Vehicle dynamics

Lesson n.1:

Fundamentals

Outline

- Introduction
- Vehicle dynamics in general
- Lumped parameter modelling
- Reference frames
- Fundamentals of rigid-body dynamics

Introduction

VEHiCLE DYNAMICS

Naval

Aerospace

Rail

Road vehicles

Tires → control forces at road-tire interface patches

Scope of the course

Core components and simulation (predictive) models

Longitudinal dynamics

- Acceleration
- Braking

Vertical dynamics

- Ride (f < 50 Hz)
- Noise (50 Hz < f < 20 kHz)

Lateral dynamics

-Handling
-Manoeuvring

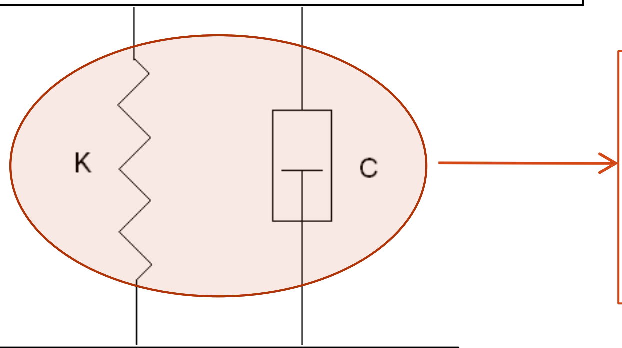
-Reference frames
-Suspensions
-Tire-road contact

Lumped parameter modelling

Sprung mass

Ms
(Engine, body, passengers, compartment)

Suspensions



-Mechanism
-Elastic element (spring)
-Viscous element (damper or shock absorber)

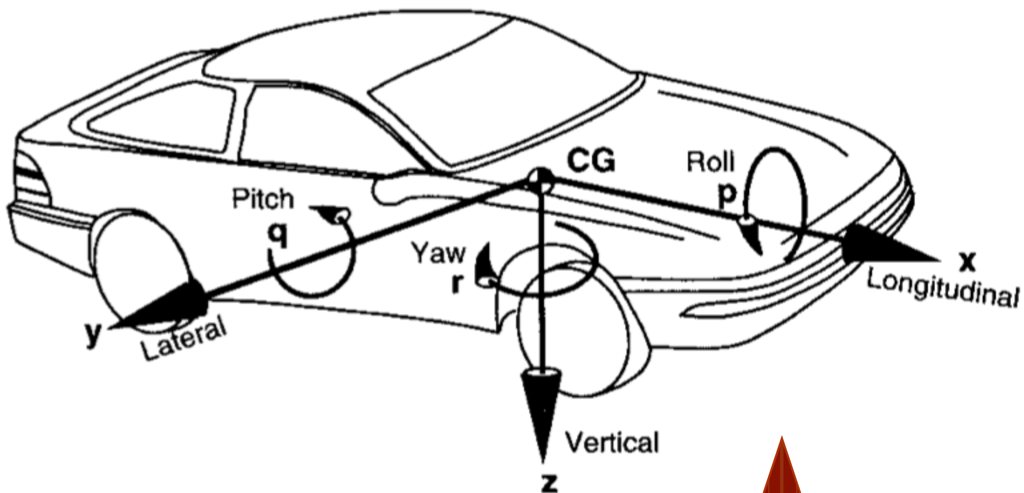
Unsprung mass

Mu
(Wheels, Braking, …)

1. Control forces transfer from tire-road contact patches to vehicle body
2. Comfort for passengers and goods

Vehicle reference frame

SAE Vehicle axis system



- CG Centre of Gravity
- x-axis: longitudinal, forward
- y-axis: lateral, pointing to the left
- z-axis: vertical, aligned with **g**

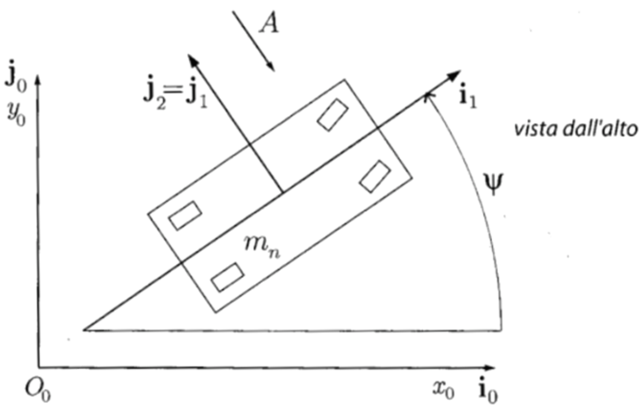
Generalized coordinates:

- displacement along x
- displacement along y
- displacement along z
- Rotation p around x-axis
- Rotation q around y-axis
- Rotation z around z-axis

