AMEYA 2020-21. >> SUSPENSION REPORT <<

INTRODUCTION.

Damping Ratio: Damping ratio is the ratio of the amount of viscous damping present in a system to that required for critical damping. Where comfort takes priority over performance, leading to low damping ratios, and minimum pitching over bumps. Race cars in general run higher damping ratios, and have a much smaller concern for comfort, leading to some race cars using higher front ride frequencies. The higher damping ratios will reduce the amount of oscillation resultant from road bumps, in return reducing the need for a flat ride.

Sprung weight and un-sprung weight: All weight which is supported by the suspension, including portions of the weight of the suspension members are regarded as sprung weight. Un-sprung weight includes the suspension upright and all components attached to it; the brake calliper, brake disc, wheel, tire and a portion of suspension arms. Sprung weight is protected from the shocks and vibrations that the wheels experience as they travel over every bump and pothole. This makes for a more comfortable ride and protects the sprung components from destructive and life shortening shocks and vibrations. Conversely, un-sprung weight must be designed to be tough enough to survive the constant shocks and vibrations, which can be difficult for complex parts such as wireless pressure sensors. In general, it's best to have a high ratio of sprung to un-sprung weight. A higher proportion of sprung weight can then push down on the wheels and tires with more force, keeping them in contact with the pavement or whatever surface they are traveling across. Maintaining contact with the roadway improves handling and traction, and this becomes more of an issue for off-roading and traveling over rough roads. So as a rule, designers try to minimize un-sprung weight to improve handling and steering.

Spring Rate: The change of load on a spring per unit deflection is spring rate. To minimize the pitching motion of vehicle, the equivalent spring rate and the natural frequency of the front end should be slightly less than those of the rear end. This ensures that both ends of the vehicle will move in phase within a short time after the front end is excited.

Camber Angle: Camber is the angle of the wheel relative to vertical line to the road, as viewed from the front or the rear of the car. If the top of the wheel is farther out than the bottom (that is, away from the axle), it is called positive camber; if the bottom of the wheel is farther out than the top, it is called negative camber. The cornering force that a tire can develop is highly dependent on its angle relative to the road surface, and so wheel camber has a major effect on the road holding of a car. A tire develops its maximum lateral force at a small camber angle. This fact is due to the contribution of camber thrust, which is an additional lateral force generated by elastic deformation as the tread rubber pulls through the tire/road interface.

Caster Angle: It is the Forward or rearward inclination of the steering axis.

Positive Caster: Positive caster is when the steering axis is in front of the vertical. The purpose of this is to provide a degree of self-cantering for steering the wheel casters around, so as to trail behind the axis of steering. This makes a car easier to drive and improves its directional stability (reducing its tendency to wander). Excessive caster angle will make the steering heavier and less responsive, although, in racing, large caster angles are used to improve camber gain in cornering. Power steering is usually necessary to overcome the jacking effect from the high caster angle.

Negative Caster: Negative caster is when the steering axis is behind the vertical. This is generally only found on older vehicles due to tire technology, chassis dynamics, and other reasons. Modern vehicles do not use negative caster. It will lighten the steering effort but also increases the tendency for the car to wander down the road.

Toe Angle: When a pair of wheels is set so that their leading edges are pointed slightly towards each other, the wheel pair is said to have toe-in. If the leading edges point away from each other, the pair is said to have toe-out. The amount of toe can be expressed in degrees as the angle to which the wheels are out of parallel, or more commonly, as the difference between the track widths as measured at the leading and trailing edges of the tires or wheels. Toe settings affect three major areas of performance: tire wear, straight-line stability and corner entry handling characteristics.

Suspension Roll: The rotation of the vehicle sprung mass about the x-axis with respect to a transverse axis joining a pair of wheel centres.

Roll Centre and Roll axis: The roll axis is the instantaneous line about which the body of a vehicle rolls. Roll axis is found by connecting the roll centre of the front and rear suspensions of the vehicle. Assume we cut a vehicle laterally to disconnect the front and rear half of the vehicle. Then, the roll centre of the front or rear suspension is the instantaneous centre of rotation of the body with respect to the ground

Motion Ratio: Motion ratio in suspension of a vehicle describes the amount of shock travel for a given amount of wheel travel. Mathematically it is the ratio of shock travel and wheel travel. The amount of force transmitted to the vehicle chassis reduces with increase in motion ratio. A motion ratio close to one is desired in vehicle for better ride and comfort. One should know the desired wheel travel of the vehicle before calculating motion ratio which depends much on the type of track the vehicle will run upon.

