ETH
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 2022)

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	Pol Duhr, `pduhr@ethz.ch`, office: ML K 39
	Marc Neumann, `mneumann@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 21	Introductory Lecture: Internal Combustion Engines (Optional, Wednesday)	-	-
L1	Sep 26	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	Oct 03	Models I: Causality Diagrams, Air Path **Additional class** on Modeling and Control (Optional, Wednesday Oct 5)	1.3-2.0	**IM:** Parameter Identification. **TS:** Hand Out #2.
L3	Oct 10	Models II: Air path, Fuel path, A/F dynamics	2-2.4	**IM:** Linearization, Normalization, Comparison Linear vs. Nonlinear Model. **TS:** Hand In #1,
L4	Oct 17	Models III: Torque Production	2.5	**Idle Speed Control System (ISCS) 1/1:** Implementation of a Nonlinear Model. **TS:** Hand Out #3.
L5	Oct 24	Test Benches, Sensors, Actuators	-	**ISCS 1/2:** Implementation of a Nonlinear Model. Hand In Milestone 1. **TS:** Hand In #2,
L6	Oct 31	Models IV: Thermal Models	2.6	**ISCS 2/1:** Model Identification and Validation. **TS:** Hand In #3, Hand Out #4.
L7	Nov 07	Models V: Emissions, TWC	2.7-2.8	**ISCS 2/2:** Parameter Identification. Test Bench Session. Hand In Milestone 2.
L8	Nov 14	Models VI: Emissions, SCR	2.9	**ISCS 3/1:** Model Linearization, Normalization. **TS:** Hand In #4, Hand Out #5.
L9	Nov 21	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 3/2:** Controller Design.
L10	Nov 28	Guest Speaker	-	**ISCS 3/3:** Controller Design. Hand In Milestone 3. **TS:** Hand In #5, Hand Out #6.
L11	Dec 05	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 12	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. Hand In Milestone 4. **TS:** Hand In #6
L13	Dec 19	SCR Control, Thermomanagement Control	-	**ISCS Competition**