University of Macau
Department of Electromechanical Engineering
MECH471－Computational Methods
Syllabus
2nd Semester 2011/2012
Part A – Course Outline

Required elective course in Electromechanical Engineering

Course description:

Introduction of computational methods in engineering with MATLAB programming, the pros and cons of classical and modern methods. This course covers mathematical modeling, curve fitting, and optimization techniques. Linear regression and nonlinear regression algorithms. Artificial neural networks for function fitting, multilayer neural networks, back-propagation learning algorithms, supervised and unsupervised learning, and radial basis function (RBF) neural networks. Optimization methods such as golden search method, quadratic approximation method, Nelder–Mead method, steepest descent method, Newton method, simulated-annealing (SA) method, and genetic algorithm (GA). The implementation of the computational methods with MATLAB language.

Prerequisite:

None

Textbook:

- Steven C. Chapra, ***Applied Numerical Methods with MATLAB for Engineers and Scientists***, 3rd Edition, McGraw-Hill, 2012.
- S. Sumathi and Surekha P., ***Computational Intelligence Paradigms Theory & Applications using MATLAB***, CRC Press, 2010.

References:

- W. Y. Yang, W. Cao, T.-S. Chung, and J. Morris, *Applied numerical methods using MATLAB*, John Wiley & Sons, 2005.
- Michael Negnevitsky, Artificial Intelligence - A Guide to Intelligent Systems, 2nd Edition, Addison-Wesley, 2005.
- S. Sumathi, T. Hamsapriya, and P. Surekha, *Evolutionary Intelligence-An Introduction to Theory and Applications with Matlab*, Springer, 2008.
- Alfio Quarteroni, Fausto Saleri, and Paola Gervasio, *Scientific Computing with MATLAB and Octave*, 3rd Edition, Springer, 2010.
- Howard Demuth, Mark Beale, and Martin Hagan, *MATLAB Neural Network Toolbox User's Guide*, Version 7.0, The MathWorks, 2010.
- *MATLAB Global Optimization Toolbox User's Guide*, Version 3.0, The MathWorks, 2010.

Course objectives:

1. Learn fundamental computational methods in modeling, curve fitting, and optimization. Learn artificial neural networks for function fitting and genetic algorithm for optimization applications. [a, e, f]
2. Learn the basic of MATLAB language and the implementation of both classic and modern computational methods with MATLAB language. [a, f, g, l]
3. Solve an engineering problem by design and implement a computational algorithm with MATLAB language. [a, e, f, g, l]

Topics covered:

1. **Introduction** – Review of Syllabus; Introduction to Classical and Modern Computational Methods in engineering applications; Concepts of Computational Intelligence and Applications; MATLAB basics.

2. **Mathematical Modeling, Numerical Methods, and Problem Solving** – A Simple Mathematical Model based on Newton's Second Law, Conservation Laws in Engineering and Science, Lagrange's Equation, Numerical Methods Covered in This Course, Case Study
3. **MATLAB Fundamentals, Programming with MATLAB** – The MATLAB Environment, Assignment, Mathematical Operations, Use of Built-In Functions, Graphics, Other Resources, M-Files, Input-Output, Structured Programming, Nesting and Indentation, Passing Functions to M-Files
4. **Optimization Methods –** Unconstrained Optimization, Golden Search Method, Quadratic Approximation Method, Nelder–Mead Method, Steepest Descent Method, Newton Method, Conjugate Gradient Method, Simulated Annealing Method, Genetic Algorithm, Constrained Optimization, Lagrange Multiplier Method, Penalty Function Method, MATLAB Built-In Routines for Optimization, Unconstrained Optimization, Constrained Optimization, Linear Programming
5. **Evolutionary Computation and Genetic Algorithm –** Introduction of Evolutionary Computation, Encoding and Optimization Problems, Historical Overview of Genetic Algorithm, Genetic Algorithm Description, Role of Genetic Algorithms, Solution Representation of Genetic Algorithms, Parameters of Genetic Algorithm, Schema Theorem and Theoretical Background, Crossover Operators and Schemata, Genotype and Fitness, Advanced Operators in GA, GA Versus Traditional Search and Optimization Methods, Benefits of GA, MATLAB Programs on Genetic Algorithm Case Study
6. **Linear Regression** – Statistics Review, Random Numbers and Simulation, Linear Least-Squares Regression, Linearization of Nonlinear Relationships, Computer Applications, Case Study
7. **General Linear Least-Squares and Nonlinear Regression** – Polynomial Regression, Multiple Linear Regression, General Linear Least Squares, QR Factorization and the Backslash Operator, Nonlinear Regression, Case Study: Fitting Experimental Data
8. **Artificial Neural Networks –** Introduction, A Brief History of Neural Networks, Artificial Neural Networks, Comparison of Neural Network to the Brain, Artificial Neurons, Implementation of Artificial Neuron Electronically, Operations of Artificial Neural Network, Training an Artificial Neural Network, Comparison between Neural Networks, Neural Network Components, Teaching an Artificial Neural Network, Learning Rates, Learning Laws, MATLAB Implementation of Learning Rules, Case Study

