Automatic Control Basic course (China), FRT010, Fall 2014

Version: 2014-10-21

Higher education credits: 7.5 ECTS (one eighth of a year of full-time studies).
Grading scale: Fail, 3, 4, 5.
Level: G2 (Secondary basic level).
Language of instruction: English.
Course coordinators: Associate Professor Charlotta Johnsson and post Doc Martina Maggio, Department of Automatic Control, Lund University, Sweden.
Recommended prerequisites: Calculus in One Variable, Calculus in Several Variables, Linear Algebra, Linear Systems or Systems and Transforms.
Assessment: Written exam, three laboratory exercises.
Further information: The course is given at Zhejiang University in Hangzhou, China.

Course homepage:
http://www.control.lth.se/Educationa/Engineering/EngineeringProgram/FRT010_China.html

Aim
The aim of the course is to give knowledge about the basic principles of feedback control. The course will give insight into what can be achieved with control—the possibilities and limitations. The course mainly covers linear continuous-time systems.

Knowledge and understanding
For a passing grade the student must

- be able to define the fundamental concepts of control.
- be able to linearize nonlinear dynamical models.
- be able to compute the relations between dynamical models in the form of transient responses, transfer functions, differential equations on state-space form, and frequency responses described with Bode or Nyquist diagrams.
- be able to analyze dynamical systems with respect to stability, robustness, stationary characteristics, controllability, and observability.
- be able to implement controllers using discretization of analog controllers.

Skills and abilities
For a passing grade the student must

- be able to design controllers from given specifications on robustness and performance based on models on state-space form, transfer function form, Bode diagrams or Nyquist diagrams.
- be able to design controllers based on cascade connections, feedforward, and delay compensation.
- be able to evaluate controllers by analysing transient and frequency responses, and via laboratory experiments on real processes.

Judgement and approach
For a passing grade the student must

- understand relationships and limitations when simplified models are used to describe complex dynamical systems.
- show ability for teamwork and collaboration at laboratory exercises.

Lectures and Problem Solving Sessions
Charlotta Johnsson gives the first three lectures and Martina Maggio gives the remaining eight lectures. Yang Xu leads the eleven problem solving sessions. The lectures and the problem

solving sessions are given in Building 7. Please note that the slots for lectures/exercises at the later part of the course are not yet fixed.

Nr	Date	Time (to be verified)	Room (to be verified)	Topic
Week 43				
L1	Monday Oct 20	18.30-20.55	7:308	Introduction. The PID controller. State-space models
L2	Wednesday Oct 22	15.55-18.00	7:204	Linearization. Transfer functions. Transient response.
E1	Friday Oct 24	18.30-20.55	7:308	Process models.
Week 44 *Note (22/10):* • *Exam in Signal processing Friday 31/10* • *L2 originally scheduled 28/10 has been moved to 23/10,* • *E2 originally scheduled 30/10 has been moved to 29/10 and,* • *E3 originally scheduled 31/10 has been moved to week 45.*				
L3	Tuesday Oct 28	18.30-20.55	7:208	Second-order systems. Frequency response. Review of process models
E2	Wednesday Oct 29	18.30-20.55	7:208	(Add: Linearization), System representations. Block diagrams. Step response.
Week 45 *Note:* • *Lab-session 1 (Thu and Fri only). Exact time to be announced.*				
E3	Wednesday Nov 5	18.30-20.55	7:208	Frequency response. Bode & Nyquist diagrams. Step response.
L4	Thursday Nov 6	18.30-20.55	7:208	Feedback. Stability. Stationary errors.
E4	Friday Nov7	18.30-20.55	4:303	Lab 2 preparations. Stability. Root locus.
Week 46 *Note:* • *Lab-session 2. Exact time to be announced.*				
L5	Tuesday Nov 11	18.30-20.55	7:208	The Nyquist criterion. Stability margins. Sensitivity.
L6	Wednesday Nov 12	18.30-20.55	7:208	State feedback. Controllability. Integral action.
E5	Thursday Nov 13	18.30-20.55	7:208	The Nyquist criterion. Stability margins.
E6	Friday Nov 14	18.30-20.55	4:303	Sensitivity. Stationary errors. Controllability.
Week 47 *Note:* • *No lectures (week of examination at ZJU)*				
Week 48				
L7	Tentative: Tuesday Nov 25	Tentative 18.30-20.55	To be announced	Observability. Kalman filtering. Output feedback.
L8	Tentative:	Tentative	To be	Lead-lag compensation. Frequency