Wheel travel: Wheel travel is the distance that is designed for the wheel/tire assembly to move vertically without bottoming out either at the top or the bottom of the motion. The suspension's job is to ensure that despite any bumps or droops, the vehicle stays as levelled and smooth as possible. While wheel travel is measured on both independent and solid axle suspensions, it is mostly referred to with independent

suspension where the vertical travel of each wheel/tire assembly is separate from any of the others, and therefore best able to provide that smooth ride and safe driving experience.

Anti-dive: Anti-dive is a suspension parameter that affects the amount of suspension deflection when the brakes are applied. When a car is decelerating due to braking there is a load transfer off the rear wheels and onto the front wheels proportional to the centre of gravity height, the deceleration rate and inversely proportional to the wheelbase. If there is no anti-dive present, the vehicle suspension will deflect purely as a function of the wheel rate. This means only the spring rate is controlling this motion. As anti-dive is added, a portion of the load transfer is resisted by the suspension arms. The spring and the suspension arms are sharing the load in some proportion. If a point is reached called “100-percent anti-dive”, all of the load transfer is resisted by the suspension arms and none is carried through the springs. When this happens, there is no suspension deflection due to braking and no visible brake dive. There is still load transfer onto the wheels, but the chassis does not pitch nose down. The method to achieve anti-dive is controlled by upper and lower control arm pivot points on chassis. Just like anti-dive in the front suspension, there can be anti-lift in the rear suspension that reduces rebound travel under braking. There is also anti-squat in the rear suspension under acceleration for rear-wheel drive cars.

CALCULATIONS:

→Dimensions and required parameters to start suspension calculations

PARAMETERS:

1) Tyre dimensions
   Height of tyre = 24inch
   Width of tyre = 8 inch
   Rim size diameter = 16inch
2) Wheel base = 56inch = 1422.4mm
3) Track width = 44.8inch =1137.92mm
4) Scrub radius = 1.5inch =38.1mm
5) KPI angle = 8degrees
6) CG height from ground = 20 inch
7) Roll centre height from ground = 18.0315inch
8) Chassis dimensions
   Width of chassis = 35inch
   Length of chassis = 65inch
   Height of chassis = 42.35inch
9) Weight ratio

Front = 40%

Rear = 60%

10)Initial caster angle = positive 5 degree

→To find, angle to with stand dive condition (while breaking weight on front is increased so rear end goes up and front end goes down) So %Anti dive condition is applied.

1) %Front Anti dive = % front braking * tan **Φ * L/ h**

   Where,

   L= wheel base= 1422.4mm

   H= CG height from ground= 508mm

   %front braking = 60 %

   We have to fix %front anti dive condition. So, %front anti dive = 60%

$0.6 = 0.6 * \tan \Phi * 1422.4/ 508$

$\tan \Phi = 1 / 2.8$

$\Phi = 19.65$ → angle to with stand dive condition.

→To find, angle to with stand squat condition (while accelerating weight on rear is increased so front end goes up and rear end goes down). So %Anti squat condition is applied.

