ELEC440 Automatic Control

1. Introduction

These notes are a guide to the course **ELEC440 Automatic Control** and give students information regarding course content, available learning resources, reference textbooks, tutorials, laboratories, assessment and course timetable.

The purpose of the course is to serve as an introduction to control system design. Strong emphasis will be given to the demonstration of the theoretical material with examples drawn from real life. Application cases will be discussed during the lectures, and will be further illustrated with simulation studies during the tutorials and with real examples during the laboratories.

2. Contents

The main topics that we will cover in this course are:

- Motivation to Control Systems
- Feedback Principles
- Modeling
- Laplace Transforms
- Transfer Functions
- Stability
- PID Controllers
- Design Issues
- Embellishments: Topics in Advanced Control

3. Learning resources

The course will be based, mainly, on the textbook:

Graham C. Goodwin, Stefan F. Graebe and Mario E. Salgado. Control System Design. Prentice Hall, 2001.

The bookshop on campus has copies in stock. We will cover **chapters 1—8, 10 and 12**. The book has an accompanying CD-ROM containing a set of MATLAB-SIMULINK files. These files provide support for many problems posed in this book, and, at the same time, facilitate the study and application of selected topics.

There is a web page for the book:

http://csd.newcastle.edu.au/control/

There, you will find:

- Previews and summaries of all the chapters in the book.
- Online interactive Java simulations for practical problems. You are encouraged to try these animated simulations to gain a 'feeling' for control systems.
- Lecture Slides, developed around the contents of the book. Some of them will be used by the lecturers during the classes and may serve students as a reminder of the material covered in the lectures.
- A download page with MATLAB files for all illustrative examples and lecture slides.
- Example problems with worked solutions.

4. Reference textbooks

Besides the above, there are many other excellent books in the library which cover, from various perspectives, the topics of the course. These references include:

- Richard Dorf and Robert Bishop. Modern control systems. Addison-Wesley, 1998.

- Katsuhiko Ogata. Modern control engineering. Prentice Hall, 1997.

- Joseph DiStefano, Allen Stubberud and Ivan Williams. Schaum's outline of theory and problems of feedback and control systems. Schaum Pub. Co., 1967.

5. Tutorials

The main purpose of the tutorials is to illustrate the theoretical content by solving practical problems. Special attention will be given to the specific difficulties which students may have due to different engineering backgrounds.
A big component of the practical work of the course is the design and simulation of control systems using computers. Tutorial classes will be conducted in classrooms with computing facilities and the use of MATLAB and SIMULINK, in connection with the course, will be explained. (Previous knowledge of these packages is not assumed.)

There will be **12 tutorials** of **one-hour** duration, during **term-weeks 2 to 13**.
Each tutorial will be repeated **6 different times** during the corresponding week. The available tutorial times are:

Tutorial A ---------- Mondays 10:00-11:00, Room: ES 137

Tutorial B ---------- Mondays 11:00-12:00, Room: ES 137

Tutorial C ---------- Mondays 3:00-4:00, Room: ES 137

Tutorial D ---------- Mondays 4:00-5:00, Room: ES 137

Tutorial E ---------- Tuesdays 3:00-4:00, Room: ES 137

Tutorial F ---------- Wednesdays 11:00-12:00, Room: ES 137

Students are required to choose, during the first week, their preferred tutorial times for the whole semester (stating 1st, 2nd and 3rd preferences). Tutorial classes will then be filled accordingly. (Chemical Engineering students: See (*) below.)

Note for Chemical Engineering students

Since this course utilizes some previous knowledge and terminology that these students might not be totally familiar with, an **extra** session called **Help Session** will be offered during **term-weeks 2 to 13** in parallel with the tutorials. During these help sessions, **no new material** will be introduced. Instead, bridging material, specifically addressed to Chemical Engineering students, will be presented by a tutor graduated from this specialty.

Help Session -------- Tuesdays 11:00-12:00, Design Studio (ES building)

(*) Chemical Engineering students are expected to attend both, a normal tutorial and the help session. Since the help session will be given on Tuesdays, these students are expected to choose a **Monday tutorial**.

6. Laboratories

The laboratory exercises complement the tutorials by illustrating the theory in practical situations. It is here where students will get a real feeling for the subject and, hopefully, will become motivated to learn more advanced topics.

There will be **two** laboratories:

Laboratory 1: "Introduction to UNAC and PLC's".

Laboratory 2: Elective from:
"Servo System"
"Two Tanks System"
(Students may choose to conduct only one of the above for the second laboratory.)

