Vehicle Actuation

Course 1, Module 4, Lesson 6
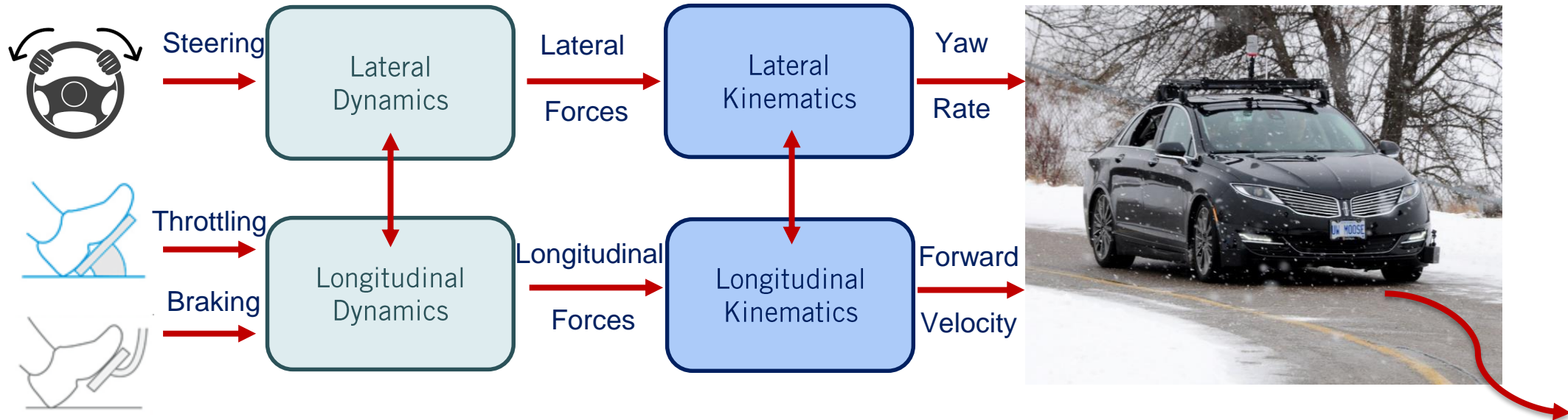
Learning Objectives

- Build models for the main vehicle actuation systems such as steering, throttling, and braking

