

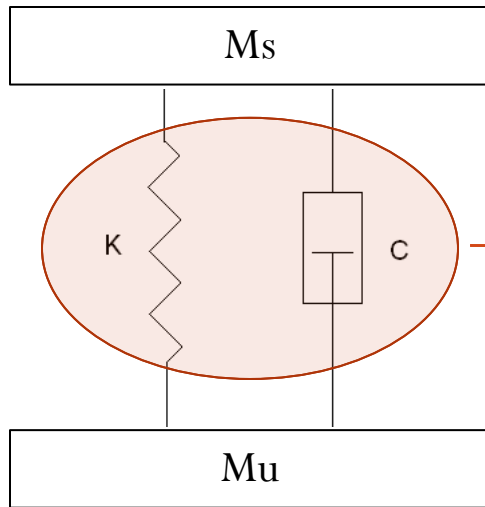
Vehicle Dynamics

Lesson n.4:
Suspensions

Outline

- General introduction:
 - Kinematics parameters
 - Types of automotive suspensions
- Independent suspensions:
 - Double Wishbone (SLA)
 - Multilink
 - MacPherson
- Anti-squat and Anti-dive
- Roll center

Suspensions functions



- Mechanism

- Spring

- Damper

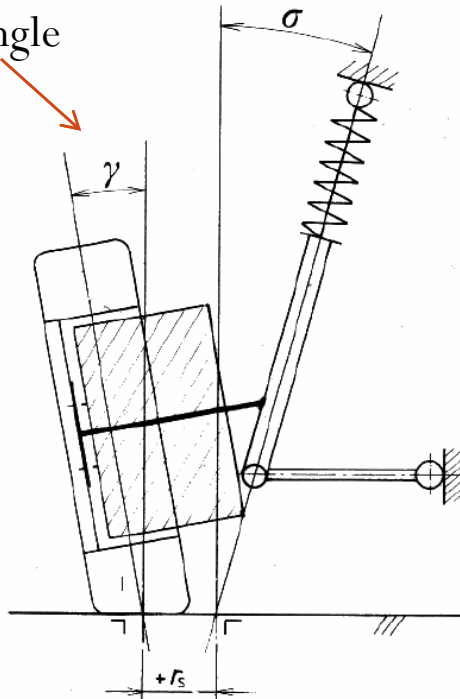
1. Isolate of M_s from M_u (comfort)
2. Transfer (react to) control forces
3. Limit roll motion
4. Limit load transfer
5. Control wheel motion (proper ranges for kinematic parameters)

- Camber angle (campanatura);
- Scrub (spazzolamento);
- Kingpin axis (sterzata) and Caster angle (incidenza del montante);
- Toe angle (convergenza);
- Roll center