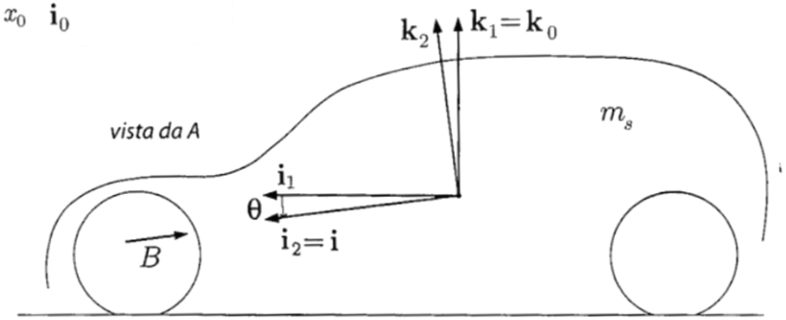
- Roll (moto di rollio)
- Pitch (moto di beccheggio)
- Yaw (moto di imbardata)

Earth-fixed axis system

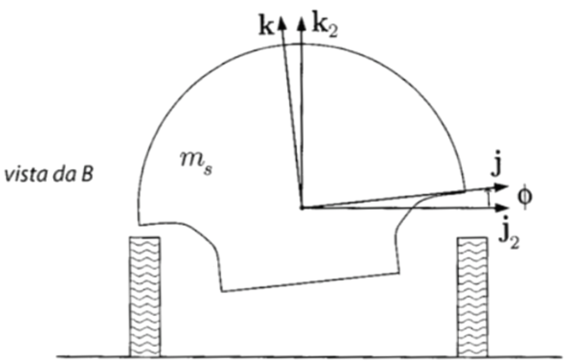
SAE Earth-fixed axis system



- x0-axis: forward direction
- y0-axis: lateral direction
- z0-axis: vertical direction, aligned with -**g**



- Yaw
- Pitch
- Roll



Rigid-body dynamics

D'Alembert's Principles:

$$\sum F_X = M \cdot a_X$$

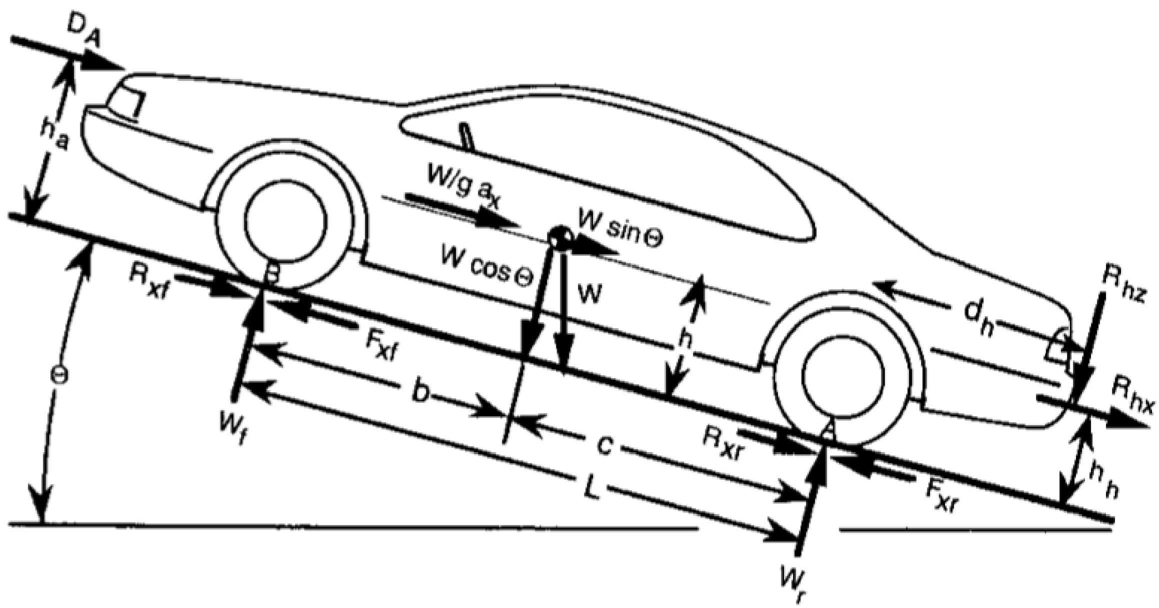
(1-directional motion)

$$\sum T_X = I_{XX} \cdot \alpha_X$$

(Planar motion)

Application example:

Hp: steady-state conditions (no pitching)



Let's compute

W_f e W_r to understand the following:

- How the static load is distributed between front and rear axle (W_{fS} e W_{rS})
- How the road grade affects the load transfer
- How the acceleration affects the load transfer