AUTOMOTIVE SUSPENSION SYSTEM-A REVIEW

Dr. Pushpendrakumar Sharma[1], Prof. Sunil Shukla[2], Hiren Natvarbhai Makwana[3]
Department of Mechanical Engineering
NRI Institute of Science and Technology, Bhopal, India.

Abstract: Suspension is the term given to the system of springs, shock absorbers and linkages that connects a vehicle to its wheels and allows relative motion between the two. Suspension systems serve a dual purpose — contributing to the vehicle's road holding/handling and braking for good active safety and driving pleasure, and keeping vehicle occupants comfortable and reasonably well isolated from road noise, bumps, and vibrations, etc. These goals are generally at odds, so the tuning of suspensions involves finding the right compromise. It is important for the suspension to keep the road wheel in contact with the road surface as much as possible, because all the road or ground forces acting on the vehicle do so through the contact patches of the tires. The suspension also protects the vehicle itself and any cargo or luggage from damage and wear. The design of front and rear suspension of a car may be different.

I. INTRODUCTION

Suspension is the term given to the system of springs, shock absorbers and linkages that connects a vehicle to its wheels and allows relative motion between the two. Suspension systems serve a dual purpose — contributing to the vehicle's road holding/handling and braking for good active safety and driving pleasure, and keeping vehicle occupants comfortable and reasonably well isolated from road noise, bumps, and vibrations etc. These goals are generally at odds, so the tuning of suspensions involves finding the right compromise. It is important for the suspension to keep the road wheel in contact with the road surface as much as possible, because all the road or ground forces acting on the vehicle do so through the contact patches of the tires. The suspension also protects the vehicle itself and any cargo or luggage from damage and wear. The design of front and rear suspension of a car may be different.

II. OBJECTIVES

- To provide good ride and handling performance Vertical compliance providing chassis isolation ensuring that the wheels follow the road profile very little tire load fluctuation
- To ensure that steering control is maintained during maneuvering wheels to be maintained in the proper position wrt road surface
- To ensure that the vehicle responds favorably to control forces produced by the tires during longitudinal braking accelerating forces, lateral cornering forces and braking and accelerating torques .this requires the suspension geometry to be designed to resist squat, dive and roll of the vehicle body
- To provide isolation from high frequency vibration from tire excitation requires appropriate isolation in the suspension joints Prevent transmission of ‗road noise' to the vehicle body

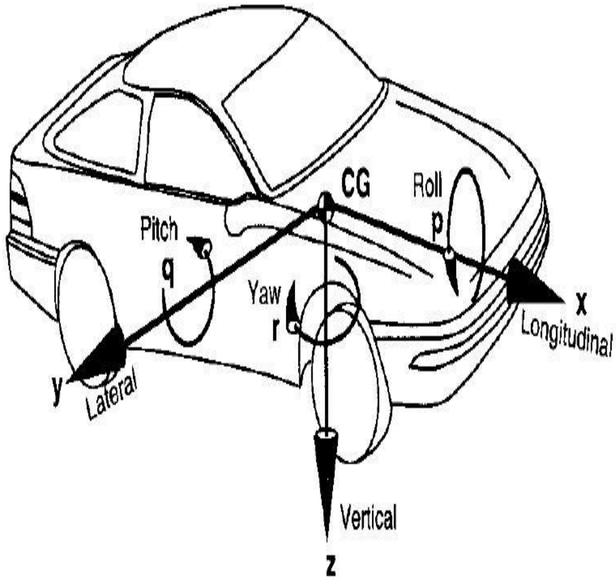
III. VEHICLE AXIS SYSTEM

A. Un-sprung mass:

- Right-hand orthogonal axis system fixed in a vehicle
- x-axis is substantially horizontal, points forward, and is in the longitudinal plane of symmetry.
- y-axis points to driver's right and
- z-axis points downward.