Camber angle

Front view

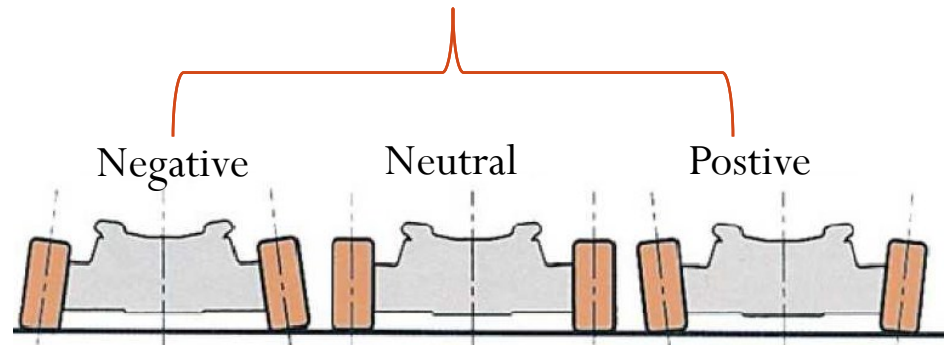
Camber angle



Static

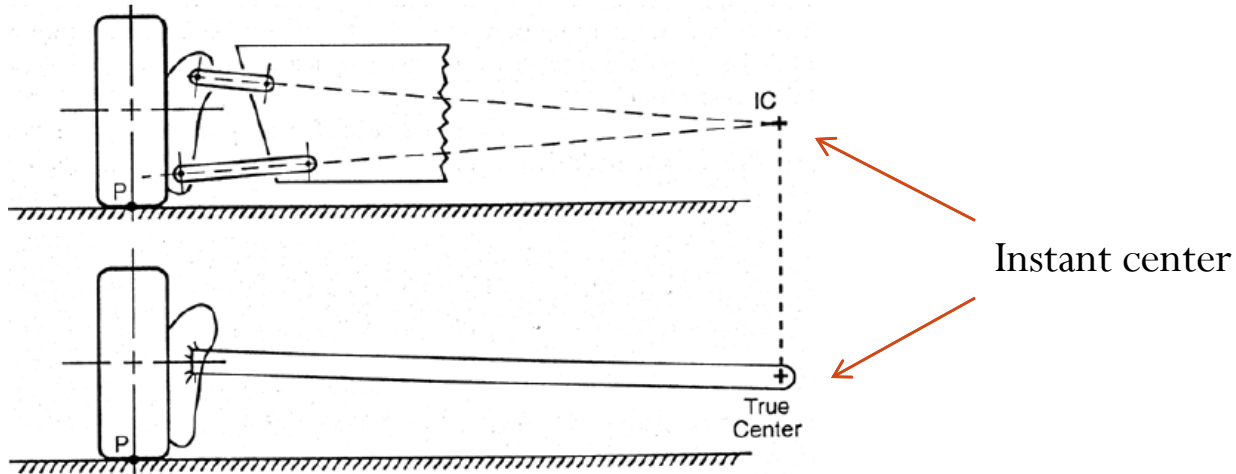
Dynamic

Camber



Aim: to maximize the contact area

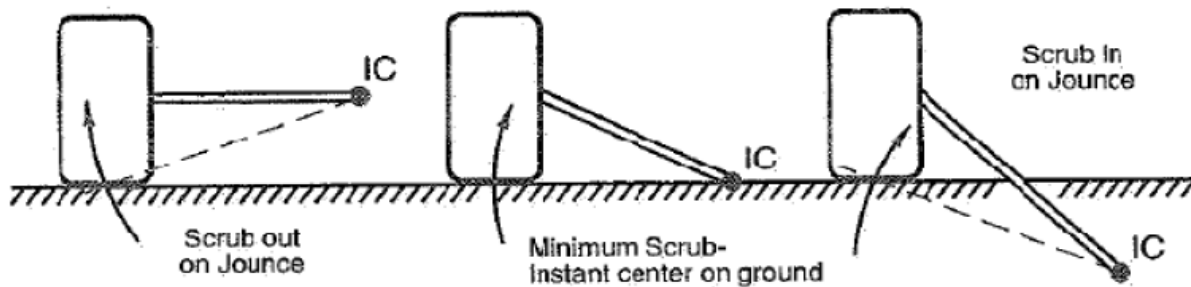
Scrub



External scrub

No scrub

Internal scrub

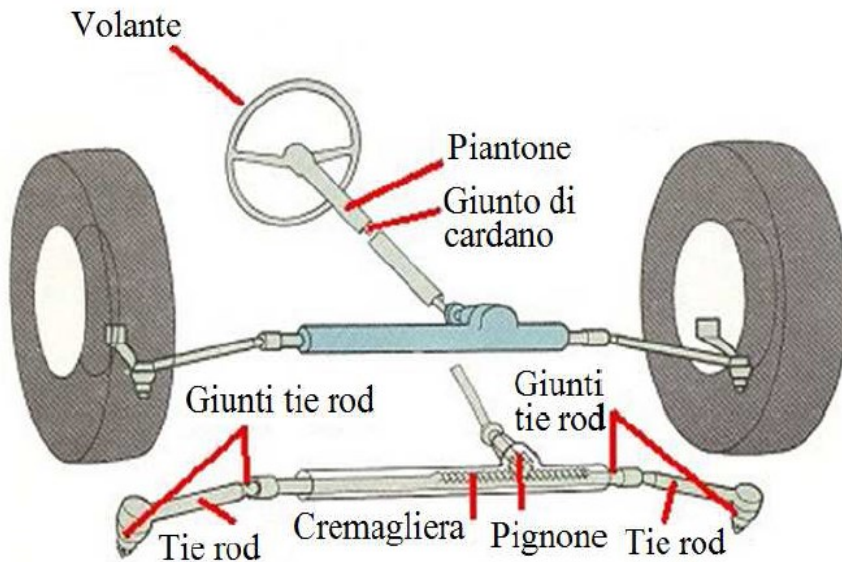


Note

- Track variation
