# ZJU-UIUC Institute – Course Syllabi

1. **Course number and name**
   MATH 257, Linear Algebra with Computational Applications, Fall Semester 2022

2. **Credits and contact hours**
   3 credits
   4 contact hours (2 h lecture, 2 h discussion)

3. **Instructor**
   Prof. Dr. Thomas Honold, ZJU-UIUC Institute

4. **Teaching Assistants**
   Yuan Yue, Si Zhenzuo, Xu Jiazhen, Li Zihao, Lv Xin, Jin Kailong, Ouyang Yichen, Wei Dong, Chen Shengjian

5. **Textbook**

   **[NM20]** Daniel Norman, Dan Wolczuk, *Introduction to Linear Algebra for Science and Engineering*, 3rd Edition, Pearson Education 2020

   (a) **Other supplemental materials**
   Teaching material: Lecture slides, whiteboard illustrations, worksheets, homework sheets
   Supplementary references: SageMath documentation (especially the SageMath tutorial, available from `www.sagemath.org`; Lorenzo Robbiano, *Linear Algebra for Everyone*, Springer 2011

6. **Specific course information**

   (a) **Brief description** The course offers an introduction to basic concepts and techniques of Linear Algebra, covering the standard material that is contained in [NM20], Chapters 1–8 (and, optionally, Chapter 9). Foundational prerequisites (about mathematical logic, sets, functions) will be included on demand in the 1st course week. For the computational part the computer algebra system SageMath `www.sagemath.org` is used. Lectures provide introductory examples of Linear Algebra computations in SageMath, and students practice these computations in weekly exercises and a more extensive lab exercise (small lab project) towards the end of the course.

   (b) **Prerequisites or co-requisites**
   Required: MATH 221 Calculus I
   Co-recommended: MATH 213 Discrete Mathematics; MATH 231 Calculus II; MATH 241 Calculus III

(c) **Course status**
Mandatory course

7. **Specific goals of the course**

   (a) Upon successful completion of the course, students should

   - know the basic concepts and techniques of Linear Algebra and Analytic Geometry (vector spaces, representation of subspaces, matrices, inner products, quadratic forms, Gaussian elimination, diagonalization)
   - be able to model certain real-world problems, including those involving large-scale "linear" data, in the language of Linear Algebra and solve them through standard techniques such as Gaussian elimination, the method of least squares, or diagonalization.
   - have a working knowledge of the computer algebra system SageMath and its objects/methods for Linear Algebra computations.

   (b) For acquiring a good working knowledge of Linear Algebra students need to practise a lot, including computer experimentation. This goal is addressed in the accompanying weekly worksheet and homework assignments with both theoretical and programming exercises of varying difficulty.

8. **Teaching calendar (tentative)**

**Week 1** Foundations of logic, sets, functions (other sources)
Analytic Geometry ([NM20], 1.1–1.3)

**Week 2** Analytic Geometry cont'd ([NM20], 1.4–1.5)
Matrices, linear maps ([NM20], 3.1–3.2)

**Week 3** System of Linear equations ([NM20], 2.1–2.2, 2.4)

**Week 4/5** Vector spaces ([NM20], 4.1–4.7)
Linear independence, spanning sets, bases, Fundamental Theorem of Linear Algebra, dimension, subspaces, dimension formula for subspaces, direct sums
Application to matrices ([NM20], 2.3, 3.4–3.6)
Row space, column space, rank, matrix inversion

**Week 6** Determinants ([NM20], 5.1–5.4)

**Week 7/8/9** Eigenvectors and diagonalization ([NM20], 4.6–4.7, 6.1–6.3)
Matrices of linear maps, eigenvectors, eigenspaces, characteristic polynomial, diagonalisation, applications of diagonalization

**Week 10** Generalized eigenvectors, Jordan canonical form (other sources)

**Week 11** Inner product spaces ([NM20], 7.1–7.5])

**Week 12/13** Symmetric matrices and quadratic forms ([NM20], 8.1–8.4, 9.5)
Spectral theorem, principal axes theorem, Sylvester's algorithm, classification of quadric surfaces, unitary diagonalization

**Week 14** Optimization (other sources)
Fourier-Motzkin elimination, Simplex algorithm

Optimization is considered an optional topic and can be replaced by other applications, e.g., Markov chains and the Perron-Frobenius theorem, or numerical Linear Algebra.

9. **Schedule of Lectures**
   Section AC: Tue 10-11, Wed 9–10, Residential College 2
   Section BE: Tue 11-12, Wed 8–9, Residential College 2
   28 lectures from Sep 13 to Dec 20 (15 weeks, no lectures on Oct 4, Oct 5)

10. **Schedule of Discussion sessions**

| Group | Time | Venue | TA |
|---|---|---|---|
| A1 | Tue 6-8 pm | LTN-A 421 | Yuan Yue |
| A2 | Tue 6-8 pm | LTN-A 423 | Si Zhenzuo |
| A3 | Tue 6-8 pm | LTN-A 424 | Xu Jiazhen |
| A4 | Tue 6-8 pm | LTN-A 410 | Li Zihao |
| A5 | Tue 6-8 pm | LTN-A 425 | Lv Xin |
| A6 | Tue 6-8 pm | LTN-A 426 | Jin Kailong |
| A7 | Tue 6-8 pm | LTN-A 404 | Ouyang Yichen |
| A8 | Tue 6-8 pm | LTN-A 408 | Wei Dong |
| A9 | Tue 6-8 pm | online | Chen Shengjian |

    14 discussion sessions (est.) on Sep 13, Sep 20, Sep 27, Oct 11, Oct 18, Oct 25, Nov 1, Nov 8, Nov 15, Nov 22, Nov 29, Dec 6, Dec 13, Dec 20

11. **Schedule of Homework**
    13 homework assignments (est.), due on Sep 20, Sep 27, Oct 11, Oct 18, Oct 25, Nov 1, Nov 8, Nov 15, Nov 22, Nov 29, Dec 6, Dec 13, Dec 20

12. **Examination Schedule (tentative**
    Midterm 1: Tue Nov 1, 18:00–19:30
    Midterm 2: Tue Nov 29, 18:00–18:45
    Lab exercise: Assigned after Midterm 2 and due in Course Week 14
    Final Exam: 3 hours, during examination week

13. **Grading Policy**
    The final score is calculated as follows:

    **40 %** final exam (closed book)

    **22.5 %** 2 midterm exams (closed book), contributing $\max\{a + b/4, 5a/8 + b\}$ points, where $a$ ($\leq 20$), $b$ ($\leq 10$) denote the individual midterm scores.

    **20 %** homework

    **10 %** discussion session work

    **7.5 %** lab exercise

    The rationale behind the formula for the midterm score is that the worst 25 % of the midterm score is discarded. The ratio of score weight to examination time is the same for the midterms and the final exam.