B. Rotations:

- A yaw rotation about z-axis.
- A pitch rotation about y-axis.
- A roll rotation about x-axis



SAE vehicle axes

IV. TIRE TERMINOLOGY – BASIC

A. Camber angle:

- angle between the wheel plane and the vertical
- taken to be positive when the wheel leans outwards from the vehicle

• Swivel pin (kingpin) inclination

- angle between the swivel pin axis and the vertical

• Swivel pin (kingpin) offset

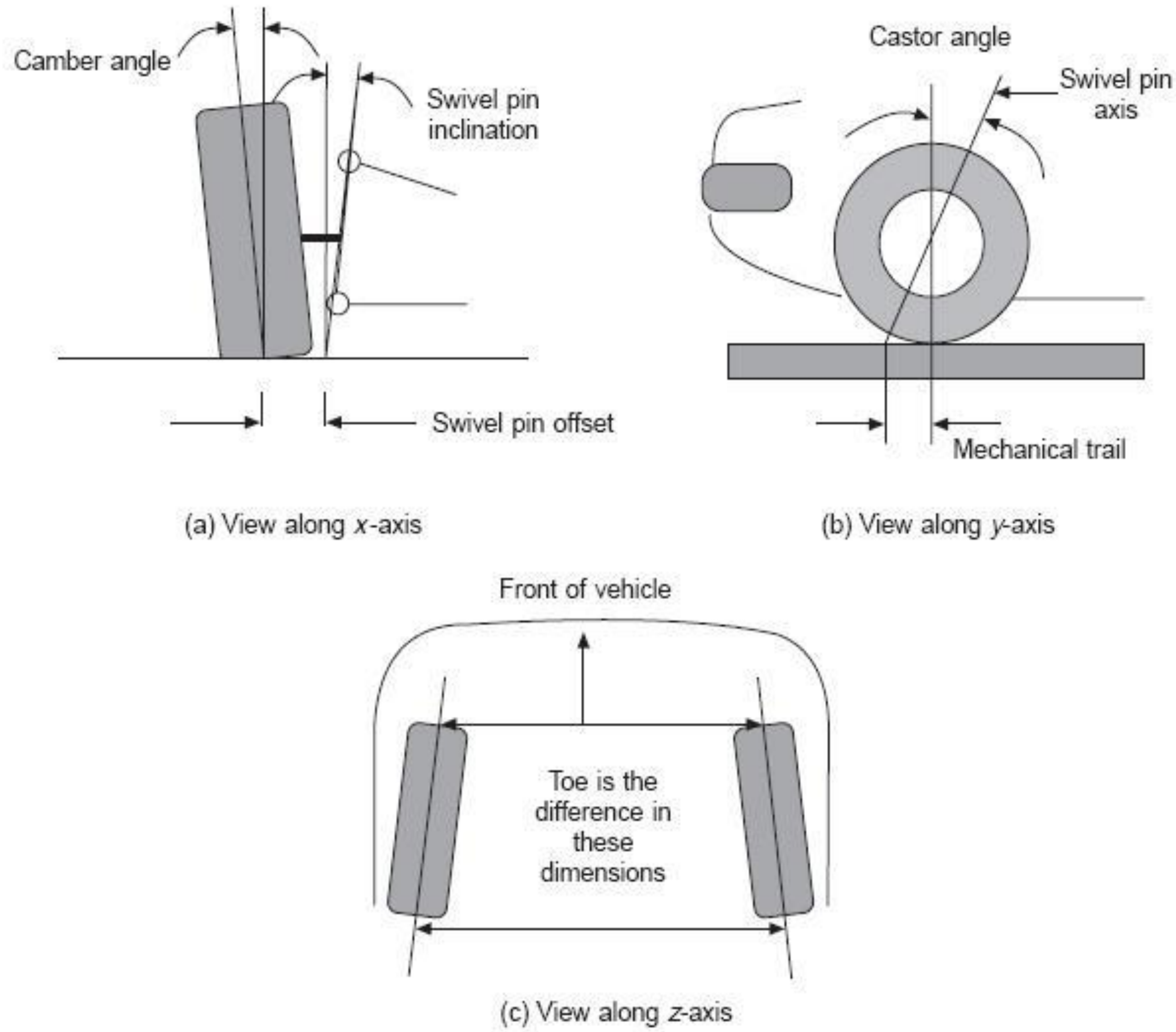
- distance between the centre of the tire contact patch and
- intersection of the swivel pin axis and the ground plane

B. Castor angle

- inclination of the swivel pin axis projected into the fore–aft plane through the wheel centre
- positive in the direction shown.
- provides a self-aligning torque for non-driven wheels.