- Unwanted lateral dynamics

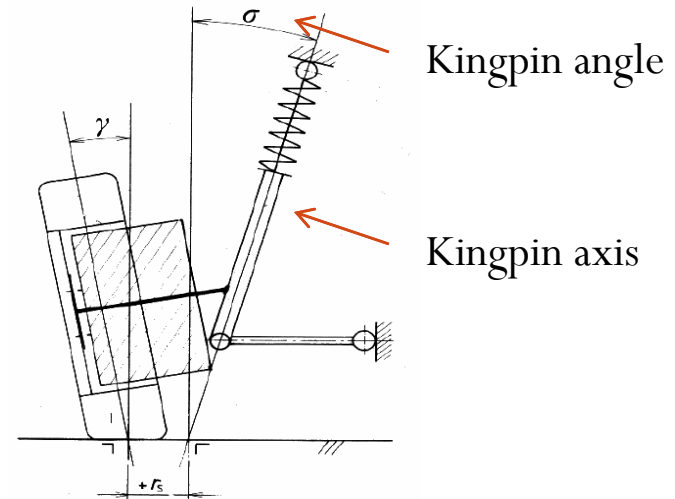
Kingpin axis and angle (sterzo)

Steering system

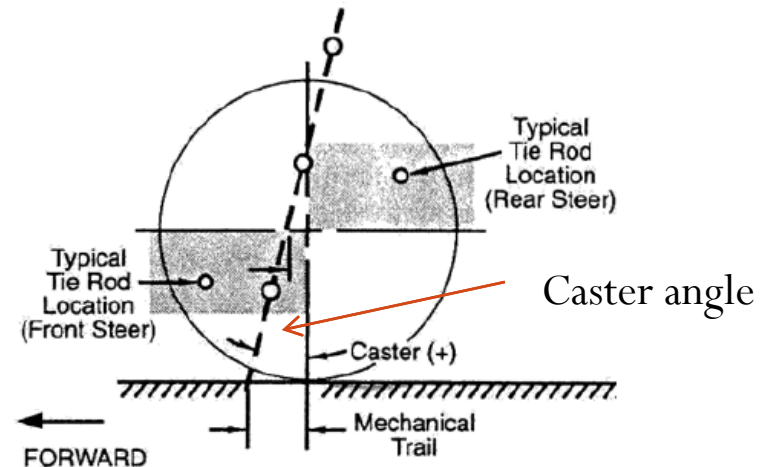


Impact on camber variation due to wheel steering

Front view

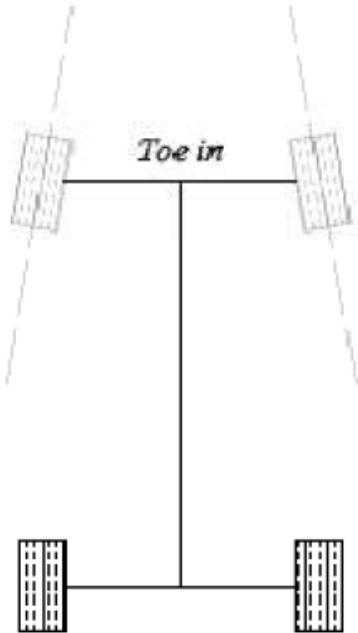


Lateral view

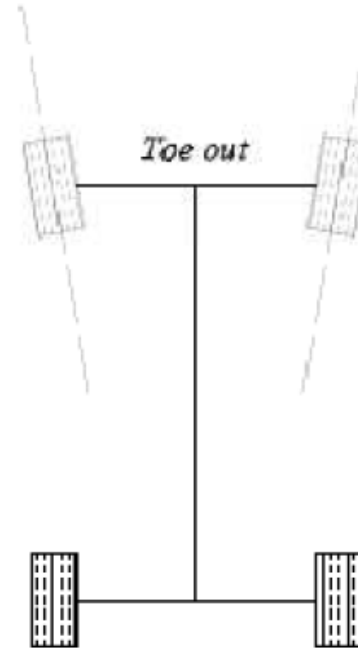


Toe angle (convergenza)