1) %Front Anti squat = tan **Φ * L/ h**

   Where,

   L= wheel base= 1422.4mm

   H= CG height from ground= 508mm

   We have to fix %front anti squat condition. So, %front anti squat = 60%

$0.6 = \tan \Phi * 1422.4/ 508$

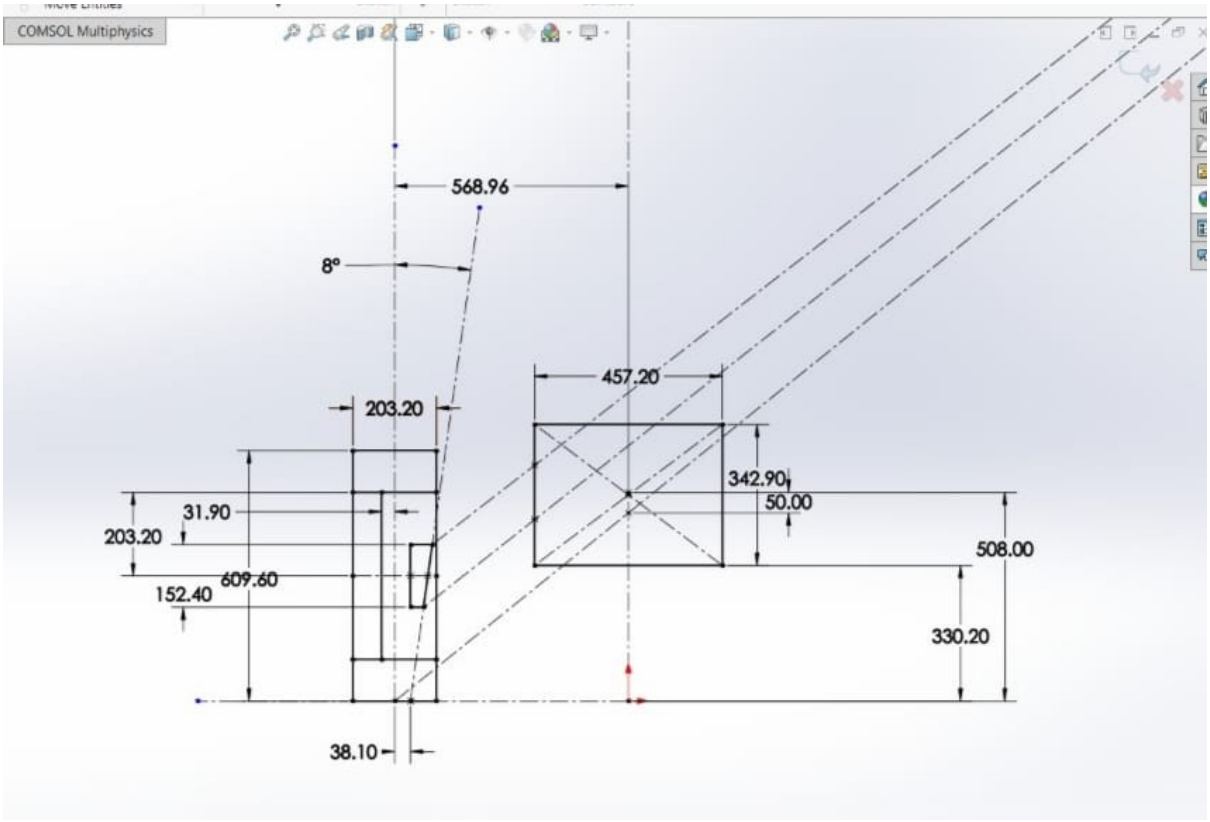
$\tan \Phi = 0.2142$

$\Phi = 12.09$ → angle to with stand squat condition.

→To find the coordinates of wishbones we are using solid works software by designing our assumed wishbone dimensions by drawing front and side view of wishbones by above angles we got and parameters known.