- Connect these models to longitudinal and lateral vehicle dynamic models
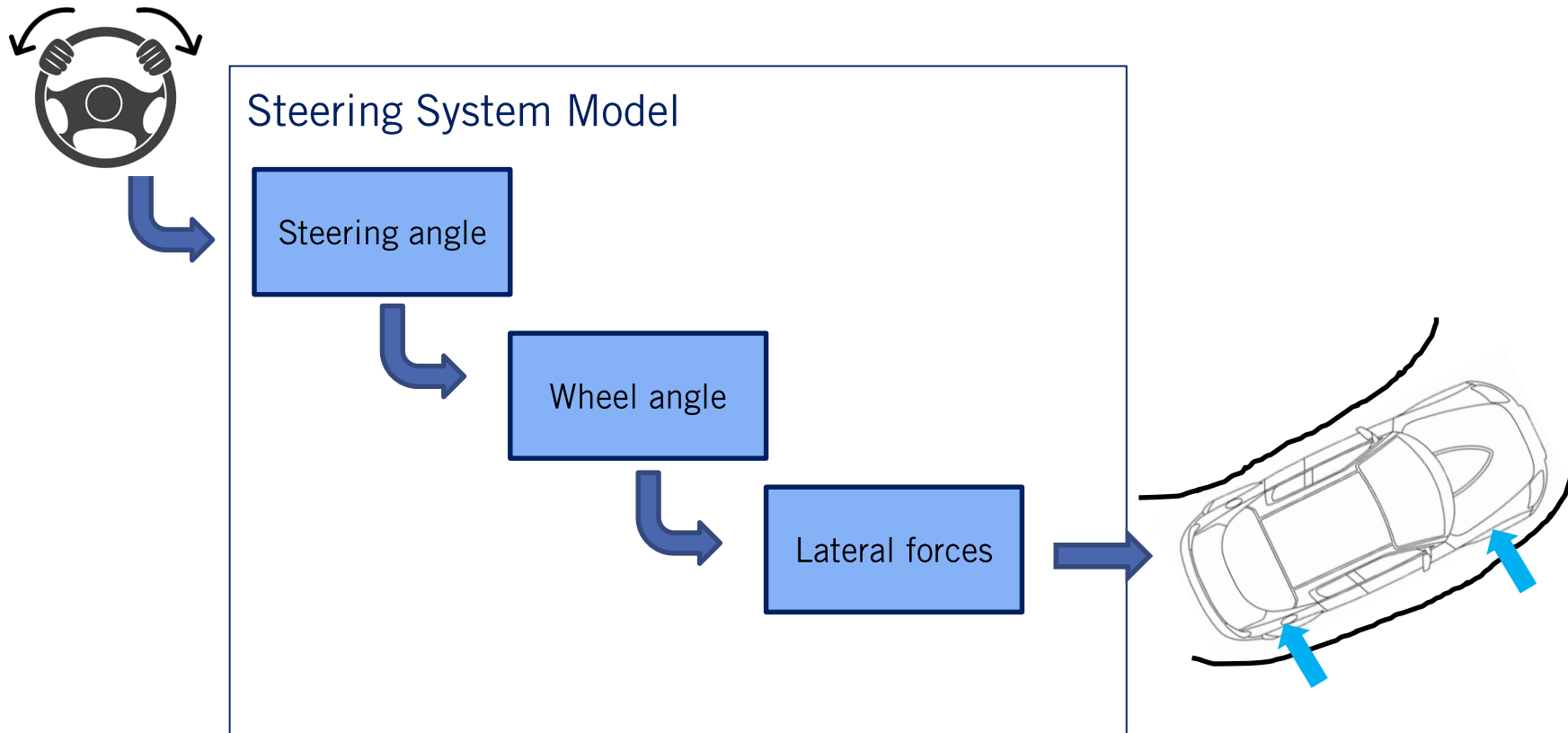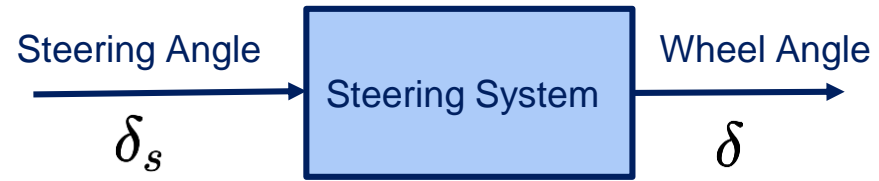
Coupled Lateral & Longitudinal

