

## Annexe A: New/Revised Course Content in OBTL+ Format

### Course Overview

The sections shown on this interface are based on the templates [UG OBTL+](#) or [PG OBTL+](#)

If you are revising/duplicating an existing course and do not see the pre-filled contents you expect in the subsequent sections e.g. Course Aims, Intended Learning Outcomes etc. please refer to [Data Transformation Status](#) for more information.

|  |  |
|--|--|
| Expected Implementation in Academic Year                   | AY2021-2022                                |
| Semester/Trimester/Others (specify approx. Start/End date) | Semester 1                                 |
| Course Author<br>* Faculty proposing/revising the course   | Liang Kaicheng and Ni Ran                  |
| Course Author Email  | kaicheng.liang@ntu.edu.sg; r.ni@ntu.edu.sg |
| Course Title   | Numerical Methods and Data Analytics       |
| Course Code  | CH4244                                     |
| Academic Units   | 3  |
| Contact Hours  | 39   |
| Research Experience Components                             | Not Applicable                             |

## Course Requisites (if applicable)

|                       |                  |
|-----------------------|------------------|
| Pre-requisites        | CH2107 or BG2111 |
| Co-requisites         |                  |
| Pre-requisite to      |                  |
| Mutually exclusive to |                  |
| Replacement course to |                  |
| Remarks (if any)      |                  |

## 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.

## Course's Intended Learning Outcomes (ILOs)

Upon the successful completion of this course, you (student) would be able to:

|       |   |
|-------|---|
| ILO 1 | Develop and use numerical algorithms to solve integration and differential equations.           |
| ILO 2 | Develop linear regression models and evaluate its goodness of fit criteria and common pitfalls. |
| ILO 3 | Apply machine learning to regression and classification problems.                               |
| ILO 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
8. Decision trees
9. Model evaluation and performance metrics
10. Neural networks for numerical modelling and machine learning
11. Generative AI for images and language
12. Foundation models

## Reading and References (if applicable)

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.
4. Elements of Statistical Learning, Hastie and Tibshirani.

NOTE: The above listing comprises the foundational readings for the course and more up-to-date relevant readings will be provided when they become available

## Planned Schedule

| Week or Session | Topics or Themes   | ILO   | Readings                          | Delivery Mode | Activities |
|-----------------|--|-------|-----------------------------------|---------------|------------|
| 1               | Optimization - 1D  | 1     | Lecture notes and course readings | In-person     | Lecture    |
| 2               | Optimization - 2D  | 1     | Lecture notes and course readings | In-person     | Lecture    |
| 3               | Parameter estimation                                     | 3     | Lecture notes and course readings | In-person     | Lecture    |
| 4               | Numerical Integration                                    | 2     | Lecture notes and course readings | In-person     | Lecture    |
| 5               | Numerical ODE  | 2     | Lecture notes and course readings | In-person     | Lecture    |
| 6               | Numerical PDE  | 2     | Lecture notes and course readings | In-person     | Lecture    |
| 7               | Quiz   | 1 & 2 | Prepare for quiz                  | In-person     | Quiz       |
| 8               | Modelling framework, Data exploration, Linear Regression | 3     | Lecture notes and course readings | In-person     | Lecture    |
| 9               | Linear and logistic regression, model evaluation         | 3     | Lecture notes and course readings | In-person     | Lecture    |
| 10              | Decision trees   | 4     | Lecture notes and course readings | In-person     | Lecture    |
| 11              | Neural networks  | 5     | Lecture notes and course readings | In-person     | Lecture    |
| 12              | Generative AI  | 6     | Lecture notes and course readings | In-person     | Lecture    |
| 13              | Foundation models, Quiz                                  | 6     | Lecture notes and course readings | In-person     | Lecture    |

## Learning and Teaching Approach

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

## Assessment Structure

Assessment Components (includes both continuous and summative assessment)

| No. | Component   | ILO     | Related PLO or Accreditation | Weightage | Team/Individual | Rubrics  | Level of Understanding |
|-----|---|---------|------------------------------|-----------|-----------------|----------|------------------------|
| 1   | Continuous Assessment (CA):<br>Assignment(Continuous Assessment 1 (CA1): Assignment ) | 1,<br>2 | EAB SLO* a,<br>b, c, d       | 10        | Individual      | Holistic | Not Applicable         |
| 2   | Continuous Assessment (CA):<br>Test/Quiz(Continuous Assessment 2 (CA2): Quiz )        | 1,<br>2 | EAB SLO* a,<br>b             | 40        | Individual      | Holistic | Not Applicable         |
| 3   | Continuous Assessment (CA):<br>Assignment(Continuous Assessment 3 (CA3): Assignment)  | 3,<br>4 | EAB SLO* a,<br>b             | 10        | Individual      | Holistic | Not Applicable         |
| 4   | Continuous Assessment (CA):<br>Test/Quiz(Continuous Assessment 4 (CA4): Quiz )        | 3,<br>4 | EAB SLO* a,<br>b             | 40        | Individual      | Holistic | Not Applicable         |

Description of Assessment Components (if applicable)

Assignments are takehome and are either a set of more challenging practice problems or a small individual project. Quizzes test material covered in the course.

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.