Toe In



Toe out



Impact on lateral slip

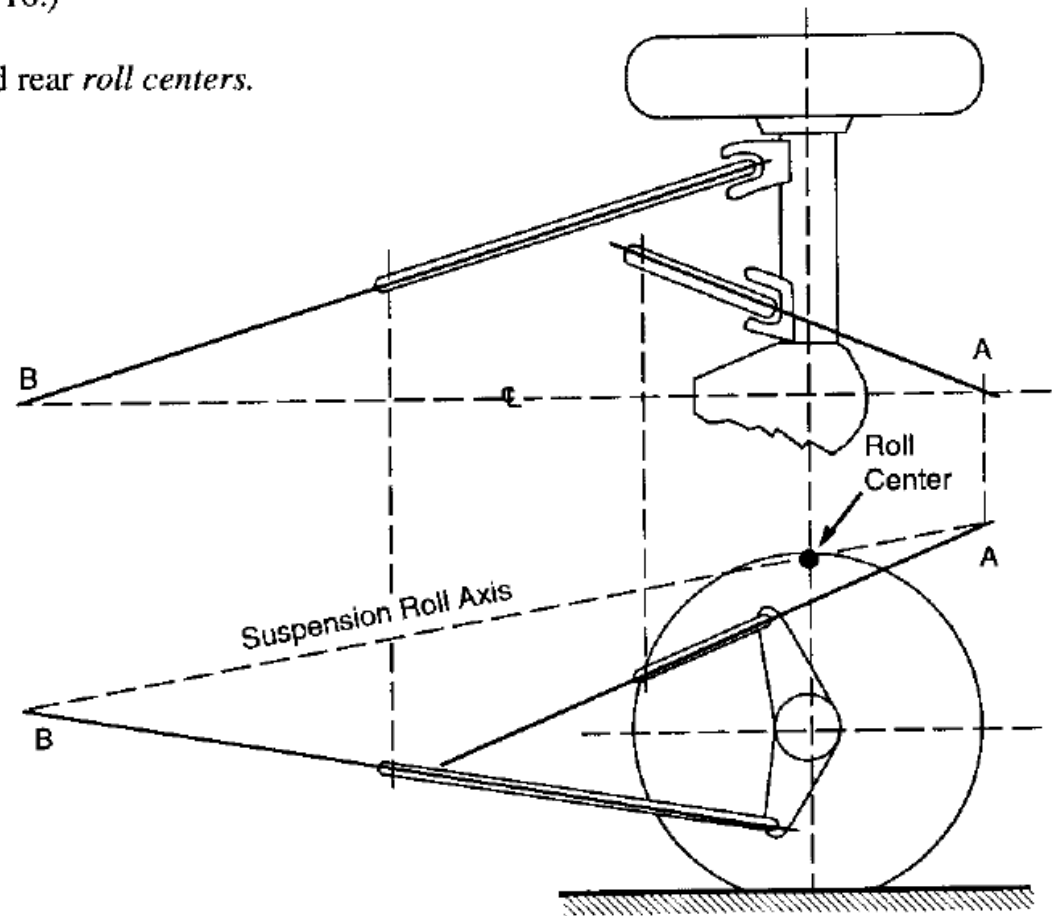


Lateral dynamics and cornering

Roll center

9.4.28 ROLL CENTER — The point in the transverse vertical plane through any pair of *wheel centers* at which lateral forces may be applied to the *sprung mass* without producing *suspension roll*. (See Note 16.)

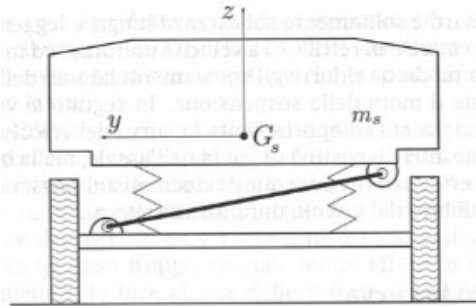
9.4.29 ROLL AXIS — The line joining the front and rear *roll centers*.



