ENGN 3223 Control Systems, Semester 1, 2006
Course Outline

Subject details: First Semester 2006
Unit Credits: 6
Pre-requisites: ENGN2223 or MATH2305
Lectures: 4 hours per week **Laboratories**: 3 hours per week
(Student must expect to spend a minimum of 3-4 hours of private study per week.)

Lecturer: Dr Jonghyuk (Jon) KIM,
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Office hours: By appointment, or Fri 10-11am. **Course Website**: WebCT

Synopsis: *Introduction to control systems. Laplace transform and properties and review of linear systems response. Time domain specifications of performance. Closed loop and open loop control. Classical PID controllers. Steady state tracking errors and system type. Stability and robustness. Rouths stability criterion. Root locus of a feedback system. Control design using root locus. Frequency Response and Bode plots for continuous and discrete time systems. Nyquist plots and stability. Stability margins. Lead-Lag Frequency based control design. Sensitivity and robustness of control systems. Sampled-data systems and design by emulation. Discrete-time systems and the Z-transform. Root locus for a discrete-time system. Direct discrete-time design.*

Venues and Time:

Lectures:
- Wednesday 12.00pm - 1.00pm Engn-T
- Thursday 12:00pm - 1:00pm Engn-T
- Friday 1:00pm - 3:00pm Engn-T

Laboratories: Starting from Week-3 (7th of March).
- Tuesday 2.00pm - 5.00pm Engn E105
- Wednesday 2.00pm - 5.00pm Engn E105
- Thursday 2:00pm - 5:00pm Engn E105

Tutorials: starting from Week-2 (27th/Feb).
- Monday 9.00am – 10.00am Cop1151
- Tuesday 9.00am – 10:00am Cop1151
- Wednesday 9:00am – 10:00am Cop1151

Super-tutorials: starting from the Week-3 (8th of March)
- Wednesday 5.00pm -7.00pm Grad-T (Ian Ross)

Assessments:

Assessments	Marks	Times
Laboratory Book	12%	Submitted at certain lab sessions during semester. Selected problems set will also be assessed.
Root-locus design lab report	20%	Lab during week8-10. Report due Friday 19 May
Tutorial participation	5%	Attendance and participation at tutorial sessions
Tutorial presentation	10%	Once per semester
Mid Semester Quiz	10%	1:15pm-2:30pm Friday 7th April
Final Exam	43%	During exam period

- **Laboratory Sessions: laboratory classes are compulsory** (even for repeating students). Only Laboratory-05 (Root locus design) will be explicitly assessed with a separate report to be submitted on Friday 19 May 2006. All other laboratory sessions are assessed via notes in a laboratory book. Submission dates for assessment of lab books is given in the following table.
- **Problem Sheets:** A set of problem sheets covering the course material will be prepared and posted on the web along with worked solutions. Certain problems in the problem sheets will be assessable to be collected and marked along with laboratory books during semester. Due dates for particular problem sets are given in the table below. The solutions to problem sets may be written in your lab book.
- **Due dates for Laboratory Book & Problem Set:**

Week	Due dates	Assessed items
4	Friday 17/03/06	Lab01 & Selected Problems from Prob01, Prob02.
6	Friday 31/03/06	Lab02, Lab03 & Selected Problems from Prob03, Prob04.
9	Friday 05/05/06	Lab04 & Selected Problems from Prob05, Prob06.
11	Friday 19/05/06	Lab05 (Loot-locus design lab report)
12	Friday 26/05/06	Selected Problems from Prob07.
13	Friday 02/06/06	Selected Problems from Prob08.

- **Tutorial Sessions:** There are 5 tutorial sessions during the semester. Attendance and participation is worth 5% of student's final mark. Tutorials are based on peer instruction. Each tutorial group will be split into 5 presentation groups. Each presentation group will be responsible for preparing, presenting and providing follow-up material for one tutorial session during the semester. This process will count 10% of student's total grade. **In the week preceding their presentation**, the presenting group will attend a separate 'super tutorial' session to help plan the material for the following week.

Web site & Lecture Notes: A web site for the course will linked to the department course web site and the ANU WebCT. All documents (including lecture notes) prepared for the course and administrative arrangements will be posted on the WebCT.