Main Control Task:
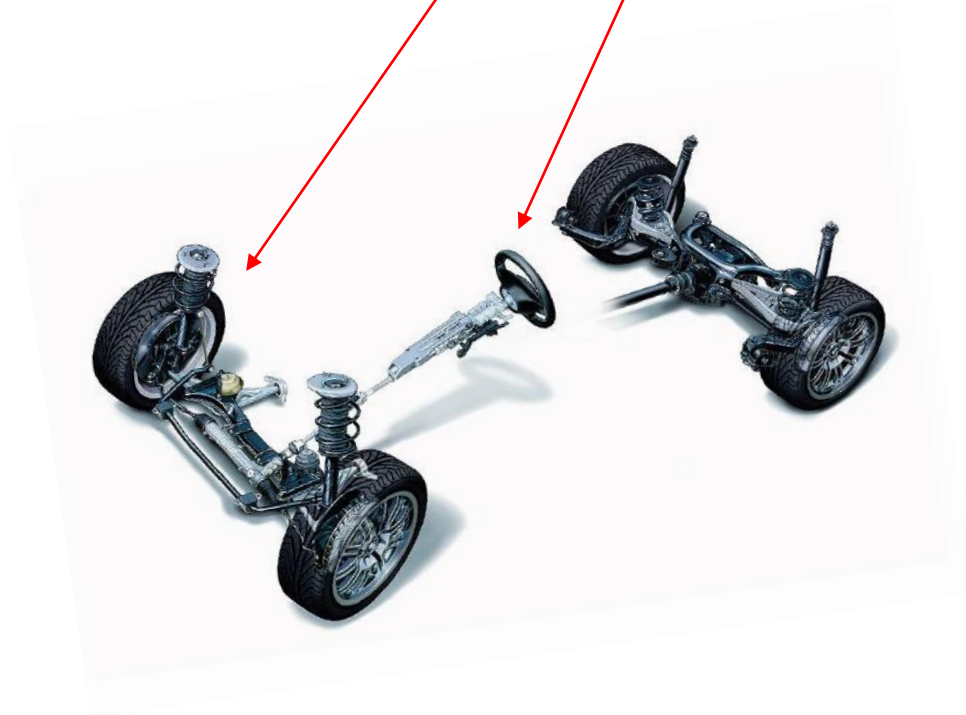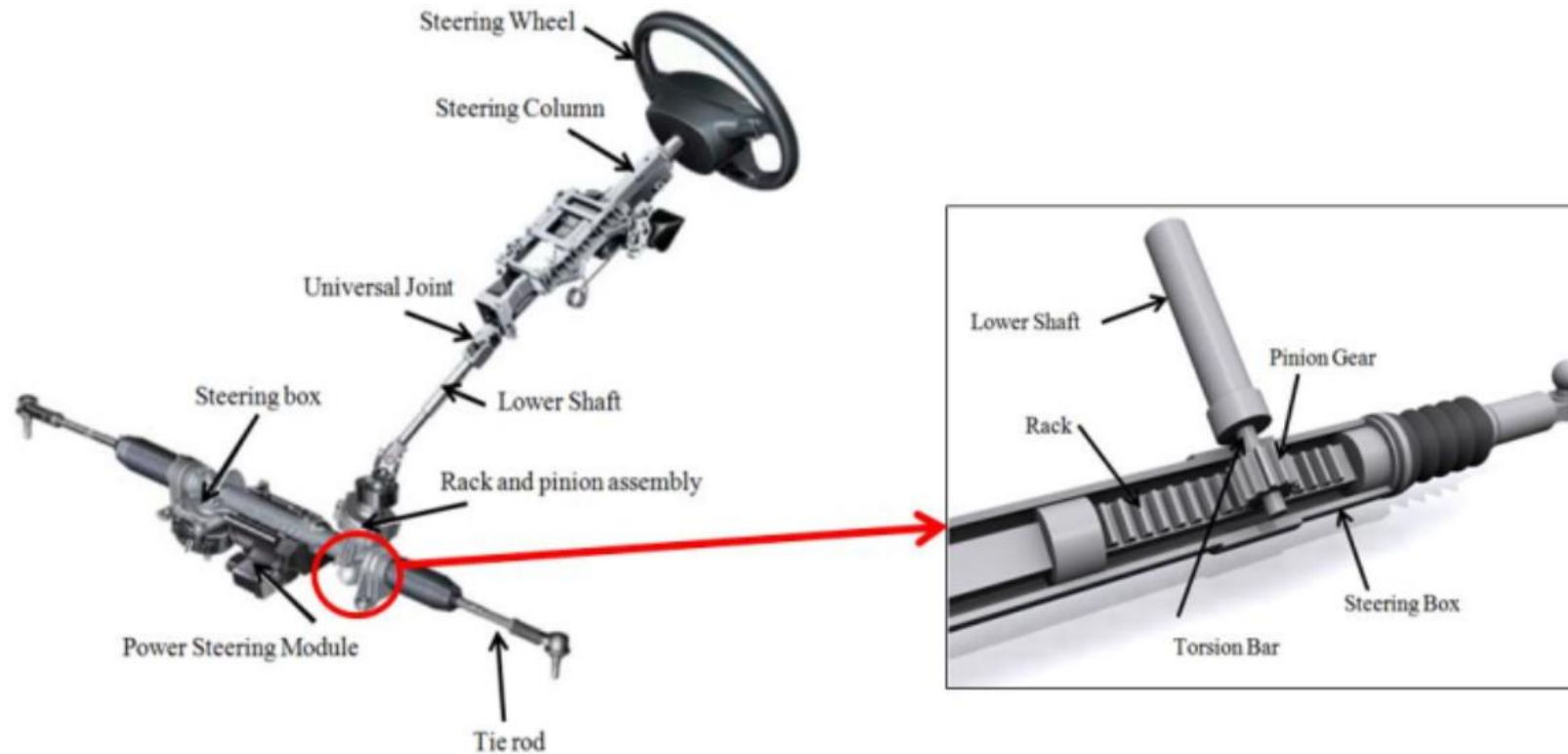To keep the vehicle on the defined path at the desired velocity