There will be an open-laboratory philosophy, students may come and go as they please while doing the laboratory exercises. In addition, to assist the students with the experiments, there will be a demonstrator present in the laboratory **every day from 4:00 to 5:00 p.m.**

Students are expected to work in groups of three people. The group work will be assessed during an interview in which the three members must be present. The maximum score of each Laboratory will be **10 points**. To encourage participation of the three members of the group, questions will be asked of the individuals and the group score will be based on the individual responses. Assessment times for the laboratories should be arranged with the lab demonstrator. However, to keep the pace of the course, **Laboratory 1** must be assessed before the end of term-week 6, i.e., by **Friday 24th of August**; and **Laboratory 2** must be assessed before the end

of term-week 12, i.e., by **Friday 19th if October**. Due to the size of the class, **no extensions** will be granted on these deadlines.

7. Assessment

There will be **four assignments** of approximately three questions each. The maximum score of each assignment will be **5 points**. The timetable for the assignments is as follows:

Assignment 1	Out: Monday 16th of July	(Week 1)
	Due: Friday 10th of August	(Week 4)
Assignment 2	Out: Monday 6th of August	(Week 4)
	Due: Friday 31st of August	(Week 7)
Assignment 3	Out: Monday 27th of August	(Week 7)
	Due: Friday 21st of September	(Week 10)
Assignment 4	Out: Monday 17th of September	(Week 10)
	Due: Friday 26th of October	(Week 13)

Assignments should be placed in the assignment-box located in the foyer of the EA building. Due to the size of the class, **no extensions** will be granted on due dates for submission.

The total assessment will be based on the following weights:

Average of Assignments Marks:	20 %
Average of Laboratory Marks:	20 %
Final Examination:	60 %

8. Course timetable

Book referred to: Control System Design, G.C. Goodwin, S.F. Graebe and M.E. Salgado
Web-site referred to: http://csd.newcastle.edu.au/control/

Week	Broad Topic	Lecture 1 Monday 6pm–7pm	Lecture 2 Monday 7pm–8pm	Lecture 3 Tuesday 6pm–8pm	Tuts, Labs Assignments
1 **16/7/01**	Motivation	Control Engineering (Chapter 1)	Mould Level Example (Section 2.3)	Open Loop Control (Section 2.5)	
2 **23/7/01**	Feedback Principles	High Gain and Inversion (Sections 2.6, 2.7)	Design Trade-offs I (Section 2.8)	ON/OFF Control PLC's (Web-site)	Tutorial 1
3 **30/7/01**	Modelling	Modelling (Chapter 3)	Linearization (Section 3.10)	Some Examples (Web-site)	Tutorial 2
4 **6/8/01**	Laplace Transforms	Intro. to Laplace (Chapter 4)	Formal Laplace (Section 4.3)	Properties (Section 4.4)	Tutorial 3 **Assignment 1 due on 10/8/01**
5 **13/8/01**	Transfer Functions	Transfer Functions (Section 4.5)	Transient Response (Section 4.7)	Poles (Section 4.8.1)	Tutorial 4
6 **20/8/01**		Zeros (Section 4.8.2)	Frequency Response (Section 4.9)	Bode Diagrams (Section 4.9.1)	Tutorial 5 **Laboratory 1 due on 24/8/01**
7 **27/8/01**		Frequently Encountered Models (Section 4.11)	Model Errors (Section 4.12)	Closed Loops & Sensitivity (Sections 5.2, 5.3)	Tutorial 6 **Assignment 2 due on 31/8/01**
8 **3/9/01**	Stability	Stability via Polynomials (Section 5.5)	Routh's Algorithm (Section 5.5.3)	Root Locus (Section 5.6)	Tutorial 7
9 **10/9/01**		Nyquist Stability (Section 5.7)	Stability Margins (Section 5.8)	Robust Stability (Section 5.9)	Tutorial 8
10 **17/9/01**	PID Controllers	PID Structure (Section 6.2)	Ziegler Nichols Reaction Curve (Sections 6.4, 6.5)	Lead-Lag Smith Predictor (Section 6.6, 7.4)	Tutorial 9 **Assignment 3 due on 21/9/01**
11 **8/10/01**	Design Issues	Sensors & Actuators (Sections 8.2, 8.3)	Integrators (Section 8.6.4)	Zeros (Section 8.6.5)	Tutorial 10
12 **15/10/01**		Anti-windup (Section 8.8.3)	Architecture (Feedforward/ Cascade) (Sections 10.5, 8.8.5)	Example (Section 8.7)	Tutorial 11 **Laboratory 2 due on 19/10/01**
13 **22/10/01**	Embellishments	Internal Model Principle (Section 10.3)	Computer Control (Chapter 12)	Computer Control (Chapter 12)	Tutorial 12 **Assignment 4 due on 26/10/01**