COURSE SYLLABUS

**MTH000\_\_ – Numerical Methods for Information Technology**

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| **1. GENERAL INFORMATION** |  |
| Course name: | Numerical Methods for Information Technology |
| Course name (in Vietnamese): | Ohuowng pháp tính cho Công nghệ thông tin |
| Course ID: | MTH000\_\_ |
| Knowledge block: | General Education Knowledge |
| Number of credits: | 4 |
| Credit hours for theory: | 45 |
| Credit hours for practice: | 30 |
| Credit hours for self-study: | 90 |
| Prerequisite: | none |
| Prior-course: | none |
| Instructors: |  |

# COURSE DESCRIPTION

The course is designed to provide students with a system of mathematical concepts learned in the first semesters of university (calculus, linear algebra), introducing algorithmic skills to be able to solve CS/AI problems. Specifically, the course includes 3 knowledge blocks:

* Computational methods for matrix algebra.
* Computational methods for approximating and optimizing functions.
* Computational methods for statistical data description.

# COURSE GOALS

At the end of the course, students are able to

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| **ID** | **Description** | **Program LOs** |
| G1 | Apply teamwork and individual skills | 2.2, 2.3.1 |
| G2 | Explain terminologies in numerical methods. | 2.4.3, 2.4.5 |
| G3 | Explain terminologies in computer science and AI. | 1.4, 3.3 |
| G4 | Define applied mathematical problems. | 1.3.6, 1.4 |
| G5 | Apply math knowledge to solve CS/AI problems. | 5.1.1, 5.1.3, 5.2.1,   5.2.2, 5.3.1, 6.1.1 |
| G6 | Apply Python programming. | 1.2.1, 1.3.1 |

# COURSE OUTCOMES

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| **CO** | **Description** | **I/T/U** |
| G1.1 | Establish, organize, operate, and manage the team. | I |
| G1.2 | Participate in group discussions. | I, T |
| G1.3 | Writing a technical report. | U |
| G2.1 | Explain terminologies. | I |
| G2.2 | Apply reading skills on English lectures and textbooks. | I |
| G3.1 | Explain basic concepts. | I |
| G3.2 | Apply ethics. | I |
| G3.3 | Apply self-study. | I |
| G4.1 | Use the learned models. | I, T |
| G5.1 | Describe the learned mathematical and statistical methods | I, T |
| G5.2 | Design an algorithm. | I, T, U |

# TEACHING PLAN

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| **ID** | **Topic** | **Course outcomes** | **Teaching/Learning**  **Activities (samples)** |
| 1 | Solution of linear equations system  . Gaussian elimination with Back-substitution  . Iterative improvement of a solution  . Invertible matrices  . Sherman-Morrison formula |  | Lecturing  Demonstration  Discussion  Q&A |
| 2 | Matrix decompositions  . LU decomposition  . QR decomposition  . Eigenvalue and eigenvector  . Matrix Diagonalization  . Singular Value Decomposition |  | Lecturing  Demonstration  Discussion  Q&A |
| 3 | Interpolation - Extrapolation  . Polynomial Interpolation and Extrapolation  . Cubic spline interpolation  . Rational function interpolation/extrapolation |  | Lecturing  Demonstration  Discussion  Q&A |
| 4 | Interpolation on data in multidimensions  . Interpolation by Kriging  . Laplace Interpolation |  | Lecturing  Demonstration  Case study  Discussion  Q&A |
| 5 | Evaluation of Function  . Polynomials  . Rational functions  . Evaluation of Continued Fractions  . Chebyshev Approximation |  |  |
| 6 | Midterm review |  | Case study  Discussion  Q&A |
| 7 | Minimization/Maximization of Functions  . Convex functions  . Quadratic forms  . Data fitting |  | Lecturing  Demonstration  Discussion  Q&A |
| 8 | Min/Max of Function on n-Dimension  . Extreme values ​​of one-dimensional functions  . Line Methods in Multidimensions |  | Lecturing  Demonstration  Discussion  Q&A |
| 9 | Statistical description of data  . Moments of a distribution: mean, median, mode  . Moments of a distribution: variance  . Moments of a distribution: skewness, kurtosis |  | Lecturing  Demonstration  Discussion  Q&A |
| 10 | 2 distributions have the same mean or variance  . t-test for the significantly different means  . t-test for the significantly different variances  . Chi-square test |  | Lecturing  Demonstration  Case study  Discussion  Q&A |
| 11 | Final review |  | Case study  Discussion  Q&A |

For the practical work, there are 10 weeks which cover similar topics as it goes in the theory class. Each week, teaching assistants will explain and demonstrate key ideas on the corresponding topic and ask students to do their lab exercises either on computer in the lab or at home. All the lab work submitted will be graded. There will be a final exam for lab work.

# ASSESSMENTS

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| --- | --- | --- | --- | --- |
| **ID** | **Topic** | **Description** | **Course outcomes** | **Ratio (%)** |
| **A1** | **Assignments** |  |  | **30%** |
|  | Weekly homework: HW#1, HW#2, HW#3, HW#4,  HW#5 | HW#1: System of linear equations.  HW#2: Inverse matrices  HW#3: Matrix decompositions.  HW#4: Interpolation - Extrapolation.  HW#5: Evaluation of Function.  . |  | 30% |
| **A2** | **Assignments** |  |  | **30%** |
| **ID** | **Topic** | **Description** | **Course outcomes** | **Ratio (%)** |
|  | Weekly homework: HW#6, HW#7, HW#8, HW#9, HW#10 | HW#6: Convex functions and data fitting.  HW#7: Min/Max of Function on n-Dimension  HW#8: Statistical quantities describe.  HW#9: t-test.  HW#10: chi-square test. |  | 30% |
| **A3** | **Exams** |  |  | **40%** |
| A31 | Final exam | Closed book exam.  Describe the understanding of different topics, analyze & program to solve problems |  | 40% |

# RESOURCES

# Textbooks

* William H. Press, Soul A. Teukolsky, William T. Vetterling, Brian P. Flannery. *Numerical* *Recipes,* Cambridge University Press, 2007 (available in internet).

**Others**

* [1] G. H. Golub, C. F. Van Loan, *Matrix computations*, 4th edition, Johns Hopkins University Press, 2013.
* [2] Y. Saad, *Iterative methods for sparse linear systems*, 2nd edition, Society for Industrial and Applied Mathematics, 2003.
* [3] S. Boyd, L. Vandenberghe, *Convex optimization*, 7th edition, Cambridge University Press, 2009.
* [4] R. V. Hogg, J. W. McKean, A. T. Craig, *Introduction to mathematical statistics*, 7th edition, Pearson, 2013.
* [5] Zed Shaw, *Learn Python: The Hard* *Way*. Addison Wesley, 3rd Edition, 2014.
* [6] Stephen Boyd, Lieven Vandenberghe, *Introduction to Applied Linear: Algebra, Matrices, and Least Squares,* Cambridge University Press, 2018 (available in internet)

# GENERAL REGULATIONS & POLICIES

* All students are responsible for reading and following strictly the regulations and policies of the school and university.
* Students who are absent for more than 3 theory sessions are not allowed to take the exams.
* For any kind of cheating and plagiarism, students will be graded 0 for the course. The incident is then submitted to the school and university for further review.
* Students are encouraged to form study groups to discuss on the topics. However, individual work must be done and submitted on your own.