Steering

Steering System Model

Steering angle

Wheel angle

Lateral forces

Simple Steering Model

Steering Angle → Steering System → Wheel Angle

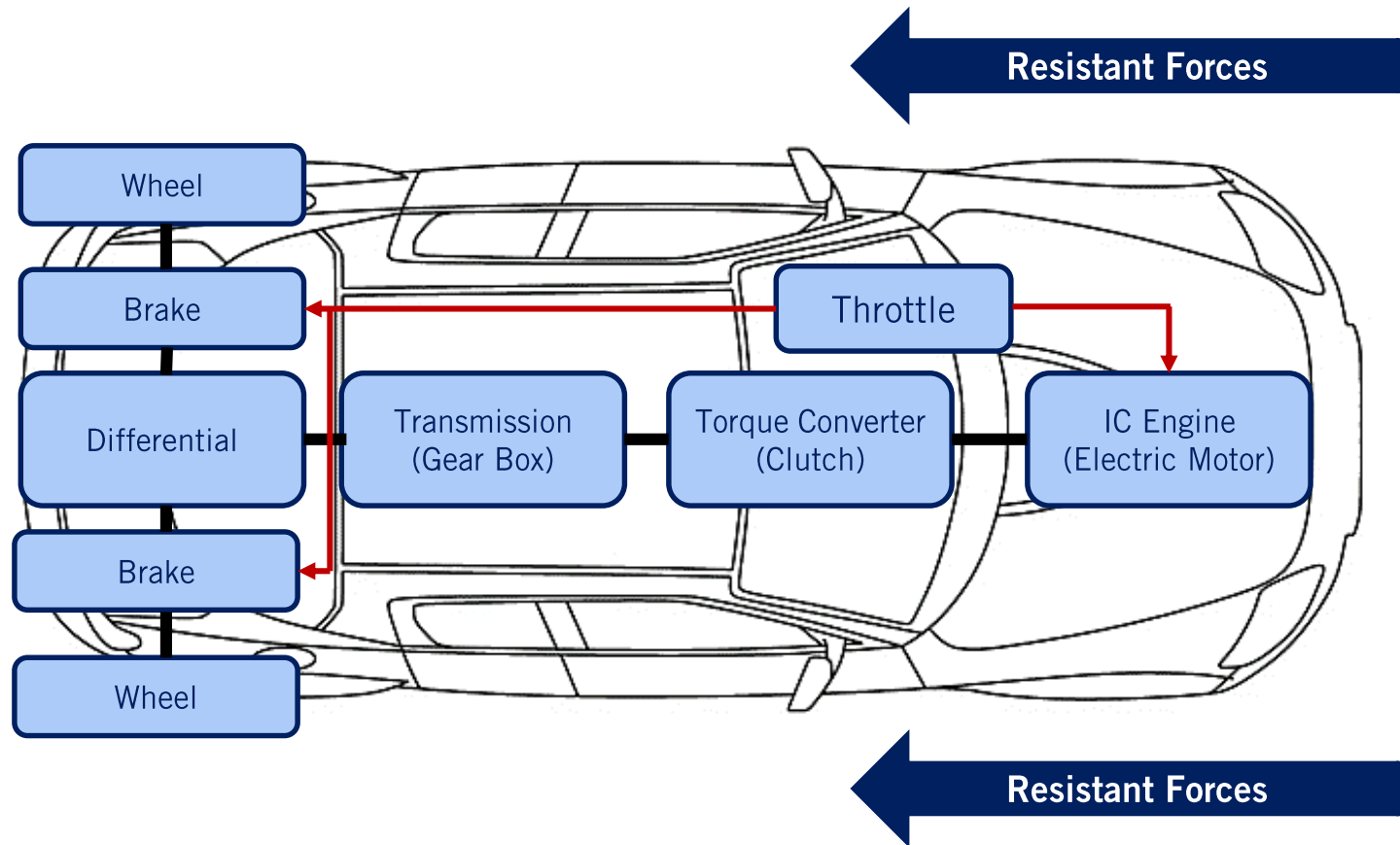δ_s

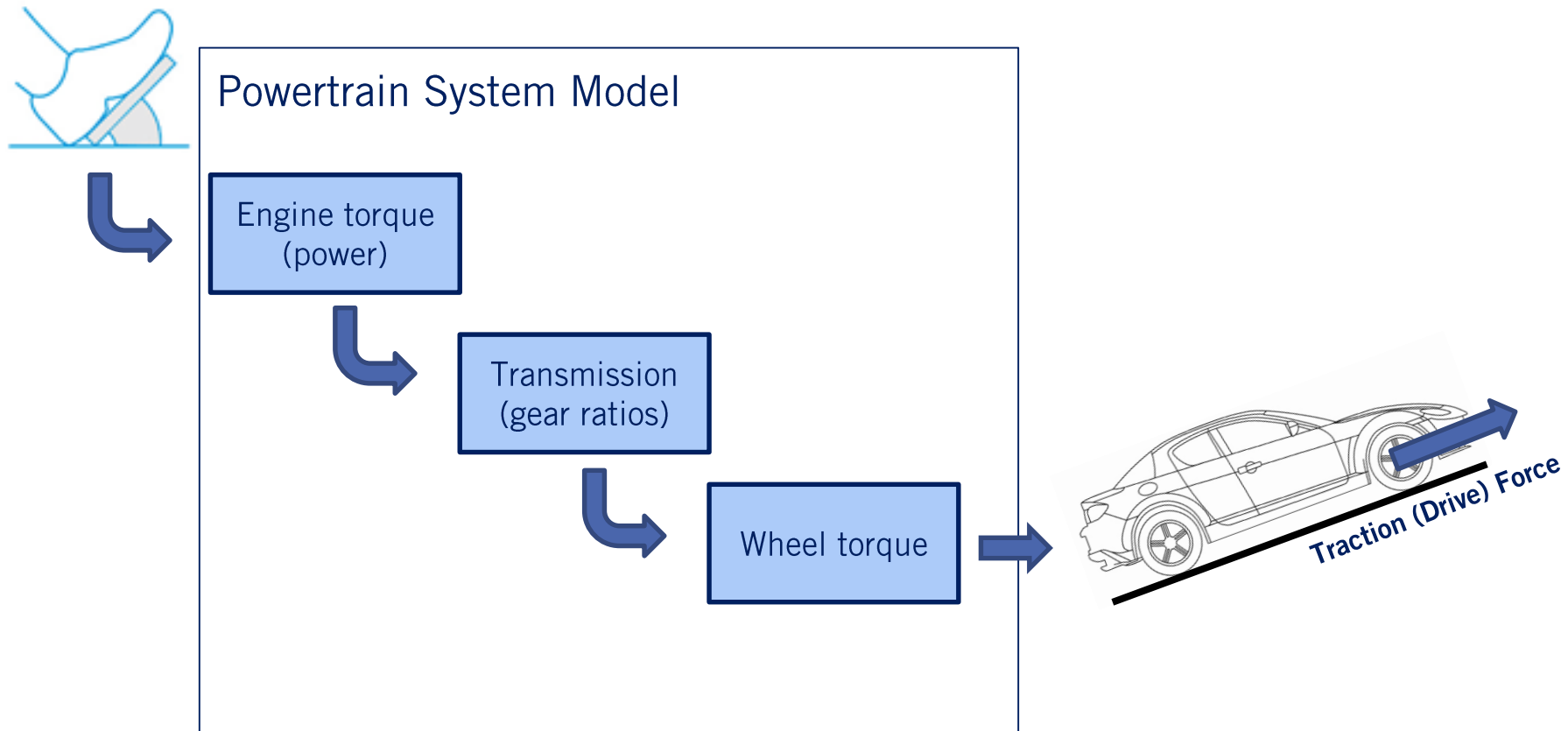δ

$$\delta = c\delta_s$$

Actual Steering System

Powertrain System (Driveline)

- Throttle and brake commands affect torque balance

Throttling (Accelerating)

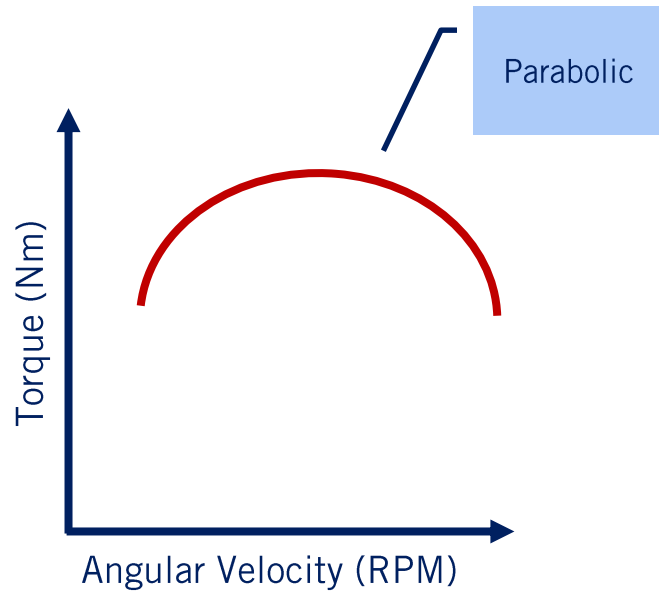Powertrain System Model