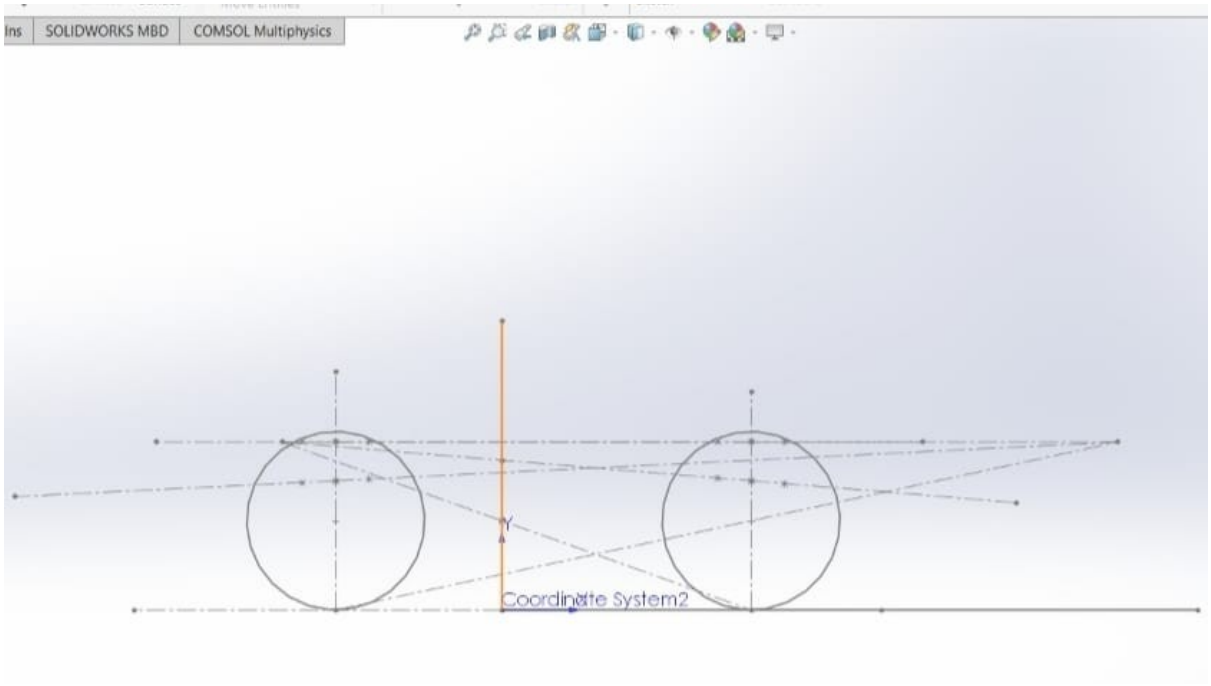
Step 1 – FRONT VIEW OF THE WISHBONES

Since taking front and rear wishbones as A member front view will be the same to front and rear.

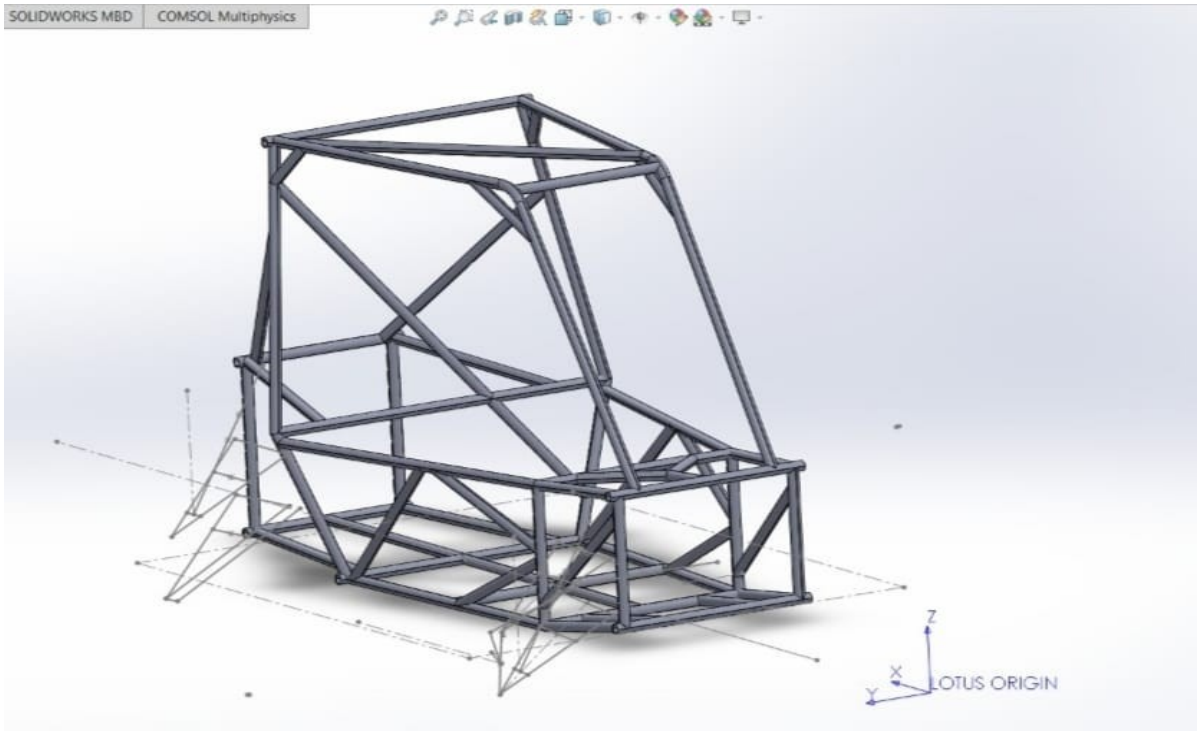


Step 2: SIDE VIEW OF THE WISHBONES

Since this is side view, the weight distribution will come into picture and accordingly the positions of the wishbones are known.