16. The *roll center* defined in 9.4.28 constitutes an idealized concept and does not necessarily represent a true instantaneous center of rotation of the sprung mass.

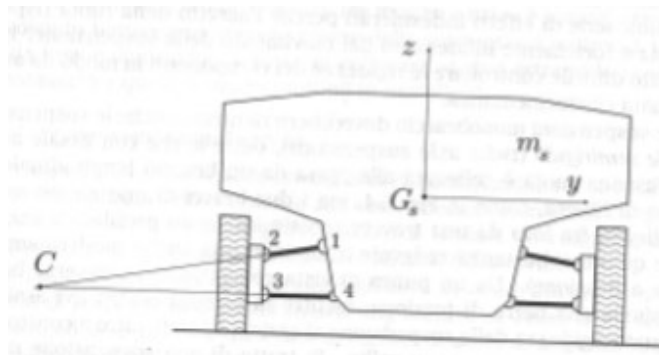
Types of automotive suspensions

1. Solid axle suspensions



- Solid axles
- 2 dof mechanism
- Ease of manufacturing

2. Independent suspensions: 1 dof mechanism per wheel

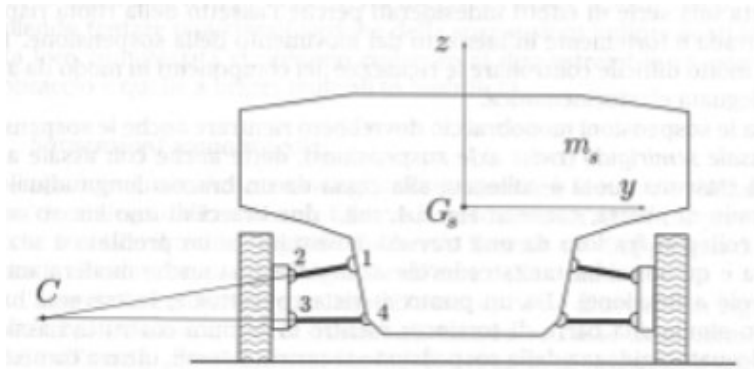


- Huger space to host the engine
- Mu limited
- Higher roll stiffness
- Independent motion for the wheels

Example of 4-bar linkage suspension

4-bar or Double Wishbone suspensions(SLA)

Kinematic schematic



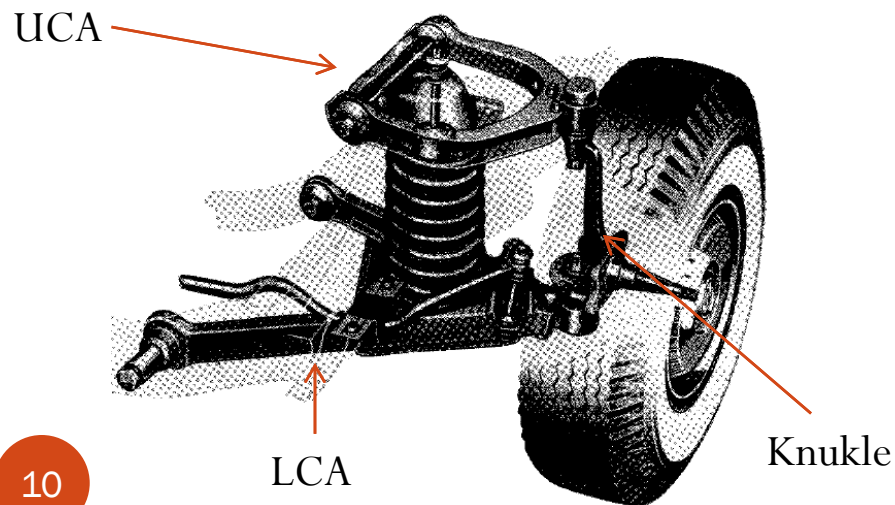
PROs:

- Low weight
- Flexible design
- Low aerodynamic drag

CONTRAs:

- Camber worsening for the inner wheel (SLA)