Engine torque (power)

Transmission (gear ratios)

Wheel torque

Traction (Drive) Force

Accelerating Model

x_θ → Power Unit (Engine) → ω_e, T_e

Accelerator pedal position (Throttle)
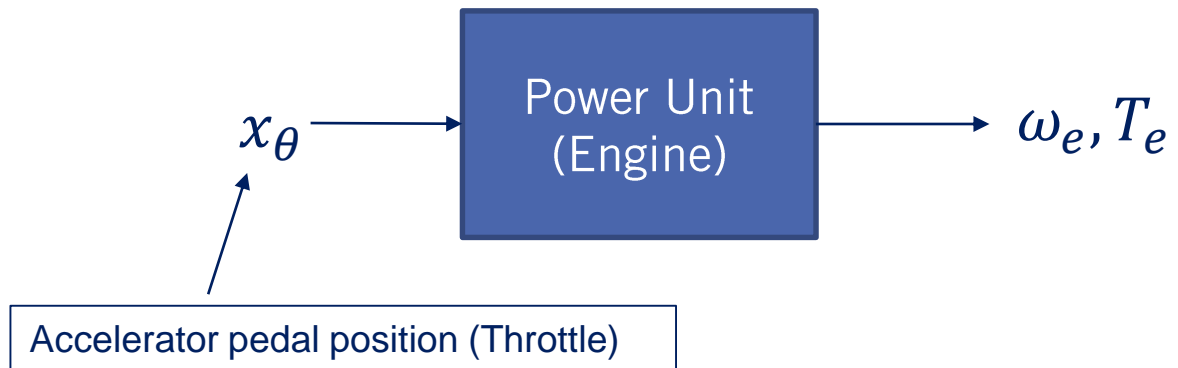
Characteristics Plots

Gasoline Engines

Torque (Nm)

Angular Velocity (RPM)

Parabolic

Diesel Engines

Torque (Nm)

Angular Velocity (RPM)

Constant Torque

Electric Motors

Torque (Nm)

Angular Velocity (RPM)

