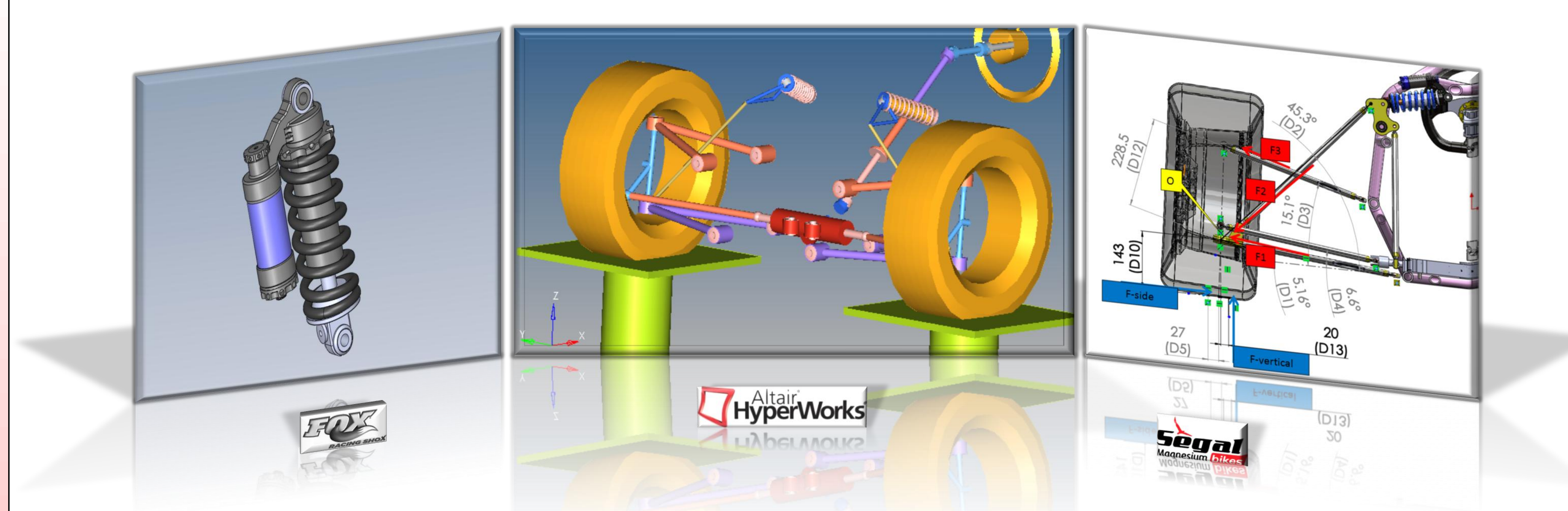
Load Transfer & Kinetics
- Push-rod through rocker actuated coil-over handles vertical loads applied from the tires.
- Front and rear rockers designed to deliver operation in the linear range of the springs.
- Anti-roll bar mechanism, consists of torsion bar and levers, is applied in both axles to resist roll movement and grip loss.
- Fox Racing® DHX 5.0 adjustable coil-over shock absorbers, donated kindly by Fox Racing® Israel, being used for damping spring movement.

Production & Materials
- Unique ultra-light weight Magnesium profiles chosen as the base of A-arms, push-rods, and tie-rods. This due to the proven knowledge and expertise of the teams' main sponsor – Alubin-Segal Magnesium Bikes®. Rod linkage was done with jig-based TIG-welding, to special made inserts.
- Rockers and inserts were fabricated by CNC, using Magnesium (AZ-80).
- Uniball joints and rod-end bearings (Aurora) used for linkage of the system to the chassis and wheel complex.

