

# BMA4723 VEHICLE DYNAMICS

## Ch1 Introduction of Vehicle Dynamics

by

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# Chapter Description

- Aims
  - Explain the definition of the vehicle
  - Explain the six degree of freedom of the four wheel vehicle
- Expected Outcomes
  - Students are able to define the track and untrack vehicle
  - Students are able to sketch the free body diagram of the vehicle
- References
  - M.Abe, Vehicle Handling Dynamics Theory and Application, Second Edition, Published by Elsevier Ltd, 2015
  - Thomas D.Gillespie, Fundamental of Vehicle Dynamics, Published by Society of Automotive Engineers

# Outlines

- 1.1 Definition of the Ground Vehicle
- 1.2 Four-wheel vehicle model
- 1.3 Basic Concept of Vehicle Control

# 1.1 Definition of Ground Vehicle

- Ground vehicle can be divided into two categories:
  - i. Restricted by a track – train, tram
  - ii. Unrestricted by tracks – motorcycle, car, lorry, bus
- Each of the vehicle will have their own dynamics.
- The motion of the vehicle is based on vehicle dynamics.



Figure 1 Track Vehicle [Image](#)



Figure 2 Track Vehicle [Image](#)

## 1.2 Four-Wheel Vehicle Model

- In general, the vehicle mathematical model is used to analyse the dynamics of the vehicle.
- The basic vehicle mathematical model consists of four wheels (two at the front and two at the rear) and fitted to a rigid body.
- The front two wheels are connected to the steering and steerable.
- This mechanism can allow the vehicle to turn left and right.

## 1.2 Four-Wheel Vehicle Model

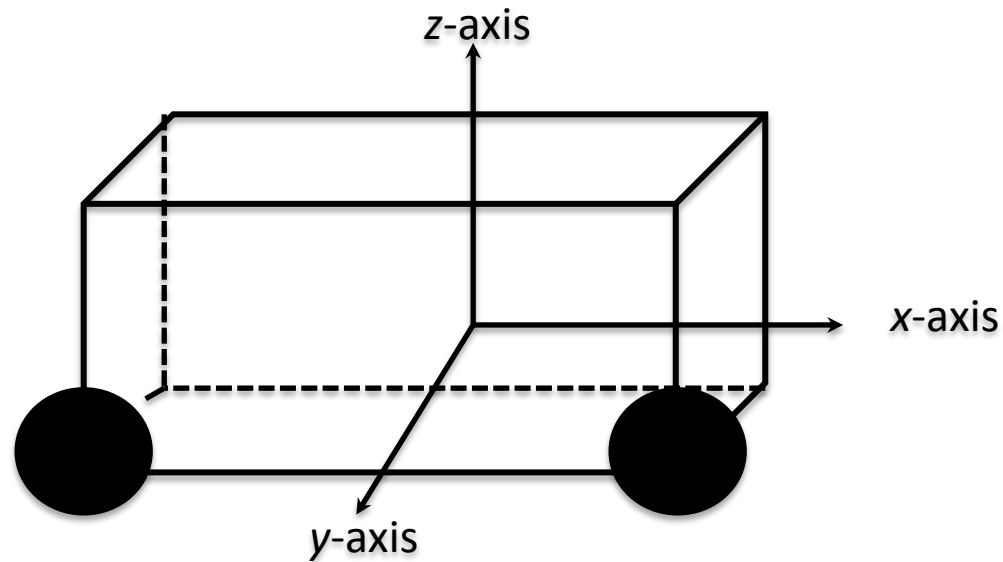


Figure 3 Mathematical Vehicle Model

## 1.2 Four-Wheel Vehicle Model

- From the vehicle model (Fig.3), the coordinate system is fixed to the vehicle and the origin at the vehicle's center of gravity.
- This vehicle model has three axes:
  - i.  $x$ -axis in the longitudinal direction,
  - ii.  $y$ -axis in the lateral direction, and
  - iii.  $z$ -axis in the vertical direction.