Textbook & References:

Recommended text: Franklin, Powell and Emami-Naeini, *Feedback Control of Dynamic Systems, 5th or 4th edition, Addison-Wesley.*

Other references: Ogata, *Modern Control Engineering, Prentice-Hall.*
Franklin, Powell, *Digital control systems*
Goodwin, Graebe, Salgado, *Control System Design*.

Learning Objectives:

As a result of successfully completing this subject, the student will be able to:

1. Understand the properties of feedback and feed-forward control architecture and specify control architecture for a real world problem.
2. Understand the importance of performance, robustness and stability in control design.
3. Have a strong intuitive understanding of the link between the ODE representation, the s-domain representation and physical characteristics of the time response of an LTI SISO system.
4. Identify simple systems and dominant response characteristics from time domain step-response data.
5. Work confidently with block diagram representations of control systems.
6. Design PID controllers based on empirical tuning rules.
7. Understand system type and steady state tracking error analysis.
8. Compute stability of linear systems using the Routh array test and use this to generate control design constraints.
9. Sketch Evan's root locus diagrams by hand.
10. Use Evans root locus techniques is control design for real world systems.
11. Sketch Bode plots for a system and understand their significance.
12. Understand and compute sensitivity and complimentary sensitivity for a feedback system.
13. Compute gain and phase margins, and understand implications for control.
14. Calculate the Nyquist conditions for a linear system and understand its implications in terms of robust stability margins.
15. Compute band-pass for a linear system and understand its significance in control design.
16. Design Lead-Lag compensators based on frequency data for an open-loop linear system.
17. Understand the basic structure of a sampled-data system, including a comprehension of issues such as Nyquist sampling theorem and aliasing as well as structure of Z-transform transfer functions and issues associated with inter-sample ripple.
18. Compute discrete-time equivalents of continuous-time plants using zero-order hold, trapezoid integration and pole matching techniques.
19. Compute control design using emulation techniques and understand its limitations. Able to use time-delay design approximation for ZOH delays in discrete time design.
20. Able to use root locus techniques to do direct discrete-time design for systems with slow sample rates.

Subjects Outlines:

1. History of Control.
- A perspective on what are the important control problems and where the modern solutions came from.

3. Dynamic Response
- Review of obtaining dynamic models
- The role of linear systems for control engineers.
- Review of Laplace transform and properties.
- Review of linear systems response and the concept of transfer function.
- Pole locations and system response.
- Time domain specifications of performance.
- Effect of Additional zeros and poles.

4. Basic Properties of Feedback
- Closed loop vs. open loop control and properties.
- Classical PID controllers.
- Steady state tracking errors and system type.
- Stability and robustness.
- Rouths stability criterion.
- Discrete-time systems and design by emulation.

5. Root locus Design.
- Root locus of a feedback system.
- Sketching an Evans root locus plot.
- Control gain assignment from root locus design.
- Dynamic compensators and root locus.
- Root locus for a discrete-time system.

6. Frequency Response Design
- Frequency response data and the control problem
- Bode plots and linear system frequency response.
- Control criteria.
- Nyquist stability criteria and stability margins.
- Lead-Lag compensation.
- PID compensation revisited.
- Nichols Chart and Inverse Nyquist.

7. State-Space Design (Not covered)

8. Sampled Data Systems
- Discrete-time systems, Z-transform properties and review of linear systems response.
- Time delay associated with the sampling
- Design by emulation. Numerical integration.
- Discrete equivalent of a sampled system.
- Root-locus for discrete system.
- Frequency response and control design.

Review.

Assessment Review and Appeals Procedures:
http://info.anu.edu.au/policies/Policies/Students/Other/Assessment_Review_and_Appeals.asp

Academic Honesty in Learning and Teaching (including plagiarism)
http://info.anu.edu.au/policies/Codes_Of_Practice/Students/Other/Academic_Honesty.asp

Code of Practice for Teaching and Learning:
http://info.anu.edu.au/policies/Codes_Of_Practice/Students/Other/Teaching_and_Learning.asp

Discrimination and sexual harassment:
http://www.anu.edu.au/equity/files/grievpol.pdf

Refer to **Engineering Handbook** for further information