Nanyang Technological University
Division of Physics and Applied Physics

| Academic Year | 2023-24 | Semester | 1 |
| :---: | :---: | :---: | :---: |
| Course Coordinator | Gu Mile |  |  |
| Course Code | MH2802 |  |  |
| Course Title | Linear Algebra for Scientists |  |  |
| Pre-requisites | H 2 maths or equivalent |  |  |
| Mutually Exclusive | CE1104/CZ1104/SC1004 Linear Algebra for Computing MH1200 Linear Algebra I <br> MH1201 Linear Algebra II <br> CY1602/RE1021 Mathematics II |  |  |
| No of AUs | 3 AU |  |  |
| Contact Hours | 38 hours ( 26 hours lecture; 12 hours of tutorial) |  |  |
| Proposal Date | 12 July 2023 |  |  |

## Course Aims

This course aims to support you in acquiring a wider range of mathematical concepts related to vector spaces and linear algebra, while also developing a strong set of mathematical skills for upper-level Physical and Computing Science courses. Through a mathematical approach to problem-solving, you will have the opportunity to develop thinking, reasoning, communication, and modelling skills.
Additionally, the course aims to help you connect ideas within mathematics and apply mathematical principles in the context of Physical and Computing Science courses. Ultimately, this course seeks to provide an experience that fosters an appreciation for the rigour and abstraction in the discipline.

## Intended Learning Outcomes (ILO)

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

## Basic Vector Operations (BAS)

1. perform simple vector operations (such as vector addition, subtraction and resolving a vector to its components in a given coordinate system) to solve related problems;
2. perform scalar, vector products whenever appropriate to solve related problems (such as determining the projection of a vector on another and calculating the torque of a system of forces);
3. perform scalar, vector triple products whenever appropriate to solve related problems;
4. solve basic problems in analytical geometry using vectors (such as determining distances between point and a line / plane);

## Linear Spaces (LS)

5. recall and use the axioms of a linear space to determine if a given set forms a linear space;
6. apply the idea of linear independence to determine whether a given set of vectors is dependent or independent;
7. explain the idea of the space / subspace is spanned by a given set of (basis) vectors and determine if a set of (basis) vectors span a subspace;
8. apply the concepts of norms and inner products to compute for a given pair of vectors and to test if a given pair of vectors are orthogonal;

## Linear Transformation and Matrices (LTM)

9. explain the concept of linear transformation, express a linear transformation as a matrix and compute the action of a linear transformation on a vector and a matrix (including the structures of rotation, reflection, scaling, stretching and shearing matrices);
10. perform basic operations on matrices (including basic algebraic operations, matrix multiplication, computing of inverses, determinants and traces of matrices);
11. solve systems of linear equations using techniques such as Gaussian elimination;
12. compute the eigenvalues, eigenvectors of a given square matrix and determine the similarity transformation that diagonalizes the given square matrix;
13. recall the definitions and use the properties of special matrices (such as Hermitian and unitary matrices); and

## Applications (APP)

14. apply the techniques from ILO $1-13$ to solve problems in Physical and Computing Science (such as analysing coupled oscillators and using Markov chains to solve problems).

## Course Content

1. Vector Algebra \& Analytical Geometry
2. Linear Spaces
3. Linear Transformations \& Matrices
4. Eigenvalues and Eigenvectors
5. Applications of Linear Algebra to problems in Physical and Computing Science

## Assessment (includes both continuous and summative assessment)

| Component | Course LO Tested | Weighting | Team/ <br> Individual | Assessment <br> Rubrics |
| :--- | :--- | :--- | :--- | :--- |
| 1. Final Examination | All LOs | $60 \%$ | Individual | Point-based <br> marking (not <br> rubrics based) |
| 2. Pre-Lesson <br> Assessments | All LOs | $12 \%$ | Individual | Point-based <br> marking, <br> automated <br> marking |
| 3. Midterm Test | BAS / LS | $28 \%$ | Point-based <br> marking (not <br> rubrics based) |  |
| Total |  | $100 \%$ |  |  |

## Formative feedback

[Component 2] Formative feedback is given through discussion within tutorial lessons as well as interactive, computer based online homework.
[Component 3] Feedback is also given after midterm on the common mistakes and level of difficulty of the problems.

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## Learning and Teaching approach

| Approach | How does this approach support students in achieving the <br> learning outcomes? |
| :--- | :--- |
| Derivation of formulas and <br> demonstrating problem <br> solving <br> (Lecture and Tutorial) | Train students to be independent learners who are able to derive <br> ideas/concepts from first principles and take ownership of their <br> own learning. Help students understand the motivation behind <br> mathematical theorems, definitions and formulas. Develop the <br> train of thought in problem solving and presentation skills in <br> presenting mathematical solutions. |
| Problem solving <br> (Lecture and Tutorial) | Develop competence in solving linear algebra related problems. |
| Peer Instruction <br> (Lecture and Tutorial) | Develop communication skills and competence in mathematics, <br> particularly in linear algebra. The students also have an <br> opportunity to work with their peers. |

## Reading and References

1. David C. Lay and Steven R. Lay, Linear Algebra and Its Applications, $5^{\text {th }}$ edition, Pearson, 2015. ISBN-13: 9780321982384
2. Gilbert Strang, Introduction to Linear Algebra, $5^{\text {th }}$ edition, Wellesley-Cambridge Press, 2016. ISBN-13: 9780980232776
3. Howard Anton, Elementary Linear Algebra: Applications Version, Wiley $10^{\text {th }}$ edition, 2010. ISBN13: 9780470432051

## Course Policies and Student Responsibilities

Students are expected to complete all assigned pre-class assessments before coming to lectures. They are expected to attend all computing labs, and take the mid-term test. Students are expected to take responsibility to understand the course materials, and to seek help when necessary.

## 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.

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## Course Instructors

| Instructor | Office Location | Phone | Email |
| :--- | :--- | :--- | :--- |
| Gu Mile | SPMS-MAS-05-42 | 65137175 | gumile@ntu.edu.sg |

## Planned Weekly Schedule

| Week | Topic | Course LO | Readings/ <br> Activities |
| :---: | :--- | :--- | :--- |
| 1,2 | Vector algebra and vector products | BAS 1,2,3 | \# |
| 2 | Solving problems in analytic geometry <br> using vectors | BAS 4 | \# |
| 3 | Linear spaces and linear independence | LS 5,6 | \# |
| 4 | Subspaces; Basis states and span of a space | LS 7 | \# |
| 5 | Inner products and orthogonality | LS 8 | \# |
| 6 | Linear transformations and matrices | LTM 9 | \# |
| 7 | Matrix algebra and operations | LTM 10 | \# MT |
| 8 | Solving systems of linear equations | LTM 11 | \# |
| 9 | Eigenvalues and eigenvectors | LTM 12 | \# |
| 10 | Special Matrices | LTM 13 | \# |
| $11-13$ | Applications in Physical and Computing <br> Science | APP 14 | \# |

MT* Mid-term - to be conducted during regular curriculum time.
\# Pre/Post-lecture online assignments; Post Lecture tutorial lessons

