University of Macau
Department of Electromechanical Engineering
MECH450 - Electronics & Instrumentation
Syllabus
1st Semester 2012/2013
Part A – Course Outline

Compulsory course in Electromechanical Engineering

Course description:
Basic principles of electronics components and operations of measuring instruments, transducers and signal conditioning techniques. Voltmeter, ammeter, ohmmeters, multi-meters, oscilloscopes, probes, bridges, diodes, bipolar junction transistors (BJT), operational amplifiers (Op Amp), transducers, noise, and filters.

Prerequisite:
MECH205 – Electrical Engineering

Textbook:
- Allan R. Hambley, Electrical engineering: principles and applications, 5th Edition. 2011.

References:
- H. S. Kalsi, Electronic instrumentation, 2nd Edition, Tata McGraw-Hill.
- B. C. Nakra, K. K. Chaudry, Instrumentation measurement and analysis, Tata McGraw-Hill.
- A. R. Hambley, Electrical engineering principles and applications, Prentice Hall.
- W. D. Cooper, Electronic instrumentation and measurement techniques, 2nd Edition, Prentice Hall.
- R. L. Boylestad, L. Nashelsky, Electronic devices and circuit theory, 10th Edition, Pearson, 2009.

Course objectives:
1. Learn to use a load-line construction to determine DC operation point of a diode in a resistive circuit. [a, c, e]
2. Understand the operation of half-wave and full-wave rectified power supply circuits. [a, c]
3. Learn to describe and model the use of diodes in instrumentation applications. [a, e]
4. Understand the operation of BJT and carry out the associated DC circuit design. [a, c, e, k]
5. Use an appropriate model of an operational amplifier to analyze the behavior of a number of circuit configurations, including the inverting and non-inverting amplifiers, differential amplifier, instrumentation amplifier, integrator and differentiator. [a, b, c, e, k]
6. Work in a team to design and conduct experiments regarding to instrumentation and measurement [b, d, e]
7. Understand the safety issues for electronic devices [h]

Topics covered:
1. **Introduction** - Review of Syllabus; Introduction to Measurement; Standards
2. **DC Meters** - D'Arsonval Principle; DC Meters; DC Ammeters; DC Voltmeters; DC Ohmmeters; Multi-range DC Meters; Ayrton Shunt; Precaution on Meters
3. **AC Meters** - Full Wave Rectifier; Half Wave Rectifier; Average Value, RMS Value, Peak-to-Peak Value; Multi-range AC Meters
4. **Diodes** - Depletion Region; Diode Characteristics; Forward Bias; Reverse Bias; Breakdown Voltage; Diode Models; Bridge Rectifier; Voltage Regulator; Special-Purpose Diodes; Troubleshooting
5. **Transistors** - Bipolar Junction Transistor (BJT); Load-Line Analysis; CE Amplifier; CC Amplifier; Class A Amplifier; Class B Amplifier; Field Effect Transistor (FET); JFET; MOSFET; CS Amplifier; CD amplifier; Application
6. **Bridges** - Wheatstone's Bridge; Kelvin's Bridge; Bridge-Controlled Circuits; AC Bridges
7. **Operational Amplifiers (Op Amp)** - Pin Configuration; Ideal Op Amp; Summing-Point Constraint; Inverting Amplifier; Non-Inverting Amplifier; Voltage Follower; Differential Amplifier; Summing Amplifier; Integrator; Differentiator; Logarithmic Amplifier; Anti-Log Amplifier; Multiplication and Division with Op Amps;

Comparator; Analog-to-Digital Converter (ADC); Digital-to-Analog Converter (DAC); Instrumentation Amplifier; Applications

8. **Transducers** - Classification; Contacting Spindle; Elastic Transducer; Mass Transducer; Thermal Transducer; Hydro-Pneumatic Transducer; Resistive Transducer; Inductive Transducer; Linear Variable Differential Transformer (LVDT); Capacitive Transducer; Piezo-Electric Transducer; Strain Gauge; Ionization Transducer; Photo Emissive Transducer; Photo Conductive Transducer; Photo Voltaic Transducer
9. **Measurement of Temperature** - Liquid-in-Glass Thermometer; Bimetallic Elements; Pressure Thermometer; Resistance Temperature Detector (RTD); Platinum Resistive Thermometer (PRT); Thermocouple; Laws of Thermocouple; Types of Thermocouples; Semiconductor-Junction Sensors; Pyrometers
10. **Signal Conditioning** - Measurement System; Grounded and Floating Signal Sources; Ground Loops; Elimination of Ground Loops; Noise Sources; Types of Noise; Coupling Mechanisms of Noise; Noise Reduction; Front-End Amplification; Filtering; Multiplexing; Isolation

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	0	2	14	70	4	1 / 3hrs

Topic Outline:

Week No.	No. of hours	Topics
1	2	**Introduction** Review of Syllabus; Introduction to Measurement; Standards
1, 2	6	**DC meters** D'Arsonval Principle; DC Meters; DC Ammeters; DC Voltmeters; DC Ohmmeters; Multi-range DC Meters; Ayrton Shunt; Precaution on Meters **Laboratory Experiment** Basic Voltmeter Design
3	4	**AC meters** Full Wave Rectifier; Half Wave Rectifier; Average Value, RMS Value, Peak-to-Peak Value; Multi-range AC Meters **Laboratory Experiment** AC Voltmeters
4, 5	6	**Diode**s Depletion Region; Diode Characteristic; Forward Bias; Reverse Bias; Breakdown Voltage; Diode Models; Bridge Rectifier; Voltage Regulator; Special-Purpose Diodes; Troubleshooting
5, 6, 7	8	**Transistors** Bipolar Junction Transistor (BJT); Load-Line Analysis; CE Amplifier; CC Amplifier; Class A Amplifier; Class B Amplifier; Field Effect Transistor (FET); JFET; MOSFET; CS Amplifier; CD amplifier; Application
7, 8	4	**Bridges** Wheatstone's Bridge; Kelvin's Bridge; Bridge-Controlled Circuits; AC Bridges. **Laboratory Experiment** Bridge-Controlled Circuit
8, 9, 10	10	**Operational amplifiers (Op Amp)** Pin Configuration; Ideal Op Amp; Summing-Point Constraint; Inverting Amplifier; Non-Inverting Amplifier; Voltage Follower; Differential Amplifier; Summing Amplifier; Integrator; Differentiator; Logarithmic Amplifier; Anti-Log Amplifier; Multiplication and Division with Op Amps; Comparator; Analog-to-Digital Converter (ADC); Digital-to-Analog Converter (DAC); Instrumentation Amplifier; Applications **Laboratory Experiment** Operational Amplifiers

11, 12	6	**Transducers** Classification; Contacting Spindle; Elastic Transducer; Mass Transducer; Thermal Transducer; Hydro-Pneumatic Transducer; Resistive Transducer; Inductive Transducer; Linear Variable Differential Transformer (LVDT); Capacitive Transducer; Piezo-Electric Transducer; Strain Gauge; Ionization Transducer; Photo Emissive Transducer; Photo Conductive Transducer; Photo Voltaic Transducer
12, 13	6	**Measurement of Temperature** Liquid-in-Glass Thermometer; Bimetallic Elements; Pressure Thermometer; Resistance Temperature Detector (RTD); Platinum Resistive Thermometer (PRT); Thermocouple; Laws of Thermocouple; Types of Thermocouples; Semiconductor-Junction Sensors; Pyrometers **Laboratory Experiment** Transducers and Temperature Measurement
14	4	**Signal conditioning** Measurement System; Grounded and Floating Signal Sources; Ground Loops; Elimination of Ground Loops; Noise Sources; Types of Noise; Coupling Mechanisms of Noise; Noise Reduction; Front-End Amplification; Filtering; Multiplexing; Isolation

Contribution of course to meet the professional component:

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

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:

(b) an ability to design and conduct experiments, as well as to analyze and interpret data.
(d) an ability to function on multidisciplinary teams.
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context, especially the importance of health, safety and environmental considerations to both workers and the general public;
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Course content:

Maths	Basic Science	Engineering Science	Engineering Design and Synthesis	Complementary Studies	Computer Studies	Total 100%
5	0	70	25	0	0	100

Persons who prepared this description:

Mr. Seng Kin Lao

Part B – General Course Information and Policies

1st Semester 2012/2013

Instructor: Mr. Seng Kin Lao
Office Hour: By appointment
Email: skeltonl@umac.mo
Office: N327C
Phone: (853) 8397-4379

Time/Venue:

Every Monday, 2:00 p.m. – 4:00 p.m., Room WLG104
Every Tuesday, 8:30 a.m. – 9:30 a.m., Room WLG104
Every Friday, 9:30 a.m. – 11:30 a.m., Room U102

Assessment:

Final assessment will be determined on the basis of:
Homework: 20%
Lab Report: 20%
Mid-term: 30%
Final Exam (Comprehensive): 30%

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:

- 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.

Quizzes/Mid-terms Exams:

One mid-term exam will be held during the semester. There will be 6 experiments, including voltmeter design, ammeter design, and frequency and phase measurements using oscilloscope, bridge-controlled circuit, Op Amp circuit design, and applications of transducers. Lab report is due one week after experiment.

Note:

- A student who is absent without applying for leave of absence from a course for more than 20% of its scheduled teaching periods in the aggregate will not be allowed to take the final examination and will receive a failing grade for that course.
- 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 give except for CLEAR medical proof.
- No exam is given if you are 15 minutes late in the midterm exam 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 (d)	5 (Excellent)	3 (Average)	1 (Poor)
Ability to work in teams	Performance on teams is excellent with clear evidence of equal distribution of tasks and effort as well as frequent meetings of the team members.	Performance on teams is acceptable with one or more members carrying a larger amount of the effort as well as infrequent meetings of the members or one or more members being absent from several meetings.	Performance on teams is poor to unacceptable with one or two members clearly carrying the majority of the effort as well as inadequate team meeting or one or more members missing the majority of the meetings.
Multi-disciplinary teams	Team consists of members from two or more different engineering/science/business fields (this could contain some members not actually enrolled in the course but interacting as part of a competition, collaboration, etc.)	Team consists of members from two or more concentrations within the Department of Electromechanical Engineering	Team consists of members from the same concentration within the Department of Electromechanical Engineering

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 (h)	5 (Excellent)	3 (Average)	1 (Poor)
Lab safety	Students will demonstrate good understanding of lab safety in electronics and instrumentations	Students demonstrate a little knowledge of lab safety in electronics and instrumentations	Students do not aware of lab safety

Rubric for (k)	5 (Excellent)	3 (Average)	1 (Poor)
Use modern hardware tools in engineering practice	Student uses the hardware to measure and/or build engineering systems/designs correctly, and understands the limitations of the hardware.	Student uses the hardware to measure and/or build engineering systems/designs correctly.	Student does not use the hardware correctly.