Possible solution: A-arms

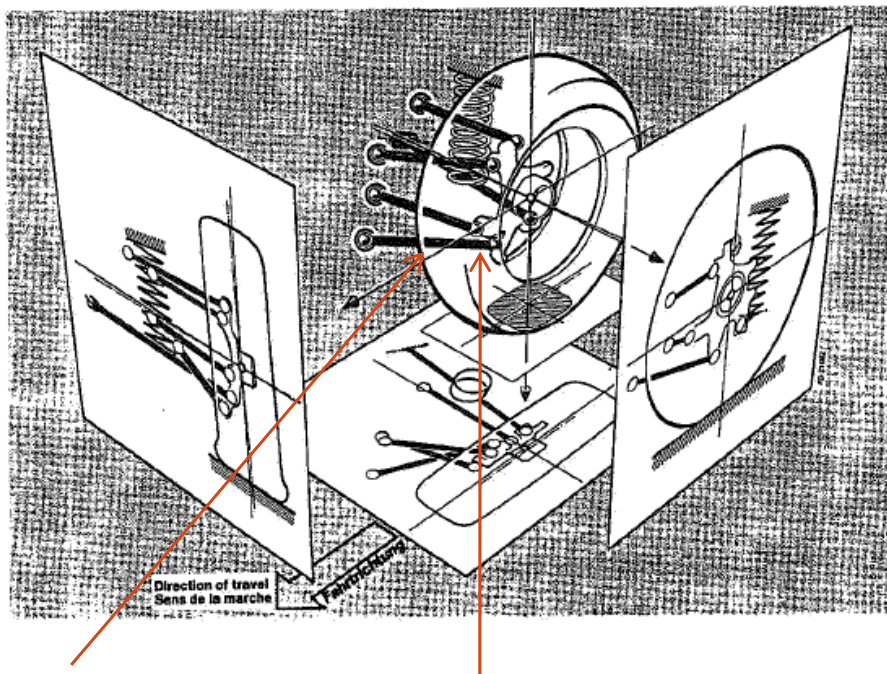


Application:

- Front suspensions for vehicles with rear traction (longitudinal engine)

Sospensione multi-link

Possibile schema della sospensione



Braccetti della
sospensione
(tipicamente 5)

Cerniere sferiche

Calcoliamo i g.d.l.!

Vantaggi:

- Flessibilità di progettazione
- Catena cinematica veramente 3D

Svantaggi:

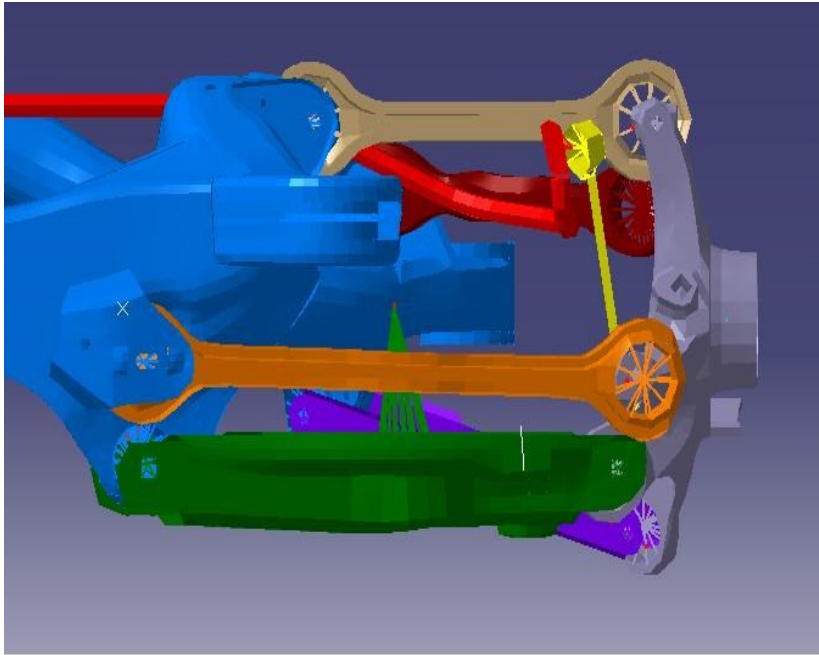
- Messa a punto difficoltosa (molti parametri)

Applicazione:

- Sospensioni posteriori



Multi-link suspension



PROs:

