Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Institute for Dynamic Systems and Control
IDSC
Institut für Dynamische Systeme und Regelungstechnik

151-0567-00 **Engine Systems** (Fall 2024)

Class Website

Class facts and contact data of the professor and the assistants can be found here:
`http://www.idsc.ethz.ch/education/lectures/engine-systems.html`

All teaching documents and exercise material, as well as a forum can be found on Moodle:
`https://moodle-app2.let.ethz.ch`

Description

Scope

- Introduction to state-of-the-art and future internal combustion engine systems and their electronic controls
- Physically based mathematical models for components and subsystems, i.e., mixture formation, load control, superchargers, emission formation
- Case studies on model-based control design for optimized fuel consumption and emissions
- Team project on a real engine test bench (design of an idle speed control system)

Goals

- Understanding of the working principles of modern Internal Combustion (IC) engines
- Ability to describe modern IC engines quantitatively with dynamic models
- Application of modern system optimization and control tools to real IC engines

Class Book

- The lecture is based on the textbook *Introduction to Modeling and Control of Internal Combustion Engine Systems , 2nd edition, 2010* by L. Guzzella and C. H. Onder

Requirements

- Knowledge of System Modeling, Control Systems I and II or similar courses, basic Matlab experience

Class Facts

Instructor	Prof. Dr. Chris Onder, `onder@idsc.mavt.ethz.ch`
Teaching Assistants	Marc Neumann, `mneumann@ethz.ch`, office: ML K 39
	Giona Fieni, `gfieni@ethz.ch`, office: ML K 39
Lecture	Monday, 08:15 to 10:00, ML F 38
Exercise	Monday, 12:15 to 13:00, ML H 41.1
Office hours	contact us to schedule a meeting

Exercise Assignments

There will be two different types of exercises:

Theory Sheets (individually)

You receive questions where the theory covered in the lecture has to be applied.

Practical Exercises (in groups)

1. **Intake Manifold Exercise:** An intake manifold is modeled in Matlab/Simulink. This model is used for a parameter identification using measurements on a real engine.
2. **Idle Speed Control Exercise:** A complete engine is to be modeled in Matlab/Simulink. This model is used for a parameter identification and to design a model-based idle-speed controller which will be applied on a real engine. There will be a competition at the end of the semester.

You will sign in for a group in the first exercise class. We recommend that at least two members of each team have experience in Matlab and Simulink. An introduction to the exercises will be given in the first exercise class.

There will be a number of test bench sessions for which each group gets a time slot to take their own measurements.

Exam

An oral exam (30 minutes) during the examination session, which covers all the material discussed in the lectures and in the exercises.

Grading

The grade is defined by the oral exam. Additionally, the **Idle Speed Control Exercise** contributes up to 0.25 grade points to the final grade, but only if it helps to improve the final grade.

Repetition

The final exam can be repeated in the summer session, but taking the course again is recommended.

Class Schedule

#	Date	Topic in the Lecture (8:15-10:00)	Reading	Exercises (12:15-13:00)
L0	Sep 19	Introductory Lecture: Internal Combustion Engines (Optional, Wednesday)	-	-
L1	Sep 23	Introduction, Goals, Administration, Examples, Wrap-up Operating Principles of IC Engines	1-1.2 Appendix C	**Intake Manifold (IM):** Introduction to Modelling and Implementation. **Theory Sheet (TS):** Hand out #1.
L2	Sep 30	Models I: Causality Diagrams, Air Path	1.3-2.0	**IM:** Parameter Identification. **TS:** Hand Out #2.
L3	Oct 07	Models II: Air path, Fuel path, A/F dynamics **Additional class** on Modeling and Control (Optional, Thursday Oct 10)	2-2.4	**IM:** Linearization, Normalization, Comparison Linear vs. Nonlinear Model. **TS:** Solution #1,
L4	Oct 14	Guest Speaker	-	**Idle Speed Control System (ISCS) 1/1:** Implementation of a Nonlinear Model. **TS:** Hand Out #3.
L5	Oct 21	Models III: Torque Production	2.5	**ISCS 1/2:** Implementation of a Nonlinear Model. Milestone 1. **TS:** Solution #2,
L6	Oct 28	Test Benches, Sensors, Actuators	-	**ISCS 2/1:** Model Identification and Validation. **TS:** Solution #3, Hand Out #4.
L7	Nov 04	Models IV: Thermal Models	2.6	**ISCS 2/2:** Parameter Identification. Test Bench Session. Milestone 2.
L8	Nov 11	Models V: Emissions, TWC	2.7-2.8	**ISCS 3/1:** Model Linearization, Normalization. **TS:** Solution #4, Hand Out #5.
L9	Nov 18	Models VI: Emissions, SCR	2.9	**ISCS 3/2:** Controller Design.
L10	Nov 25	Models VII: Discrete Event Modeling, Introduction, Crank-angle Based Modeling, Hardware, Interpretation of Measurements, Torque production, Air Mass Estimation, Fuel Path, Exhaust Gas Mixing, EGR-Model	3-3.2	**ISCS 3/3:** Controller Design. Milestone 3. **TS:** Solution #5, Hand Out #6.
L11	Dec 02	Modern Engine Control Units, Torque Based Structure, A/F Control: Feedforward	3.3-4.2	**ISCS 4/1:** Controller Validation. Test Bench Session.
L12	Dec 09	A/F control: Feedback: Switch-Type Control, Wide Range Control, MIMO-Control, Evaluation	4.3-4.5	**ISCS 4/2:** Controller Validation. Test Bench Session. Milestone 4. **TS:** Solution #6
L13	Dec 16	SCR Control, Thermomanagement Control	-	**ISCS Competition**