Constant Torque

Constant Power
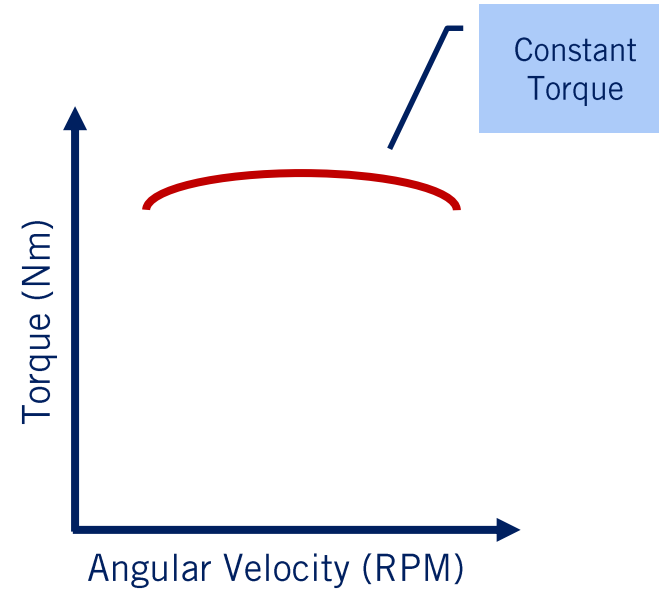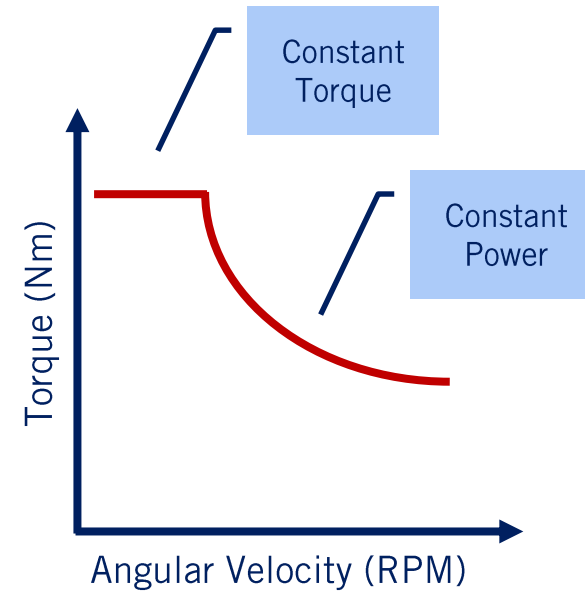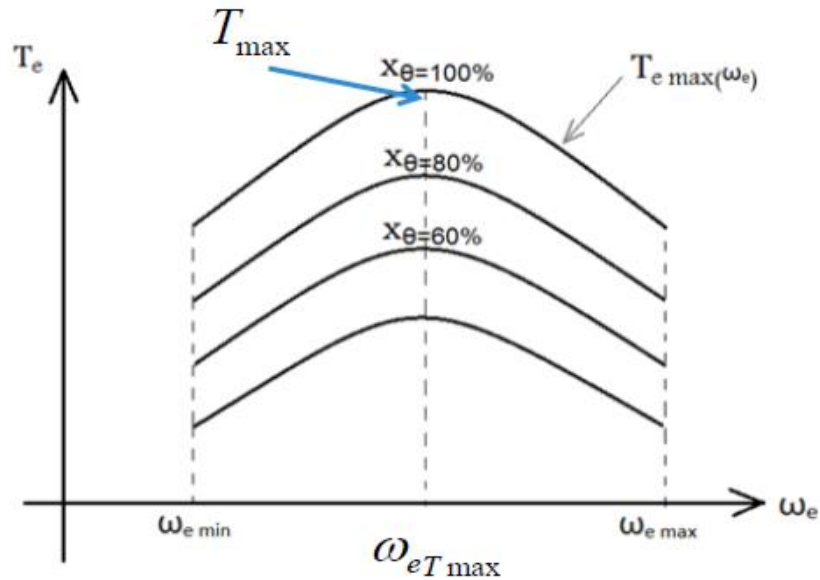