	Wednesday Nov 26	18.30-20.55	announced	analysis of PID.
E7	Tentative: Thursday Nov 27	Tentative 18.30-20.55	To be announced	State feedback. Observability.
E8	Tentative: Friday Nov 28	Tentative 18.30-20.55	To be announced	Kalman filtering. Lead-lag filtering.
Week 49 *Note:* • *Lab-session3. Exact time to be announced.*				
L9	Tentative: Tuesday Dec 2	Tentative 18.30-20.55	To be announced	More on PID. Controller structures.
E9	Tentative: Thursday Dec 4	Tentative 18.30-20.55	To be announced	PID analysis and tuning.
Week 50				
L10	Tentative: Tuesday Dec 9	Tentative 18.30-20.55	To be announced	Sampling and discretization. Course review
L11	Tentative: Wednesday Dec 10	Tentative 18.30-20.55	To be announced	Extra
E10	Tentative: Thursday Dec 11	Tentative 18.30-20.55	To be announced	Controller structures. Synthesis.
E11	Tentative Friday Dec 12	Tentative 18.30-20.55	To be announced	Old exam
Week 51				
EXAM	Tuesday Dec 16	To be announced	To be announced	
Exam corrected	Wednesday Dec 17	To be announced	To be announced	

Each lecture has a separate chapter in the lecture notes by Tore Hägglund, see 'Litterature'.

Laboratory sessions
The course contains three mandatory laboratory exercises (4 hours each). The sessions are held in Educational Building no. 10, room 3101. The exact time-slots for the laboratory sessions will be announced later.

Lab1	Nov 6 – Nov 7	Empirical PID
Lab2	Nov10 – Nov14	Model construction and calculation of PID controller.
Lab3	Dec 2 – Dec 5	State feedback and Kalman filtering.

You will work in groups of two or three students. You should ideally work in mixed Swedish/Chinese groups.

The manuals for Labs 2 and 3 contain preparatory exercises that must be solved before the laboratory exercise. At the start of Lab 2, a quiz with two review questions are given. You must

give correct answers to both questions in order to proceed with the laboratory exercise. Signup-sheets for the laboratory exercises will be circulated at the lectures.

Yang Xu is responsible for the three laboratory sessions.

Literature
The course is based on the following compendiums:

- Tore Hägglund: Automatic Control, Basic Course – Lecture Notes. Department of Automatic Control, Lund University, 2012.
- Automatic Control, Basic Course – Collection of Exercises. Department of Automatic Control, Lund University, 2012.
- Automatic Control, Basic Course – Laboratory Manuals. Department of Automatic Control, Lund University, 2012.
- Automatic Control, Basic Course – Collection of Formulae. Department of Automatic Control, Lund University, 2012. ’

As reference textbook, we recommend :

- Karl Johan Åström & Richard Murray: Feedback Systems: An Introduction to Scientists and Engineers. Princeton University Press, 2008. The newest version of the book can be downloaded for free at http://www.cds.caltech.edu/~murray/amwiki

Exam

The below information applies to students from LTH, taking the course. Examination of students from Zhejiang University is directed by Zhejiang University.

The mandatory parts of the course are:

- the three laboratory exercises,
- the written exam.

The final grade is based only on the result from the written exam.

The exam is given Tuesday, December 16. The time and location of the exam will be announced later. You may bring the collection of formulae and a pocket calculator (without any control software) to the exam.

In case of absence or failure it is possible to write any of the FRT010 re-exams at LTH.

Recommended Exercise Problems

S = Solved at exercise session. H = Recommended to be solved at home.

E1	S	1.1a, 1.3abc, 1.5
	H	1.7, 1.8
E2	S	S: 2.1ab, 2.4ab, 2.11ab, 2.12, 2.9
	H	2.5ab, 2.6, 2.11cd
E3	S	3.3bd, 3.4b, 3.5, 4.1
	H	3.1, 3.2, 3.3ac, 3.6
E4	S	Lab 2 preparatory exercises 3.1 and 3.5; 5.1, 5.2, 5.5, 5.8
	H	7.3, 7.4, 5.3a, 5.4
E5	S	5.13, 5.10, 5.11, 5.14
	H	5.7
E6	S	4.2, 4.4, 4.6, 4.7, 6.4, 6.5

	H	4.3, 4.5, 6.1a
E7	S	9.2, 9.5, 6.3
	H	9.4, 6.1b
E8	S	9.6, 9.3, 8.1, 8.2, 8.3, 8.4
	H	9.10, 8.5, 8.6
E9	S	7.5, 7.2, 7.6, 7.7
	H	7.8, 7.10
E10	S	10.1, 10.6, 10.9, 10.10, 11.1
	H	10.2, 10.5, 10.7, 11.2
E11	S	Old exam (to be distributed later)

Contact info

Charlotta Johnsson	charlotta.johnsson@control.lth.se
Martina Maggio	martina.maggio@control.lth.se
Yang Xu	yang.xu@control.lth.se
Mika Nishimura (Ladok)	mika.nishimura@control.lth.se