University of Macau
Department of Electromechanical Engineering
MECH404 - Control Techniques
Syllabus
1st Semester 2011/2012
Part A – Course Outline

Compulsory course in Electromechanical Engineering

Course description:
Introduction to Control System, Laplace Transform, Dynamic Models and Dynamic Response, Models of Industrial Control Devices and Systems, Feedback Control, Stability of Linear System, Root Locus Plots, Bode Plots, and Polar Plots.

Prerequisite:
MECH205 - Electrical Engineering

Textbook:
- Naresh K. Sinha, ***Control Systems***, 3rd edition, New Age International, 2010.

References:
- Richard C. Dorf, and Robert H. Bishop, *Modern Control Systems*, **11**th Edition, Addison-Wesley 2008.
- M Gopal, *Control Systems: Principles and Design*, 2nd edition, 2003.
- Katsuhiko Ogata, *Modern Control Engineering*, 5th edition, Prentice Hall, 2009.

Course objectives:
To provide an opportunity to students to:
1. learn the design and applications of some real systems, which use automatic control. [c, l]
2. learn mathematical modeling of physical systems. [a, c]
3. understand the control system performance with various methods for control system design. [c, e]

Topics covered:
1. **Introduction** - Review of Syllabus; Introduction to the History of Automatic Control; Examples of Control Systems
2. **Laplace Transform** - Definition; Laplace Transform Table; Laplace Integral; Properties of Laplace Transform; Inverse Laplace Transform
3. **Mathematical Models of Physical Systems** - Differential Equations and Transfer Functions; Electrical Analogs; Modeling a DC Servomotor; Simplification of Block Diagrams; Mason's Rule
4. **State-Space Methods** - Concept of State; Computation of the Transfer Function from State Equations; State Equations from Transfer Function; Linear Transformations and Canonical Forms
5. **Characteristics of Closed-Loop Systems** - Sensitivity to Parameter Variations; Transient Response; Effect of Disturbance Signals; Steady-State Error; Disadvantages of Feedback
6. **Performance of Control Systems** - Standard Test Input; Response of a First-Order System; Response of a Second-Order System; Properties of Transient Response; Steady-State Performance; Steady-State Error In Closed-Loop Transfer Function; Integral Performance Criteria
7. **Stability of Linear Systems** - Routh-Hurwitz Criterion; Special Cases; Relative Stability; Application to Design; Stability from State-Space Representation
8. **Root Locus Method** - Root Loci for a Second-Order System; Basic Principles; Properties of the Root Locus; Applications to Design; Sensitivity and the Root Locus
9. **Frequency Response** - Transfer Function and Frequency Response; Bode Plots; Logarithmic Scales; Magnitude Plots; Phase Plots; Polar Plots; Log-Magnitude and Phase Diagrams; Systems with Transport Lag

Class schedule and credits:

Timetabled work in hours per week			No of teaching weeks	Total hours	Total credits	No / Duration of exam papers
Lecture	Tutorial	Practice				
2	2	0	14	56	3	1 / 2 hours

Topic Outline:

Week No.	No. of hours	Topics
1	2	**Introduction** Review of Syllabus; Introduction to the history of automatic control; examples of control systems;
2, 3	5	**Laplace Transform** Definition; Laplace Transform Table; Laplace Integral; Properties of Laplace Transform; Inverse Laplace Transform
3, 4	6	**Mathematical models of physical systems** Differential Equations and Transfer Functions; Electrical Analogs; Modeling a DC Servomotor; Simplification of Block Diagrams; Mason's Rule
4, 5, 6	6	**State-space methods** Concept of State; Computation of the Transfer Function from State Equations; State Equations from Transfer Function; Linear Transformations and Canonical Forms
6, 7, 8	6	**Characteristics of closed-loop systems** Sensitivity to Parameter Variations; Transient Response; Effect of Disturbance Signals; Steady-State Error; Disadvantages of Feedback
8, 9	6	**Performance of control systems** Standard Test Input; Response of a First-Order System; Response of a Second-Order System; Properties of Transient Response; Steady-State Performance; Steady-State Error In Closed-Loop Transfer Function; Integral Performance Criteria
9, 10, 11	5	**Stability of linear systems** Routh-Hurwitz Criterion; Special Cases; Relative Stability; Application to Design; Stability from State-Space Representation
11, 12, 13	6	**Root locus method** Root Loci for a Second-Order System; Basic Principles; Properties of the Root Locus; Applications to Design; Sensitivity and the Root Locus
13, 14	6	**Frequency response** Transfer Function and Frequency Response; Bode Plots; Logarithmic Scales; Magnitude Plots; Phase Plots; Polar Plots; Log-Magnitude and Phase Diagrams; Systems with Transport Lag

Contribution of course to meet the professional component:

This course prepares students to work professionally in the area of **control engineering**.

Relationship to EME Programme objectives and outcomes:

This course primarily contributes to Electromechanical Engineering Programme outcomes that develop student abilities to:

(a) an ability to apply knowledge of mathematics, science, and engineering.

