NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

COURSE CONTENT

Academic Year	2023/2024	**Semester**	1
Course Coordinator	Asst Prof. Ni Ran / Asst Prof. Tong Ling		
Course Code	CH4244		
Course Title	Numerical Methods and Data Analytics		
Pre-requisites	CH2107 or BG2211/BG2111		
No of AUs	3		
Contact Hours	26 Lecture hours and 13 tutorial hours		
Proposal Date	22 May 2017		

Course Aims

The objective of this course is to introduce the concept of Data Analytics to solve problems encountered in engineering and non-engineering fields. After completing the course, you will be able to use numerical approaches learnt in this course to gain understanding, optimize and make decision from data.

Intended Learning Outcomes (ILO)

Upon successful completion of this course, you will be able to:

1. Develop and use numerical algorithms to solve integration and differential equations.
2. Develop linear regression models and evaluate its goodness of fit criteria and common pitfalls.
3. Apply machine learning to regression and classification problems.
4. Apply neural network to both numerical modelling and machine learning.

Course Content

Key topics taught:

1. Optimization – 1D
2. Optimization – 2D
3. Parameter estimation
4. Numerical Integration
5. Numerical ODE
6. Numerical PDE
7. Regression modelling
    a. Exploratory data analysis.
    b. Regression essentials: key goodness statistics and common pitfalls.
8. Briefing on fundamental modelling and business analytics–broadened applications of ‘models’ in non-engineering business.
9. New modelling paradigms and applications
    a. Supervised Machine Learning-Regression
    b. Supervised Machine Learning-Classification
    c. Neural Network for numerical modelling and machine learning.
    d. Unsupervised Machine Learning and deep learning

Assessment (includes both continuous and summative assessment)

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weighting	Team/ Individual	Assessment rubrics
1. Continuous Assessment 1 (CA1): Assignment	1, 2	EAB SLO* a, b, c, d	25%	Individual	Appendix 1
2. Continuous Assessment 2 (CA2): Quiz	1, 2	EAB SLO* a, b	25%	Individual	
3. Continuous Assessment 3 (CA3): Quiz	3, 4	EAB SLO* a, b,	25%	Individual	
4. Continuous Assessment 4 (CA4): Quiz	3, 4	EAB SLO* a, b,	25%	Individual	
Total			100%		

Formative feedback

During tutorials, the instructor will communicate expected learning outcomes in detail.
After each CA, the instructor will go through the problems during tutorials. Common mistakes and misunderstanding in concepts will also be addressed.
Specific feedback to project work will be returned you in writing. General feedback to project work will be published online.

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
LECTURE	Course materials covering all topics
TUTORIAL	12 classroom discussion sessions on tutorial questions and related topics

Reading and References

1. *Numerical Methods for Engineers, by Steven C. Chapra and Raymond P. Canale (1988)*
2. *Hands-On Machine Learning with Scikit-Learn & TensorFlow", A.Geron, O'Reilly (2017)*
3. *Regression Reference: a.Wikipedia: Linear Regression, b. Duke University course of statistical forecasting by Robert Nau http://people.duke.edu/~rnau/411home.htm Section 4 Linear Regression.*

Course Policies and Student Responsibilities

You are responsible for meeting all course requirements, observing all deadlines, examination times, and other course procedures.

You will be awarded ZERO mark for being absence from quizzes unless it is due to the following reasons:

- Illness (valid medical certificate is required, not from Chinese doctor)
- Passing away of immediate family member (parents, siblings or grandparents)
- Participate in an activity representing NTU (support letter from participating organization)

There will be no makeup given for missed quizzes. Final grade will be determined based on the participated quiz and final examination.

You are responsible for following the university regulations for final examination as indicated here:
http://www.ntu.edu.sg/Students/Undergraduate/AcademicServices/Examination/Pages/Instructionstoexamcand.aspx

You are responsible for being on time for all lectures and tutorials. Sufficient efforts should be put into solving or attempting the tutorial problems prior to attending the respective tutorial classes.

You might be award an “F” for a component or expelled from the university if you are caught cheating.

You are responsible for seeking academic help in a timely fashion.

Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU’s shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office Location	Phone	Email
Ni Ran	N1.2-B1-12	67906737	r.ni@ntu.edu.sg
Tong Ling	N1.3-B3-13	63168879	tong.ling@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Optimization – 1D	1	
2	Optimization – 2D	1	
3	Parameter estimation	3	
4	Numerical Integration	2	
5	Numerical ODE	2	
6	Numerical PDE	2	
7	Quiz	1 & 2	
8	Modelling framework, Data exploration, Linear Regression	3	
9	Linear regression	3	
10	Introduction to Machine Learning(ML), ML for regression. CA3	4	
11	ML for classification	5	
12	Neural network	6	
13	Unsupervised learning and additional ML subjects. CA4	6	

Appendix 1: Assignment

Criteria	Exceed Expectations	Meet Expectations	Meet Baseline Expectations	Below Expectations
LO 1 and 2	Choose an appropriate numerical algorithm to solve specific engineering problems. Implement the proper algorithm correctly in computer program and obtain the results. The results were interpreted clearly and conclusion was drawn in highly articulate numerical and English language.	Choose an appropriate numerical algorithm to solve specific engineering problems. Implement the proper algorithm correctly in computer program and obtain the results. The results were interpreted clearly but the conclusion can be drawn in a more technical language.	Choose an appropriate numerical algorithm to solve specific engineering problems. Implement the proper algorithm correctly in computer program and obtain the results. The results interpretation are acceptable but the conclusion was not supported by the appropriate numerical results	Unable to correctly choose and implement proper numerical algorithms for solving specific engineering problems. No result and/or interpretation to showcase.

Appendix 2: The EAB (Engineering Accreditation Board) Accreditation SLOs (Student Learning Outcomes)

a) **Engineering knowledge:** Apply the knowledge of mathematics, natural science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems
b) **Problem Analysis:** Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c) **Design/development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
d) **Investigation:** Conduct investigations of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e) **Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations
f) **The engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g) **Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for the sustainable development.
h) **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i) **Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.
j) **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k) **Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and economic decision-making, and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
l) **Life-long Learning:** Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change