CX1104 – Linear Algebra for Computing

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| **Academic Year** | AY20-21 | | **Semester** | | 1 | | | |
| **Author(s)** | Deepu Rajan (ASDRajan@ntu.edu.sg)  Anwitaman Datta ([Anwitaman@ntu.edu.sg](mailto:Anwitaman@ntu.edu.sg))  Chng Eng Siong (aseschng@ntu.edu.sg) | | | | | | | |
| **Course Code** | CX1104 | | | | | | | |
| **Course Title** | Linear Algebra for Computing | | | | | | | |
| **Pre-requisites** | MH1810, CX1103 (co-requisite), | | | | | | | |
| **Pre-requisite for** | CX4100, CX4161, CX3160 | | | | | | | |
| **No of AUs** | 3 | | | | | | | |
| **Contact Hours** | Lectures | 26 | TEL | - | Tutorials | 12 | Lab | 8 |
| **Proposal Date** | May 8, 2020 | | | | | | | |

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| **Course Aims** |
| This course aims to support you to learn mathematical concepts related to linear algebra. You will develop set of mathematical skills for applications in computer science and engineering, e.g., machine learning, computer graphics, data science etc. |
| **Intended Learning Outcomes (ILO)** |
| Solve linear equations and determine conditions for existence and uniqueness of a solution  Perform matrix operations including inverse of a matrix and matrix factorization.  Design matrices for linear transformations; interpret properties of determinants; identify and interpret properties of matrix inverses  Identify and interpret vector spaces and subspaces ;  Interpret correctly the concept of inner product, orthogonality and orthogonal projections  Evaluate least squares solution  Interpret, evaluate and apply Eigen Value and Singular value decomposition  Write code for applications in machine learning, data science, computer vision etc. |

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| **Course Content**   |  |  |  |  | | --- | --- | --- | --- | |  | Topics | Lectures (Hours) | Tutorials (Hours) | | 1 | Linear Equations  System of linear equations; Row reduction and echelon forms; Vector equations; The matrix equation; Solutions sets of linear equations; Linear independence; The matrix of a linear transformation | 4 | 2 | | 2 | **Matrix Algebra**  Matrix operations; Inverse of a matrix; Matrix LU factorization | 3 | 1 | | 3 | **Determinants**  Properties; volume and linear transformations | 1 | 1 | | 4 | **Vector Spaces**  Vector spaces and subspaces; Null spaces, column spaces and linear transformations; linearly independent sets and bases; Dimension of a vector space; Rank; Change of Basis | 4 | 2 | | 5 | **Applications** of topics 1-4 | 1 | - | | 6 | **Orthogonality**  Inner product, length and orthogonality; Orthogonal sets; Orthogonal projections; The Gram-Schmidt process; QR factorization; | 4 | 2 | | 7 | **Least squares**  Minimization Problems,  least-squares solution, | 2 | 1 | | 8 | **EigenValues and Singular Values**  EigenDecomposition : Diagonalizing a matrix  Singular value decomposition and Pseudo-Inverse; condition number and rank | 4 | 2 | | 9 | **Applications** of topics 6-8   * Fourier Series (DFT) – linear algebra for functions * Principle component analysis | 3 | 1 | |
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| **Assessment (includes both continuous and summative assessment)** |
| |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **Component** | **Course LO Tested** | **Related Programme LO or Graduate Attributes** | **Weightage** | **Team/Individual** | **Assessment Rubrics** | | 1. Final Examination | 1 to 8 | (a), (b), (c), (d), (e) | 40% | Individual | Point based marking | | 1. Quiz 1 | 1 to 4 | (a), (b), (c), (d) | 20% | Individual | Point based marking | | 1. Quiz 2 | 5 to 7 | (a), (b), (c), (d) | 20% | Individual | Point based marking | | 4. Lab Quizzes | 1 to 8 | (a), (b), (c), (d), (e), (I), (j) | 20% | Individual | Point based marking | |

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| **Mapping of Course SLOs to EAB Graduate Attributes** |
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| \*The graduate attributes as stipulated by the EAB, are: |
| 1. **Engineering knowledge**: Apply the knowledge of mathematics, natural science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems. 2. **Problem Analysis**: Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. 3. **Design/development of Solution**s: 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. 4. **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. 5. **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. 6. **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. 7. **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. 8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. 9. **Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings. 10. **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. 11. **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. 12. **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. |

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| **Formative feedback** |
| You will receive feedback through two quizzes as well as through discussions during tutorials |
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| **Learning and Teaching approach** |
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| **Reading and References** |
| References:  1) Linear Algebra and its applications, David C. Lay, Steven R. Lay and Judi J. McDonald, Pearson, 2016.  2) Elementary Linear Algebra: Application Version Editions, Anton and Rorres, 11th edition, Wiley.  3) Linear Algebra, David Cherney, Tom Denton, Rohit Thomas and Andrew Waldron, (free textbook) in https://www.math.ucdavis.edu/~linear/ |

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| **Course Policies and Student Responsibilities** |
| As a student of the course, you are required to abide by both the University Code of Conduct and the Student Code of Conduct.  The Codes provide information on the responsibilities of all NTU students, as well as examples of misconduct and details about how students can report suspected misconduct.  The university also has the Student Mental Health Policy.  The Policy states the University’s commitment to providing a supportive environment for the holistic development of students, including the improvement of mental health and wellbeing. These policies and codes concerning students can be found in the following link.  <http://www.ntu.edu.sg/SAO/Pages/Policies-concerning-students.aspx> |

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| **Academic Integrity** |
| Good academic work depends on honesty and ethical behavior. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honor 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, and collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the [academic integrity website](http://www.ntu.edu.sg/ai/ForEveryone/Pages/NTUAcademicIntegrityPolicy.aspx) for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course. |
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| **Course Instructors** |
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| A/P Chng Eng Siong N4-2c-96 67906200 aseschng@ntu.edu.sg |
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| **Planned Weekly Schedule** |
| |  |  |  |  | | --- | --- | --- | --- | | **Week** | **Topic** | **Course LO** | **Readings/ Activities** | | 1 | Linear equations | 1 | Lecture, recommended reading, problem solving | | 2 | Linear equations | 1 | Lecture, recommended reading, problem solving | | 3 | Matrices | 2 | Lecture, recommended reading, problem solving | | 4 | Matrices, Determinants | 3 | Lecture, recommended reading, problem solving | | 5 | Vector spaces | 4 | Lecture, recommended reading, problem solving | | 6 | Vector spaces, | 4 | Lecture, recommended reading, problem solving | | 7 | Applications and Quiz 1 | 8 | Lecture, recommended reading, problem solving, quiz | | 8 | Orthogonality | 5 | Lecture, recommended reading, problem solving | | 9 | Orthogonality | 5 | Lecture, recommended reading, problem solving | | 10 | Least Squares | 6 | Lecture, recommended reading, problem solving | | 11 | Eigenvalues and Singular Values | 7 | Lecture, recommended reading, problem solving | | 12 | Eigenvalues and Singular Values | 7 | Lecture, recommended reading, problem solving | | 13 | Applications and Quiz 2 | 8 | Lecture, recommended reading, problem solving, quiz | |