## 1.2 Four-Wheel Vehicle Model

- From this 3 axes, the vehicle motion has six independent degree of freedom:
  - Longitudinal motion** in the  $x$ -direction  
(forward/reverse)
  - Rolling motion** around the  $x$ -axis.
  - Lateral motion** in the  $y$ -direction  
(left/right)
  - Pitching motion** around the  $y$ -axis
  - Vertical motion** in the  $z$ -direction
  - Yawing motion** around the  $z$ -axis



## 1.2 Four-wheel Vehicle Model

- Based on the six degree of freedom of the vehicle, the motions can be divided into two main groups:
  - i. Motions generated **without direct relation to the steering** :
    - a) Longitudinal motion in the x-axis: straight-line motion and caused by the traction or braking force
    - b) Pitching motion around the y-axis: caused by the road surface, acceleration or braking. This motion is related to the vehicle ride
    - c) Vertical motion in the z-axis: caused by the road surface (smooth, bumpy, uneven surface). This motion is related to the vehicle ride and comfort.

## 1.2 Four-wheel Vehicle Model

- ii. Motions generated **with direct relation to the steering:**
  - a) Lateral motion in the  $y$ -axis: caused by the steering when driver turn the steering to the left or right
  - b) Rolling motion around the  $x$ -axis: caused by the lateral motion and yawing motion.

# 1.3 Basic Concept of Vehicle Motion from the Driver

- In general, the motions of the vehicle are controlled by the driver.
- The driver can give any input such as steer angle, acceleration and braking force.
- Fig.4 shows the block diagram of the input, which is driver and the response, which is the motion of the vehicle.

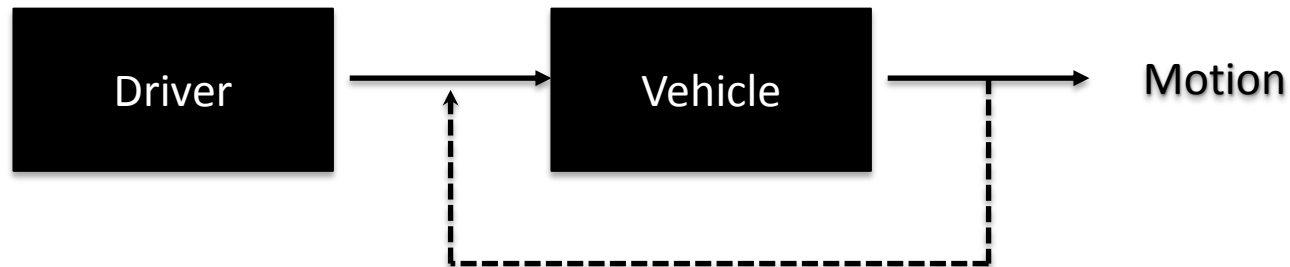


Figure 4 Basic Vehicle motion from the driver

# 1.3 Basic Concept of Vehicle Motion from the Driver

- The driver continuously looking at the front, rear and side path and will make the suitable action.
- For example; the driver will push the pedal brake if the traffic light change from green to yellow. If the vehicle still accelerate, the driver will push the pedal brake more harder until the vehicle stop.
- It is very important for the driver to concentrate during driving on the road.
- Accident can be occurred due to the late response from the driver.

# Conclusion of The Chapter 1

- Conclusion #1
  - The ground vehicle can be divided into two categories: restricted by a track and unrestricted by tracks.
- Conclusion #2
  - The mathematical model is used to analyse the dynamics motion of the vehicle
  - From the mathematical model, the vehicle has six degree of freedom (longitudinal, lateral, vertical, yawing, rolling and pitching)
- Conclusio #3
  - The motions of the vehicle mostly are controlled by the driver
  - The driver will give the input such as steer angle, braking and acceleration

# Vehicle Dynamics

## Chapter 1

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