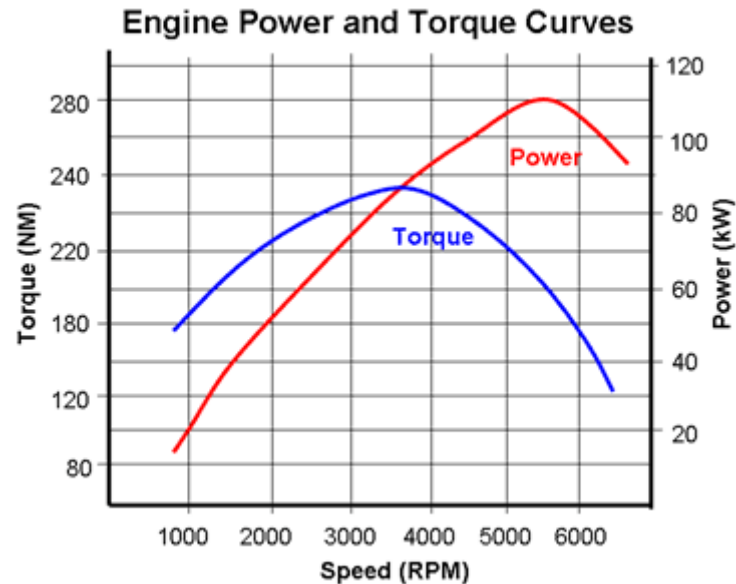
Typical Torque Curves for Gasoline Engines
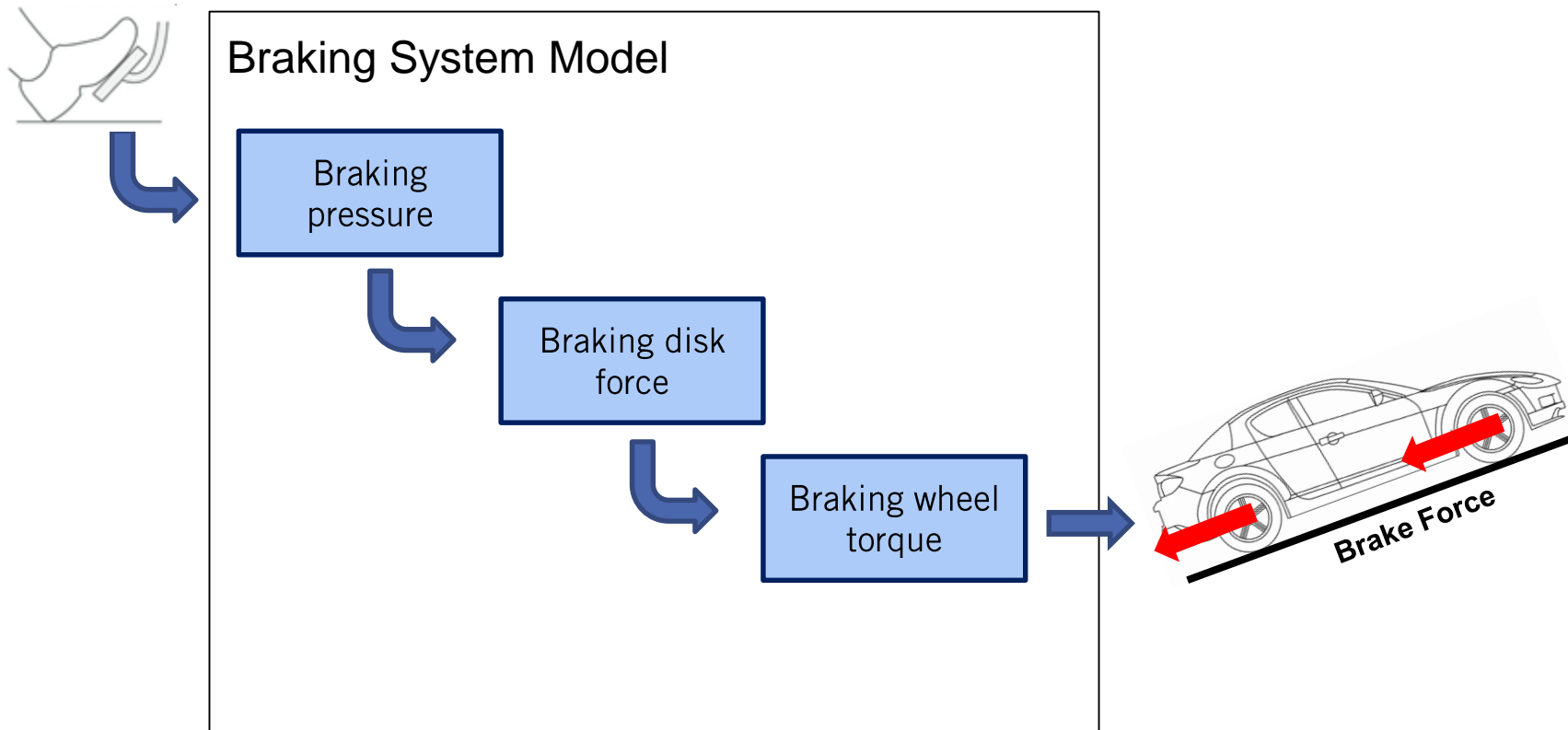