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

(e) an ability to identify, formulate and solve engineering problems.

The course secondarily contributes to Electromechanical Engineering Programme outcomes that develop student abilities to:

(l) an ability to use the computer/IT tools relevant to the discipline along with an understanding of their processes and limitations.

Course content:

Maths	Basic Science	Engineering Science	Engineering Design and Synthesis	Complementary Studies	Computer Studies	Total 100%
30	0	50	20	0	0	100

Persons who prepared this description:

Prof. Yangmin Li

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Part B – General Course Information and Policies

1st Semester 2011/2012

Instructor: Prof. Yangmin Li
Office Hour: By appointment
Email: ymli@umac.mo
Office: N412
Phone: (853) 8397-4462

Time/Venue:

Every Tuesday, 4:30 p.m. - 6:30 p.m., Room JG14
Every Friday, 4:30 p.m. - 6:30 p.m., Room JG14

Assessment:

Final assessment will be determined on the basis of:

Homework:	20%
In-class Quizzes:	5%
Mid-term:	25%
Final Exam (Comprehensive):	50%

Grading System:

The credit is earned by the achievement of a grade from 'A' to 'D'; 'F' carries zero credit.

Grades are awarded according to the following system:

Letter Grades	Grade Points	Percentage
A	4.0 (Excellent)	93-100
A-	3.7 (Very good)	88-92
B+	3.3	83-87
B	3.0 (Good)	78-82
B-	2.7	73-77
C+	2.3	68-72
C	2.0 (Average)	63-67
C-	1.7	58-62
D+	1.3	53-57
D	1.0 (Pass)	50-52
F	0 (Fail)	Below 50

Comment:

The objectives of the lectures are to explain and to supplement the text material. Students are responsible for the assigned material whether or not it is covered in the lecture. Students who wish to succeed in this course should read the assignments prior to the lecture and should work all homework and lab assignments. You are encouraged to look at other sources (other texts, etc.) to complement the lectures and text.

Homework Policy:

The completion and correction of homework is a powerful learning experience; therefore:

- There will be approximately 5 homework assignments.
- No late homework is accepted.
- Possible revision of homework grades may be discussed with the grader within one week from the return of the marked homework
- The homework grade will be based on the average of the assignment grades.

Quizzes/Mid-terms Exams:

There will be one or two in-class quizzes during the semester. One close-book mid-term exam will be held during the semester. It will be a 120-minute exam.

Note:

- Attendance is strongly recommended.
- Check UMMoodle (webcourse.umac.mo) for announcement, homework and lectures. Report any mistake on your grades within one week after posting.
- No make-up exam is given except for CLEAR medical proof.
- No exam is given if you are 15 minutes late in the midterm exams and 30 minutes late in the final exam. Even if you are late in the exam, you must turn in at the due time.
- Cheating is absolutely prohibited by the university.

Appendix - Rubric for Programme Outcomes

Rubric for (a)	5 (Excellent)	3 (Average)	1 (Poor)
Understand the theoretic background	Students understand theoretic background and the limitations of the respective applications.	Students have some confusion on some background or do not understand theoretic background completely	Students do not understand the background or do not study at all
Use a correct model and formulation correctly	Students choose a model correctly and properly apply correct techniques	Students choose a wrong model sometime, use a wrong formula, or a different technique	Students use a wrong model and wrong formula, or do not know how to model
Compute the problem correctly	Students use correct techniques, analyze the problems, and compute them correctly	Students sometime solve problem mistakenly using wrong techniques	Students do not know how to solve problems or use wrong techniques completely

Rubric for (c)	5 (Excellent)	3 (Average)	1 (Poor)
Design capability and design constraints	Student understands very clearly what needs to be designed and the realistic design constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.	Student understands what needs to be designed and the design constraints, but may not fully understand the limitations of the design constraints	Student does not understand what needs to be designed and the design constraints.
Process to meet desired needs	Student understands very clearly the process of the design	Student understands what the needs of the process design, but may not fully understand the limitations of the design constraints	Student does not understand the process.

Rubric for (e)	5 (Excellent)	3 (Average)	1 (Poor)
Identify applications in engineering systems	Students understand problem and can identify fundamental formulation	Students understand problem but cannot apply formulation.	Students cannot identify correct terms for engineering applications
Modeling, problem formulation and problem solving	Students choose and properly apply the correct techniques	Students model correctly but cannot select proper technique or model incorrectly but solve correctly accordingly	Students at loss as to how to solve a problem

Rubric for (l)	5 (Excellent)	3 (Average)	1 (Poor)
Use modern computer and software tools in engineering practice	Student uses the computer and software to correctly analyze engineering problems and/or create engineering designs, and understands the limitations of the software.	Student uses the computer and software to correctly analyze engineering problems and/or create engineering designs.	Student does not use the computer and software to correctly create engineering designs and/or does not correctly interpret the results.