University of Macau
Department of Electromechanical Engineering
MECH451 - Control and Automation
Syllabus
2nd Semester 2011/2012
Part A – Course Outline

Compulsory course in Electromechanical Engineering

Course description:
Industrial computer controlled system, Operational amplifiers and signal conditioning, relays and power-control semiconductors, sensors, stepper motors, servo motors, feedback control principles, relay logic and programmable logic controllers.

Prerequisite:
MECH404 – Control Techniques

Textbook
- Christopher T. Kilian, ***Modern Control Technology: Components and Systems***, 3rd Edition, Thomson Delmar Learning, 2004

References:
- C. Ray Asfahl, *Robots and Manufacturing Automation*, 2nd Edition, John Wiley & Sons, Inc., 1992
- Richard C. Dorf, and Robert H. Bishop, *Modern Control Systems***,** 11th Edition, Addison-Wesley 2008.

Course objectives:
1. Introduce to students some real industrial computer controlled systems. [a, l]
2. Introduce to students operational amplifiers and signal conditioning. [a, c, e]
3. Introduce to students relays and power-control semiconductors, sensors, stepper motors, servo motors, feedback control principles. [a, b, c, e]
4. Understand the operation of relay logic and programmable logic controllers. [c, b, e, l]

Topics covered:
1. **Introduction** - Review of Syllabus; Introduction to Control and Automation; Open-Loop Control Systems; Closed-Loop Control Systems; Transfer Functions; Analog and Digital Control Systems; Classification of Control Systems; Justification of Process Control
2. **Microprocessor-Based Control** - Microprocessor System Hardware; Microprocessor Operation; Interfacing to a Microprocessor Controller; Controller Programming; Microprocessor-Based Controllers
3. **Operational Amplifiers and Signal Conditioning** - Voltage Follower; Inverting Amplifier; Noninverting Amplifier; Summing Amplifier; Differential and Instrumentation Amplifiers; Integrators and Differentiators; Active Filters; Comparator; Special Interface Circuits; Signal Transmission
4. **Switches, Relays, and Power-Control Semiconductors** - Toggle Switches; Push-Button Switches; Other Switch Types; Electromechanical Relays; Solid-State Relays; Power Transistors; Silicon-Controlled Rectifiers; Triacs; Trigger Devices
5. **Sensors** - Position Sensors; Angular Velocity Sensors; Proximity Sensors; Load and Force Sensors; Pressure Sensors; Temperature Sensors; Flow Sensors; Liquid-Level Sensors; Vision Sensors and Systems
6. **Motor Control** - Direct Current (DC) Motors; DC Motor Control Using Pulse-Width Modulation (PWM); PWM Control Circuits; Permanent-Magnet Stepper Motors; Variable-Reluctance Stepper Motors; Stepper Motor Control Circuits; Stepper Motor application
7. **Feedback Control Principles** - Performance Criteria; On-Off Controllers; Proportional Control; Integral Control; Derivative Control; Proportional Integral Derivative (PID) Control; PID Controllers
8. **Relay Logic and Programmable Logic Controllers (PLC)** - Relay Logic Control; PLC Hardware; Setup Procedure and Operation; Programming the PLC

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				
3	1.71	0.29	14	70	4	1 / 3hrs

Topic Outline:

Week No.	No. of hours	Topics
1	2	**Introduction** Review of Syllabus; Introduction to Control and Automation; Open-Loop Control Systems; Closed-Loop Control Systems; Transfer Functions; Analog and Digital Control Systems; Classification of Control Systems; Justification of Process Control
1, 2, 3	7	**Microprocessor-Based Control** Microprocessor System Hardware; Microprocessor Operation; Interfacing to a Microprocessor Controller; Controller Programming; Microprocessor-Based Controllers
3, 4	8	**Operational Amplifiers and Signal Conditioning** Voltage Follower; Inverting Amplifier; Noninverting Amplifier; Summing Amplifier; Differential and Instrumentation Amplifiers; Integrators and Differentiators; Active Filters; Comparator; Special Interface Circuits; Signal Transmission
4, 5, 6	8	**Switches, Relays, and Power-Control Semiconductors** Toggle Switches; Push-Button Switches; Other Switch Types; Electromechanical Relays; Solid-State Relays; Power Transistors; Silicon-Controlled Rectifiers; Triacs; Trigger Devices
6, 7	8	**Sensors** Position Sensors; Angular Velocity Sensors; Proximity Sensors; Load and Force Sensors; Pressure Sensors; Temperature Sensors; Flow Sensors; Liquid-Level Sensors; Vision Sensors and Systems
8, 9, 10	9	**Motor Control** Direct Current (DC) Motors; DC Motor Control Using Pulse-Width Modulation (PWM); PWM Control Circuits; Permanent-Magnet Stepper Motors; Variable-Reluctance Stepper Motors; Stepper Motor Control Circuits; Stepper Motor application
10, 11	8	**Feedback Control Principles** Performance Criteria; On-Off Controllers; Proportional Control; Integral Control; Derivative Control; Proportional Integral Derivative (PID) Control; PID Controllers
12, 13, 14	9	**Relay Logic and Programmable Logic Controllers** Relay Logic Control; PLC Hardware; Setup Procedure and Operation; Programming the PLC

Contribution of course to meet the professional component:

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

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.

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

(b) an ability to design and conduct experiments, as well as to analyze and interpret data.
(e) an ability to identify, formulate, and solve engineering problems.
(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 Sciences	Engineering Science	Engineering Design and Synthesis	Complementary Studies	Computer Studies	Total 100%
20	5	45	20	0	10	100

Persons who prepared this description:

Prof. Yangmin Li

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Part B – General Course Information and Policies

2nd Semester 2011/2012

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

Time/Venue:

TBA

Assessment:

Final assessment will be determined on the basis of:

Homework:	20%
Lab report:	15%
Mid-term:	20%
Final Exam (Comprehensive):	45%

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 7 homework assignments.
- Homework is due one week after assignment unless otherwise noted, 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.

Mid-term Exam:

One mid-term exam will be held during the semester. There will be a 120-minute exam.

Note:

- Recitation session is important part of this course and attendance is strongly recommended.
- Check UMMoodle (webcourse.umac.mo) for announcement, homework and lectures. Report any mistakes 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 (b)	5 (Excellent)	3 (Average)	1 (Poor)
Conduct experiments	Student successfully completes the experiment, records the data, analyzes the experiment's main topics, and explains the experiment concisely and well.	Student successfully completes the experiment, records the data, and analyzes the experiment's main topics.	Student either does not complete the experiment successfully, or completes it successfully but does not record the correct data.
Design experiments	Student understands what needs to be tested and designs an appropriate experiment that takes into account the limitations of the equipment and measurement accuracy.	Student understands what needs to be tested and designs an appropriate experiment, but may not fully understand the limitations of the measurements.	Student does not understand what needs to be tested and/or does not design an appropriate experiment.

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.