- Flexible design
- 3D kinematic chain

CONTRAs:

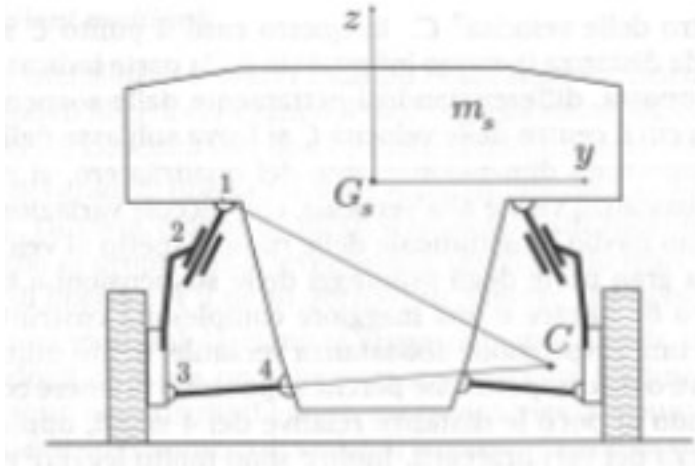
- Difficult development

Application:

- Rear suspensions

MacPherson suspension

Kinematic scheme



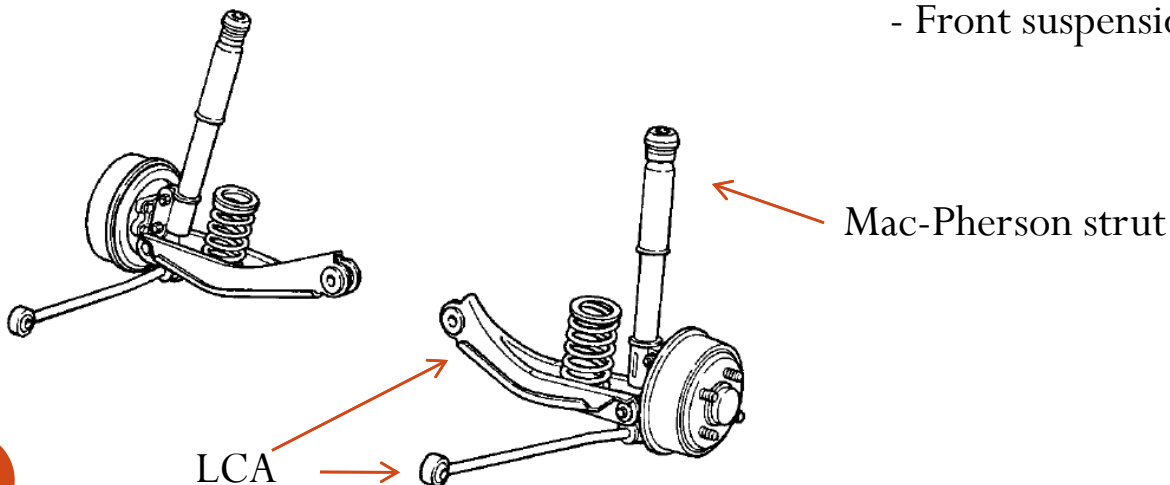
PROs:

- Wide room for engine and transmission
- Load distribution along a wide region
- Reduced number of components

CONTRAs:

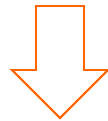
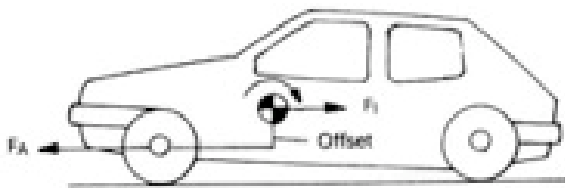
- Huge size in z -direction → height

Possible design



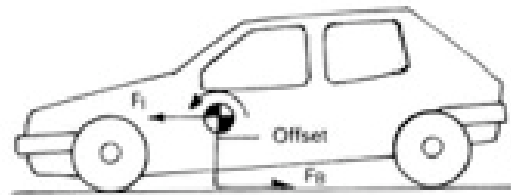
Anti-features

Acceleration



- Anti-squat
- Anti-lift
- Anti-pitch

Braking



- Anti-dive
- Anti-lift