•Toe-in and Toe-out

- difference between the front and rear distances separating the centre plane of a pair of wheels,
- Quoted at static ride height – toe-in is when the wheel centre planes converge towards the front of the vehicle



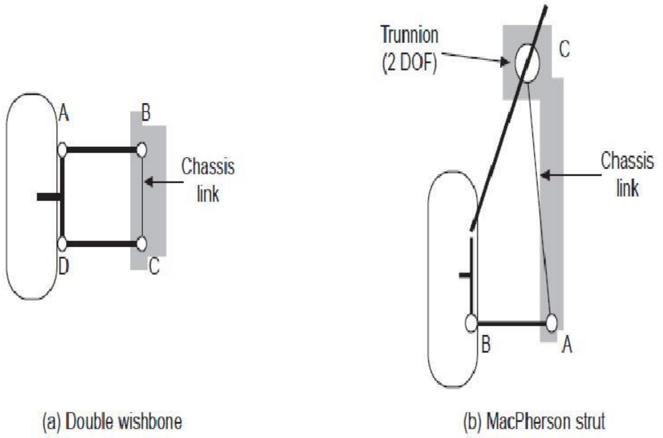
V. ANALYSIS OF SUSPENSION MECHANISMS

A. 3D mechanisms:

- Compliant bushes create variable link lengths
- 2D approximations used for analysis
- Requirement
- Guide the wheel along a vertical path
- Without change in camber
- Suspension mechanism has various SDOF mechanisms

B. The mobility of suspension mechanisms

Guide motion of each wheel along (unique) vertical path relative to the vehicle body without significant change in camber. Mobility (DOF) analysis is useful for checking for the appropriate number of degrees of freedom, does not help in synthesis to provide the desired motion



Two-dimensional kinematics of common suspension mechanisms

VI. SUSPENSION TYPES –DEPENDENT

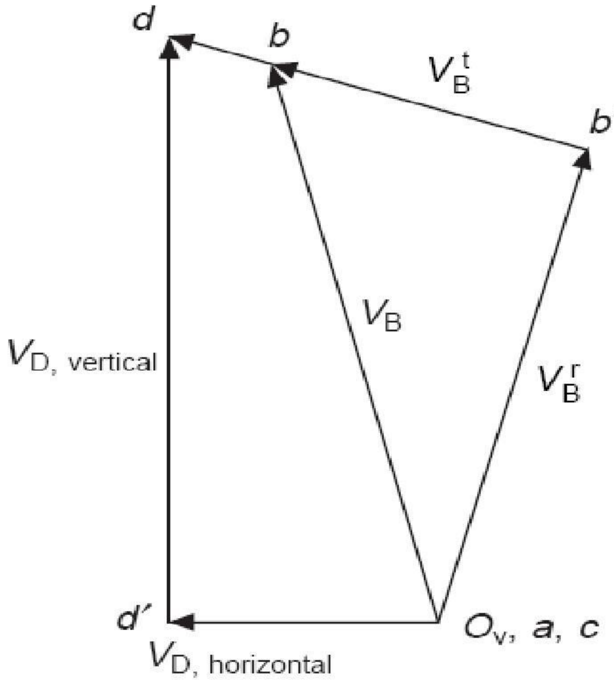
Motion of a wheel on one side of the vehicle is dependent on the motion of its partner on the other side
Rarely used in modern passenger cars

- Can not give good ride
- Can not control high braking and accelerating torques

Used in commercial and off-highway vehicles

VII. KINEMATIC ANALYSIS –GRAPHICAL

The suspension ratio R (the rate of change of vertical movement at D as a function of spring compression) the bump to scrub rate for the given position of the mechanism.



