Vehicle System dynamics

Subject Title: Vehicle System dynamics  
Subject Code: ME 6019  
Credits / hours: 2-3 credits / 36 academic hours  
Semester: Fall  
Major: Vehicle engineering, Mechanical engineering  
Pre-requisite courses: Advanced Mathematics, College Physics, Theoretical mechanics, Mechanical Design, Elementary Control Theory, Mechanical Vibration.  
Following courses: Null  
School: School of Mechanical Engineering

Course Description:  
Vehicle System Dynamics is one of core subjects in Mechanical Engineering in abroad universities. Although road vehicles can be classified as various types based on different purposes, such as the single vehicle, sedan, passenger car, truck and special purpose vehicle, it is the rubber single-tyre, single axle, four-wheel vehicle that defines the study object of this course. Based on this case, the traction and brake, ride and handling dynamics theory, and theory and design of vehicle control system are presented so as to inform students of fundamental theory of vehicle dynamics, vehicle performance as well as related tests and regulations. It is also an important goal to instruct them to apply the dynamic modeling and analysis approach in vehicle design. The course of Automotive system dynamics can be treated as a core course for undergraduates majoring vehicle engineering and for students majoring mechanical engineering as a selected course.

Objectives:  
The focus of Automotive System Dynamics is to introduce the fundamentals of vehicle dynamics and the performance indices and evaluation criterions of vehicle, to analyze the influence of vehicle configuration and design parameters on vehicle performance, and to discuss the approach to predict vehicle performance and to simulate and analyze vehicle performance as well. Through teaching and specific experiments, it is intended to inform students of related terminology and regulations, to let them master principles, properties and requirements of vehicle design, and based on which, to apply theoretical knowledge in vehicle design. The objective of
this course is to cultivate students towards specialists in vehicle engineering domain, to develop their capacities of analysis, evaluation and design based on the education of modeling the dynamic equation and performance analysis. In addition, it is also to lay foundation for the following the doctoral program Advanced Vehicle Dynamics Control.

**Subject content:**

The fundamentals of vehicle dynamics are systematically introduced including traction and braking dynamics, ride and handling dynamics as well as related control system. The multi-body modeling approach and advanced control theory are applied to the simulations of vehicle dynamics and design of control system. The main contents including:

1. **Introduction:** brief history and development of the subject, desirable vehicle properties, vehicle design philosophy, terminology and legislation;
2. **Braking and Traction:** basic equation of motion, aerodynamic forces and moment, tyre rolling resistance, acceleration and gradability performances, braking performances and ABS design, introduction to TCS and ESP(VSC);
3. **Ride:** road surfaces, suspension components and tyre rid properties, vehicle ride models, human response to vibration, suspension control system design;
4. **Handling:** tyre properties, driver-vehicle close loop system, basic handling model, linear handling results, extensions to the basic handling model, introduction to 4WS;
5. **Computer Modeling and Analysis:** introduction and comparison of some purpose-designed simulation codes, multi-body system dynamics packages and toolkit; mainly focusing on Adams and Matlab/Simulink software;
6. **Vehicle control systems and the integration technique**

**Method of Assessment and Grading:**

1. **Assessment:** Course activities + Exam
   - Three course projects for modeling, simulation, and performance analysis and control system design (weighting 60%):
     1) ABS design based on a single wheel brake dynamics and using threshold or fuzzy logic control algorithm, (weighting 20%);
     2) An optimal (LQG) suspension design based on 2-dof single wheel stationary ride model, (weighting 20%);
     3) Comparison and analysis of handling response and stability based on a
bicycle model, (weighting 20%);

- Open-book exam: weighting 40%, 2 hours of examination time.

2. **Grading:**

   Course activities (weighting 60%) + Exam weighting 40%

**Reference:**