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	0	2	14	56	3	1 / 2hrs

Topic Outline:

Week No.	No. of hours	Topics
1	4	Introduction
2	4	Mathematical Modeling, Numerical Methods, and Problem Solving
3	4	MATLAB Fundamentals, Programming with MATLAB
9, 10	8	Optimization Methods
11, 12, 13	12	Evolutionary Computation and Genetic Algorithm; MATLAB programming
4	4	Linear Regression
5	4	General Linear Least-Squares and Nonlinear Regression
6, 7, 8	12	Artificial Neural Networks; MATLAB programming
14	4	Course Review

Contribution of course to meet the professional component:

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

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.
(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.

The course secondarily contributes to Electromechanical Engineering Programme outcomes that develop student abilities to:
(f) an understanding of professional and ethical responsibility.
(g) an ability to communicate effectively.

Course content:

Maths	Basic Science	Engineering Science	Engineering Design and Synthesis	Complementary Studies	Computer Studies	Total 100%
10	0	40	0	20	30	100

Persons who prepared this description:

Dr. Qingsong Xu

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Part B – General Course Information and Policies

2nd Semester 2011/2012

Instructor: Dr. Qingsong Xu
Office: B1-A710
Office Hour: By appointment
Phone: (853) 8397-8462
Email: qsxu@umac.mo

Time/Venue:

Every Tuesday, 12:30 p.m. - 2:30 p.m., Room JG14
Every Saturday, 12:30 p.m. - 2:30 p.m., Room JG14

Assessment:

Final assessment will be determined on the basis of:

Homework:	20%
Mid-term Exam (open-book):	30%
Final Exam (2-hour comprehensive open-book exam):	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

Homework Policy:

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

- There will be approximately 4 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.

Quizzes/Mid-terms Exams:

One open-book mid-term exam will be held during the semester. There will be a 100-minute exam.

Note:

- Attendance is strongly recommended.
- No make-up exam is give 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 (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 (f)	5 (Excellent)	3 (Average)	1 (Poor)
Design	Understand how to critique and analyze design tradeoffs and constraints with respect to safety, liability, and integrity of data, and context of use	Have knowledge of safety, liability, and integrity of data, and context of use but cannot analyze thoroughly	No awareness of importance of safety, liability, and integrity of data, and context of use
Professional Engineering Practice	Understand how to critique and analyze tradeoffs and constraints with respect to research issues of credit and authorship, integrity of data, and informed consent	Have knowledge of credit and authorship, integrity of data, and informed consent but cannot completely identify ownership in practical	No awareness of credit and authorship, integrity of data, and informed consent
Group Relations	Understand how to critique and analyze tradeoffs and constraints with respect to conflict of interest, bribery, professional dissent, authorship, and discrimination	Have partial knowledge of conflict of interest, bribery, professional dissent, authorship, discrimination but cannot apply it in practice correctly	No awareness of conflict of interest, bribery, professional dissent, authorship, and discrimination

Rubric for (g)	5 (Excellent)	3 (Average)	1 (Poor)
Professional Impact	Student's/Team's/Group's document(s)/presentation(s)	Student's/Team's/Group's document(s)/presentation(s)	Student's/Team's/Group's document(s)/presentation(s)

	is/are considered to be of professional quality	is/are considered acceptable for college level work	is/are considered unacceptable for college level work
Written Component	Document is nearly error free with sophisticated use of vocabulary, formatted properly, with well developed concise sentences and paragraphs	Document contains some errors with a somewhat colloquial vocabulary, minor formatting issues, with some organizational issues that do not interfere with communication	Document contains many errors, very colloquial vocabulary, with severe organizational issues that interfere with communication. Document would be considered unacceptable.
Oral Component	Presentation is consistent, uniform, clear, direct, complete and captivating with very clear fonts and graphics with an excellent layout that clearly presents the technical content	Presentation is somewhat inconsistent between speakers, occasionally difficult to hear, with an acceptable layout containing acceptable fonts and graphics that adequately presents the technical content	Presentation is very inconsistent between speakers, difficult to hear with a poor layout containing illegible fonts and graphics that poorly presents the technical content. Would be considered unacceptable

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.