(b) Velocity diagram

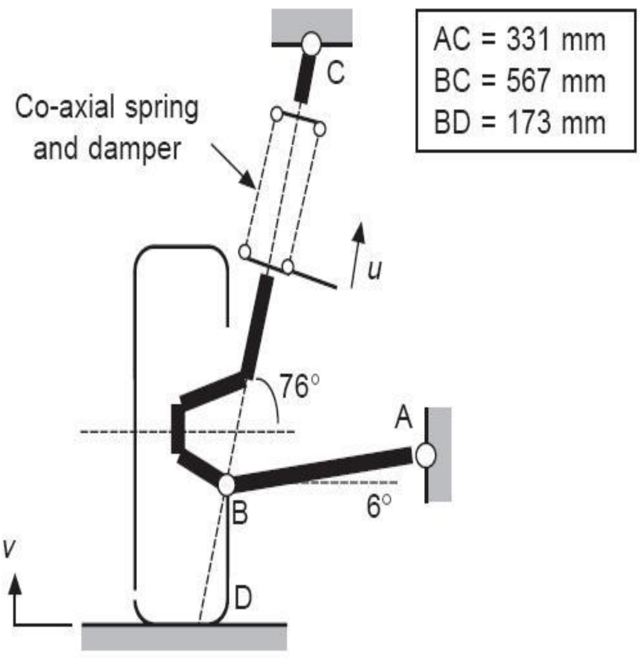
A. Kinematic Analysis – Sample calculation

Double wish bone

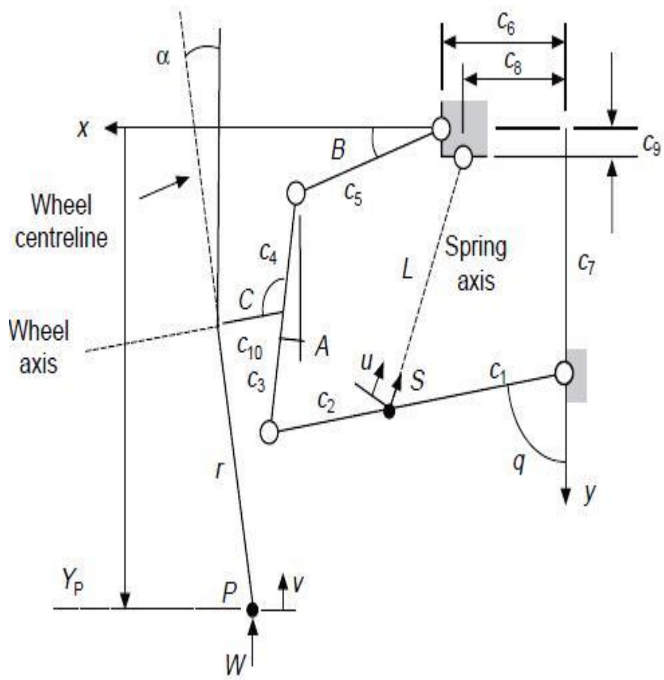
Determine camber angle α, and suspension ratio R (as defined in the previous example)

For suspension movement described by ―q‖ varying from 80° to 100°

Given that in the static laden position ―q‖ = 90°.



(a) Position of mechanism



Simplified suspension model

Positions are provided Two non-linear equations solved for positions described interval 1

Data: $c_1 := 203 \quad c_2 := 102 \quad c_3 := 127 \quad c_4 := 127 \quad c_5 := 152 \quad c_6 := 127$

$c_7 := 267 \quad c_8 := 102 \quad c_9 := 51 \quad c_{10} := 110 \quad C := 96° \quad r := 292$

Constants $c_{12} := c_1 + c_2 \quad c_{34} := c_3 + c_4 \quad k_{dr} := \frac{\pi}{180}$

Solution estimates: $A := -10 \quad B := 10$

Given

$$c_{12} \cdot \sin(q \cdot k_{dr}) - c_{34} \cdot \sin(A \cdot k_{dr}) - c_5 \cdot \cos(B \cdot k_{dr}) - c_6 = 0$$

$$c_{12} \cdot \cos(q \cdot k_{dr}) - c_{34} \cdot \cos(A \cdot k_{dr}) - c_5 \cdot \sin(B \cdot k_{dr}) + c_7 = 0$$

$$F(q) := \mathrm{Find}(A, B)$$

$$q := 80..100 \quad i := 0..20$$

$$A_i := F(80+i)_0 \quad B_i := F(80+i)_1 \quad q_i := 80 + i$$

The second part of the solution begins by expressing the length of the suspension spring in terms of the primary variable and then proceeds to determine the velocity coefficients

$K_{YP}(q) = \frac{dY_P}{dq}$ and $K_L(q) = \frac{dL}{dq}$. These allow the suspension ratio $R = \frac{K_{YP}}{K_L}$ to be determined.

