ME 540: Advanced IC Engine Systems & Modeling

Introduction:
This course develops competence in IC Engine Systems and Systems Modeling, and is oriented to graduate students who are interested in designing, testing, analyzing, or controlling next generation IC engine systems.

The course focuses on advanced SI and CI engine systems (though there will be some discussion of natural gas engines), as well as the principal aspects of IC engine modeling (thermodynamics and fluid mechanics of air path systems, in-cylinder processes, combustion and emissions, heat transfer, torque production and crankshaft dynamics), as well as the integration of these concepts into complete engine simulators. The course also provides practical experience with various engine modeling methods (zero-dimensional thermodynamic modeling, one-dimensional gas-dynamic modeling).

Course Goals:
- *To develop competence with the physical principles and equations describing the thermodynamics and gas dynamics of internal combustion engines;*
- *To design simple (zero-dimensional, crank-angle resolved) models predicting the thermodynamics of in-cylinder processes, combustion, heat transfer and torque output, and use such models to perform simulation, analysis and optimization;*
- *To develop knowledge in the basic mathematical framework of one-dimensional gas-dynamic models*
- *To develop competence in performance analysis, optimization and control of IC engines and in the use of models to accomplished the desired tasks.*
- *To introduce strategies for experimental analysis of advanced IC engine systems.*

Required Background:
- *Experience with programming in Matlab/Simulink is required, as the course will rely significantly on this tool to develop most of the models.*

Instructor: Greg Shaver, Professor, School of Mechanical Engineering gshaver@purdue.edu,
Office hours after regular lectures until 6pm, ME2004

Teaching Assistant: Dheeraj Gosala dgosala@purdue.edu
Office hours: Tuesdays 9 – 10:30am; Fridays 8:30 – 10 am, HLAB2067

Course Logistics:
Combination of lectures, labs, and special guest seminars. We have ME2004 reserved on MWF from 4:30 – 5:20pm, but will not always meet there. Watch your email!

References:

- *Course Text: Internal Combustion Engines – Applied Thermosciences, Ferguson & Kirkpatrick, 3rd Edition, Wiley*

Grading Policy:
Homework (4-5 assignments) – 40%;
Lab (4-5 assignments) – 40%
Academic Literature Review Paper & Presentation to Class – 20%.

- *All assignments will be posted on Blackboard;*

Course Content

1. Motivation – Reduced fuel consumption and cleaner environment in a period of significant worldwide growth in transportation
2. Introduction to the IC engine: characteristics, challenges and opportunities
3. Introduction to IC engine air path systems, description of components and classification of modeling methods.
4. Modeling engine crank-slider kinematics and dynamics; overview of engine friction models.
5. Air standard thermodynamic cycles for IC engines, and comparison with real cycles; Thermodynamic properties of working fluids (burned, unburned).
6. Modeling engine in-cylinder processes through mass and energy balance; simplified model of in-cylinder pressure for motored cycle.
7. Modeling combustion processes: definition of in-cylinder heat release, Wiebe functions. Single-zone thermodynamic models.
8. Overview of conventional and flexible valve actuation systems.
9. 1-D gas exchange modeling of engine - Mean-Value Engine Models, including turbo-machinery
10. Modeling the impact of valvetrain flexibility on engine gas exchange and in-cylinder processes
11. Modeling of fuel injection systems, and some basic concepts of control of fuel injection systems
12. Modeling combustion processes: multi-zone thermodynamic models.
13. Modeling combustion processes in SI engines: flame propagation models.
14. Overview of modeling approaches for predicting pollutant formation.
15. Introduction to commercial simulation tools (GT-Power)
16. Advanced-mode combustion: HCCI, PCCI, AFCI, RCCI, etc.
17. *Predicting the impact of biofuel blends on engine performance and combustion*

Course developed in collaboration with Professor Marcello Canova, Center for Automotive Research, The Ohio State University