# NTU Graduate Attributes/Competency Mapping

This course intends to develop the following graduate attributes and competencies (maximum 5 most relevant)

| Attributes/Competency | Level |
|-----------------------|-------|
|-----------------------|-------|

## Course Policy

### Policy (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. On the use of technological tools (such as Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

### Policy (General)

You are expected to complete all assigned pre-class readings and activities, attend all classes punctually and take all scheduled assignments and tests by due dates. You are expected to take responsibility to follow up with course notes, assignments and course related announcements. You are expected to participate in all discussions and activities.

### Policy (Absenteeism)

Absence from class without a valid reason will affect your overall course grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies.

### Policy (Others, if applicable)

Last Updated Date: 04-04-2025 08:53:36

Last Updated By: Lai Ru Ying

Appendix 1: Assignment

| Criteria   | Exceed Expectations (75-100%)  | Meet Expectations (50-74%)   | Meet Baseline Expectations (25-49%)   | Below Expectations (0-24%)   |
|------------|--|--|---|--|
| LO 1 and 2 | <p>Choose an appropriate numerical algorithm to solve specific engineering problems.</p> <p>Implement the proper algorithm correctly in computer program and obtain the results.</p> <p>The results were interpreted clearly and conclusion was drawn in highly articulate numerical and English language.</p> | <p>Choose an appropriate numerical algorithm to solve specific engineering problems.</p> <p>Implement the proper algorithm correctly in computer program and obtain the results.</p> <p>The results were interpreted clearly but the conclusion can be drawn in a more technical language.</p> | <p>Choose an appropriate numerical algorithm to solve specific engineering problems.</p> <p>Implement the proper algorithm correctly in computer program and obtain the results.</p> <p>The results interpretation are acceptable but the conclusion was not supported by the appropriate numerical results</p> | <p>Unable to correctly choose and implement proper numerical algorithms for solving specific engineering problems.</p> <p>No result and/or interpretation to showcase.</p> |

## Mapping of Course ILOs to EAB Graduate Attributes

|                                |   |
|--------------------------------|---|
| <b>Course Code &amp; Title</b> | CH4244 Numerical Methods and Data Analytics |
| <b>Course Type</b>             | UG  |

| Overview   |   |     |   |     |   |     |   |     |   |     |   |
|--|---|-----|---|-----|---|-----|---|-----|---|-----|---|
| (a)  | ● | (b) | ● | (c) | ● | (d) | ● | (e) | ● | (f) | ● |
| (g)  | ◐ | (h) | ◐ | (i) | ● | (j) |   | (k) |   |     |   |
| Legend:<br>● Fully consistent (contributes to more than 75% of Student Learning Outcome)<br>◐ Partially consistent (contributes to about 50% of Student Learning Outcome)<br>○ Weakly consistent (contributes to about 25% of Student Learning Outcome)<br>Blank Not related to Student Learning Outcome |   |     |   |     |   |     |   |     |   |     |   |

| Course ILOs |   | EAB Graduate Attributes |
|-------------|---|-------------------------|
| 1)          | Develop and use numerical algorithms to solve integration and differential equations.           | a,b,c,d,e,f,i           |
| 2)          | Develop linear regression models and evaluate its goodness of fit criteria and common pitfalls. | a,b,c,d,e,f,i           |
| 3)          | Apply machine learning to regression and classification problems.                               | a,b,c,d,e,f,i           |
| 4)          | Apply neural network to both numerical modelling and machine learning.                          | a,b,c,d,e,f,g,h,i       |
| 5)          |   |                         |
| 6)          |   |                         |
| 7)          |   |                         |
| 8)          |   |                         |
| 9)          |   |                         |
| 10)         |   |                         |

## EAB GRADUATE ATTRIBUTES

- a) **Engineering Knowledge:** Apply the knowledge of mathematics, natural science, computing and engineering fundamentals, and an engineering specialisation as specified in WK1 to WK4 respectively 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 with holistic considerations for sustainable development. (WK1 to WK4)
- c) **Design / Development of Solutions:** Design creative solutions for complex engineering problems and design systems, components or processes that meet identified needs with appropriate consideration for public health and safety, whole-life cost, net zero carbon as well as resource, cultural, societal, and environmental considerations as required. (WK5)
- d) **Investigation:** Conduct investigations of complex problems using research-based knowledge (WK8) 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 problems, with an understanding of the limitations. (WK2 and WK6)
- f) **The Engineer and the World:** When solving complex engineering problems, analyse and evaluate sustainable development impacts to: society, the economy, sustainability, health and safety, legal frameworks and the environment (WK1, WK5, and WK7).
- g) **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice and adhere to relevant national and international laws. Demonstrate an understanding of the need for diversity and inclusion (WK9).
- h) **Individual and Collaborative Team Work:** Function effectively as an individual, and as a member or leader in diverse and inclusive teams and in multidisciplinary, face-to-face, remote and distributed settings (WK9).
- i) **Communication:** Communicate effectively and inclusively 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, taking into account cultural, language, and learning differences.
- j) **Project Management and Finance:** Demonstrate knowledge and understanding of engineering 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.
- k) **Life-long Learning:** Recognise the need for, and have the preparation and ability to (i) engage in independent and life-long learning, and (ii) adapt to new and emerging technologies, and (iii) think critically, in the broadest context of technological change (WK8).

## KNOWLEDGE PROFILE

- WK1** A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.
- WK2** Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.
- WK3** A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
- WK4** Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.
- WK5** Knowledge including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts that supports engineering design and operations in a practice area.
- WK6** Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.
- WK7** Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline such as the professional responsibility of an engineer to public safety and sustainable development.
- WK8** Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.
- WK9** Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc with mutual understanding and respect, and of inclusive attitudes.