Length of suspension spring

$$L_i := \sqrt{(c_1 \cdot \sin(q_{r_i}) - c_8)^2 + (c_7 + c_1 \cdot \cos(q_{r_i}) - c_9)^2}$$

Mean position of suspension spring $L_0 := L_{10} \quad L_0 = 238.447$ mm

Deflection from mean position $u_i := L_0 - L_i$

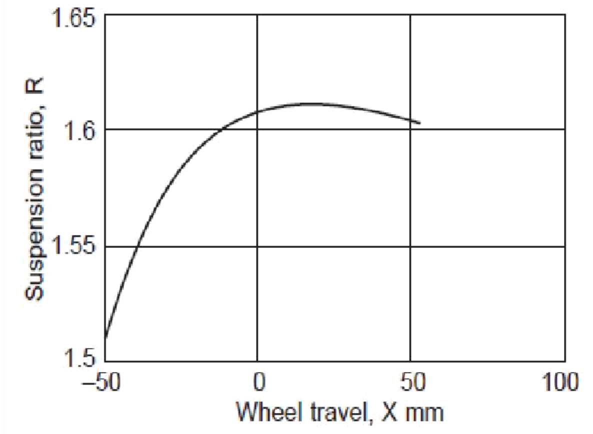
Velocity coefficients $$K_{A_i} := \frac{c_{12} \cdot \cos(q_{r_i} + B_{r_i})}{c_{34} \cdot \cos(A_{r_i} + B_{r_i})}$$

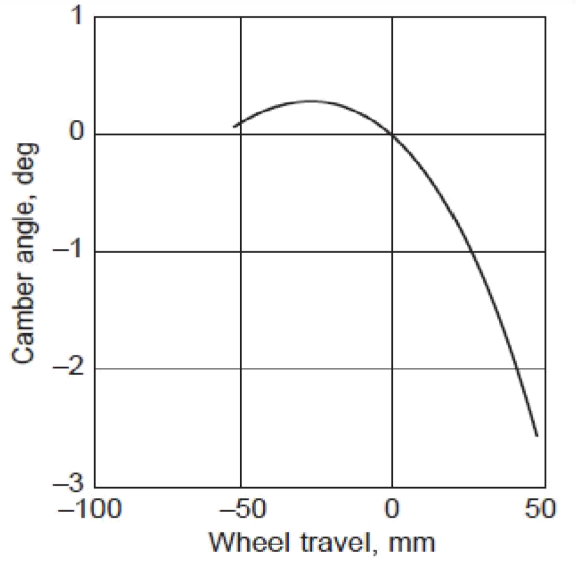
$$K_{YP_i} := c_{12} \cdot \sin(q_{r_i}) + K_{A_i} \cdot (c_3 \cdot \sin(A_{r_i}) - c_{10} \cdot \cos(\alpha_{r_i}) + r \cdot \sin(\alpha$$

$$K_{L_i} := \frac{c_1 \cdot c_9 \cdot \sin(q_{r_i}) - c_1 \cdot c_7 \cdot \sin(q_{r_i}) - c_1 \cdot c_8 \cdot \cos(q_{r_i})}{\sqrt{\left[(c_1 \cdot \sin(q_{r_i}) - c_8)^2 + (c_7 + c_1 \cdot \cos(q_{r_i}) - c_9)^2\right]}}$$

Suspension ratio $R_i := \frac{K_{YP_i}}{K_{L_i}} \quad R_{10} = 1.607$ **at static ride height**

B. Kinematic Analysis - Results





REFERENCE

[1] Automobile Transmission Volume II – A.W.Judge.
[2] Car Maintenance and Repairs.
[3] Work Book for Automotive Chassis Automotive Fundamentals – Earnest & Venk & Walter Billiet.
[4] The Motor Vehicle – Newton & Steeds.
[5] Automobile Transmission – P.M.Held.
[6] Automobile engineering vol I – Dr.kirpal singh – standard publishers – 10th edition 2007.