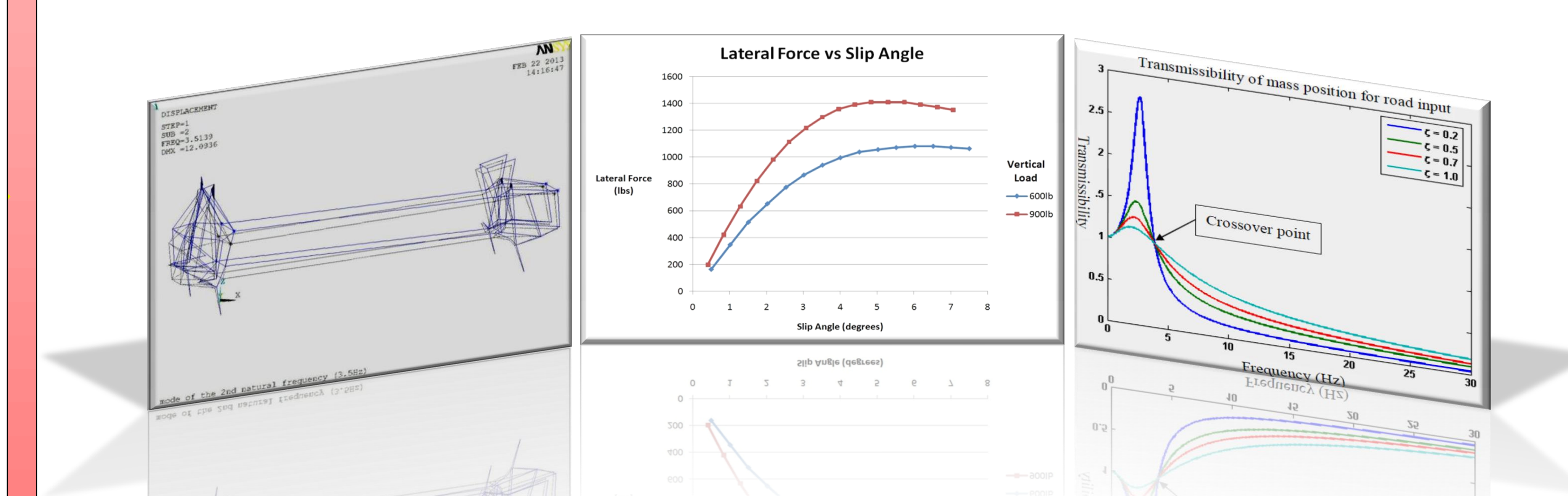
Analysis

Comprehensive analysis, using various tools, was conducted during the design process, in order to achieve the desired requirements, and resulted in the following characteristics:

Suspension Model
The systems' geometric parameters were set via iterative modeling process, using Altair® MotionView™ multi-body dynamics simulation software.
- Primary achieved geometric characteristics:
  - Camber: -1° degree static, 0.9° degree of change per in inch of suspension travel.
  - Toe-in: 0.5° [deg] @ front.
  - Toe-out: -0.5° [deg] @ rear.
  - Roll center (front / rear): 80 [mm] / 120 [mm] – static from ground.
  - Steering lock angles: 30° to -35° [deg].



Dynamic Behavior
Extensive calculations, mostly manual made, were conducted in order to calculate spring and damper rates for both axles. A parametric subroutine was developed especially for calculating anti-roll bars' rate, stiffness and material essential to achieve the desired vehicle dynamic behavior (moderate under steer).
- Primary achieved dynamic characteristics:
  - Spring rate (front / rear): 250 [lb/inch] / 250 [lb/inch].
  - Damping rates (front / rear) : Jounce - 0.65 / 0.65.
    Rebound - 0.7 / 0.7.
  - Motion Ratio (front / rear) - 0.76 / 0.75 - progressive rate.
  - Roll resistance: 1.13° [deg/g].
  - Validated natural frequency (front / rear - using ANSYS®) – 3.1 [Hz] / 2.7 [HZ].



Experimental & Finite Elements Analysis
Finite element analysis was done using SolidWorks® under strict factors of safety, guided by the worst case scenarios of braking and accelerating at 1.5[g], bumping at 3[g] and turning at 1.5[g]. For final validation, experimental analysis was made by applying loads on real fabricated A-arms.

Acknowledgements

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