Step 3: TOTAL ASSEMBLY OF WISHBONES BEFORE LOTUS ANALYSIS



Step 4: Now we got the values of every point along with the steering considerations.

In lotus to do analysis we have to get total 18 points for front suspension and 18 points for rear suspension those are:

Lower wishbone front point , lower wishbone rear point , lower wishbone outer point, upper wishbone front point, upper wishbone rear point , upper wishbone

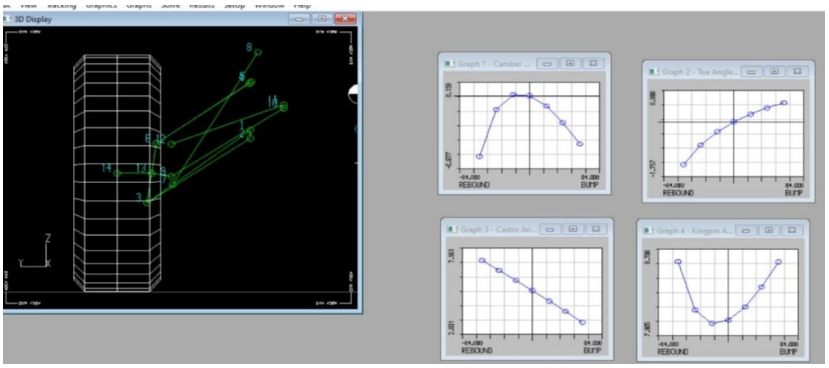
outer point, damper wishbone end, damper body end, outer track rod ball joint, inner track rod ball joint, upper spring pivot point, lower spring pivot point, wheel spindle point, wheel centre point, part1 CG (lower wishbone CG), part2 CG (upper wishbone CG), part3 CG(damper), part4 (damper centre).

Step 5: ANALYSIS OF WISHBONE POINTS IN LOTUS SHARK SOFTWARE.

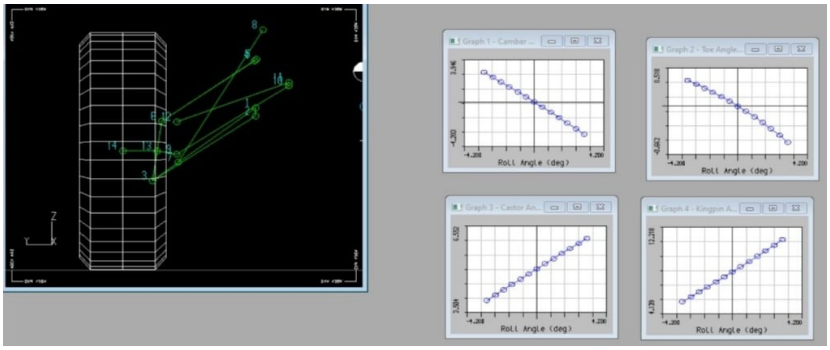
In lotus shark we have to first input the values and according to the camber, toe change, caster and KPI graphs while bumping, rolling, steer conditions.accordingly we have to fix the wishbone points.

GRAPHICAL REPRESENTATIONS

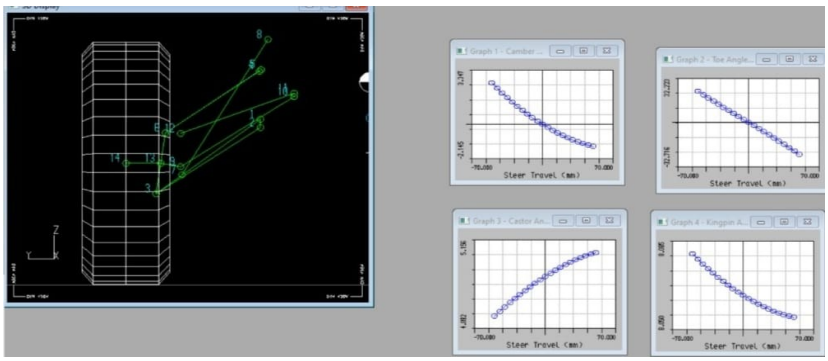
FRONT SUSPENSION:



BUMP CONDITION

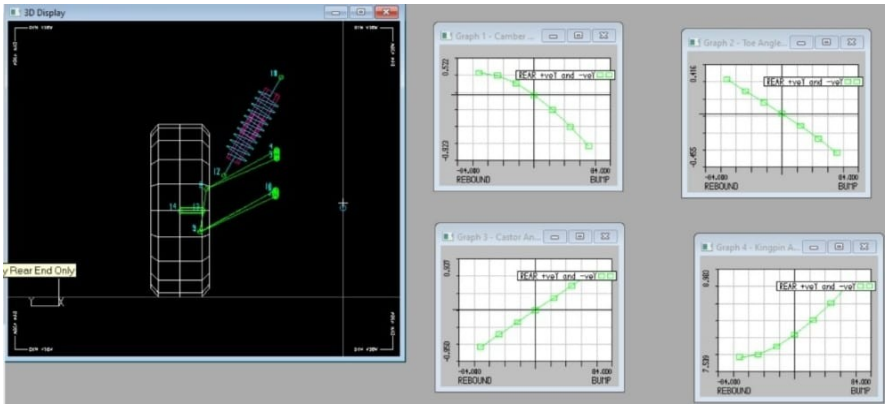


ROLL CONDITION



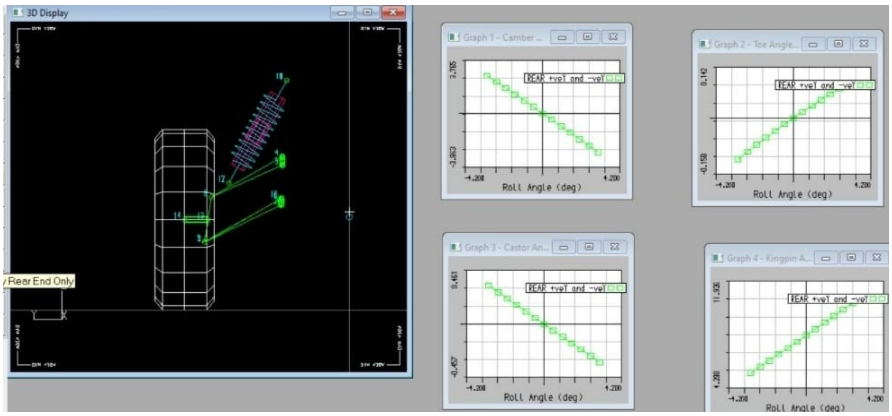
STEER CONDITION

REAR SUSPENSION:



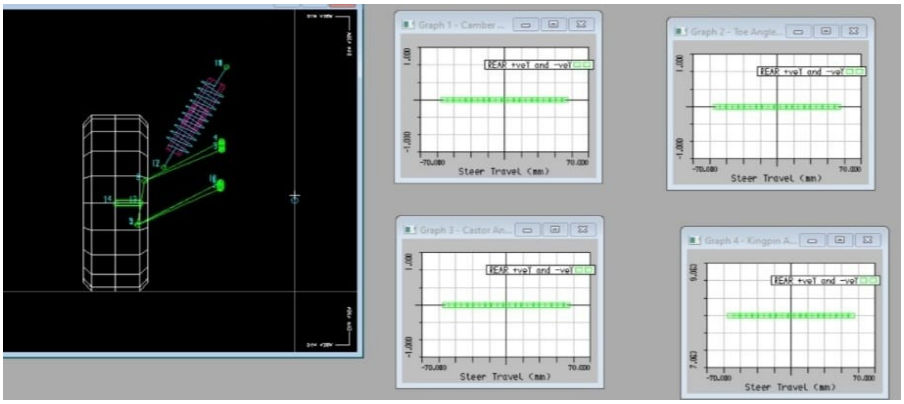
BUMP

CONDITION



ROLL

CONDITION



STEER CONDITION

The lengths of wishbones after lotus analysis are

1) Front lower wishbone – 11.82inch
2) Front upper wishbone – 10.67inch
3) Rear lower wishbone – 11.68inch
4) Rear upper wishbone – 10.8inch