$$T_{e_{max}}(\omega_e) = A_0 + A_1\omega_e + A_2\omega_e^2$$

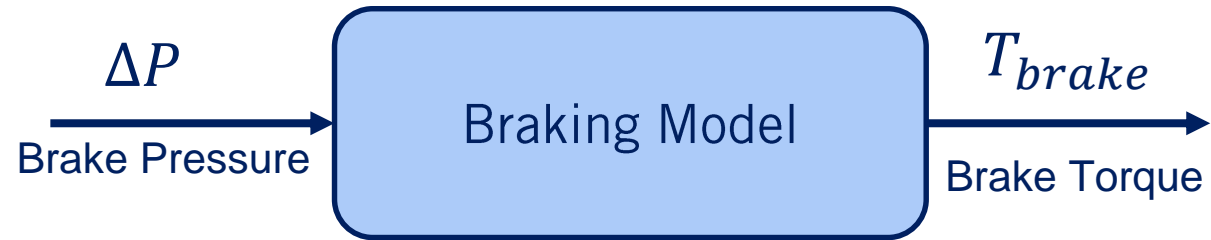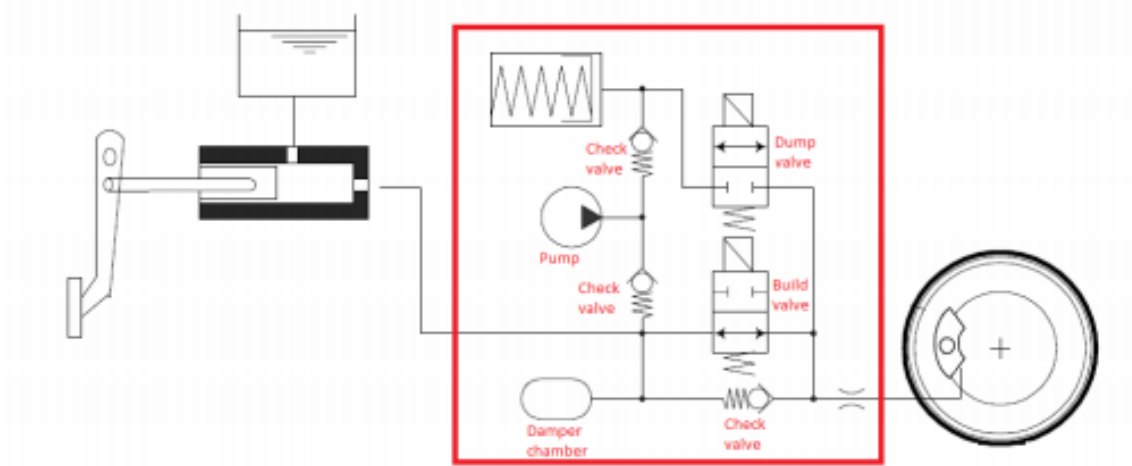$$T_e(\omega_e, x_\theta) \approx x_\theta(A_0 + A_1\omega_e + A_2\omega_e^2)$$
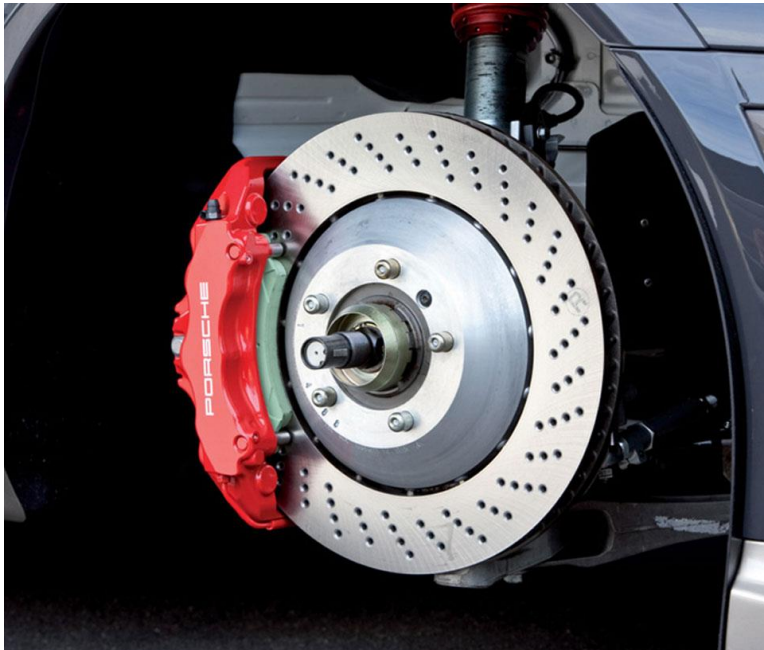
Throttle position (percentage)

Braking (Decelerating)

Braking Model

$$T_{brake} = k \, \Delta P$$

Braking System

- Basic functionality of braking includes:
  - Shorten stopping distance
  - Steerability during braking through ABS systems
  - Stability during braking to avoid overturning

Summary

What we have learned from this lesson:
- The workings of the vehicle actuation systems such as steering, power generation, and braking
- How to convert steering, throttle and brake inputs to wheel angles and torques

What is next?
- Tire modeling, connecting the car to the road