

# MATH 146: Linear Algebra 1 (Advanced Level) [W25]

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**Course description:** This course is a rigorous treatment of the theory of finite dimensional vector spaces over an arbitrary field. We also cover the theory of determinants over an arbitrary commutative ring with identity, and many aspects of the theory of polynomials in one variable over a field. The ultimate goal is the *Primary Decomposition Theorem*, which characterizes a linear operator on a finite dimensional vector space in terms of invariant subspaces annihilated by the primary factors of its minimal polynomial.

**Prerequisites:** The course prerequisite is Math 145 [Algebra (Advanced Level)]. This course is for Honours Mathematics students only. You are expected to have had some previous exposure to and be comfortable with rigorous mathematical proofs. We will cover a large amount of difficult material at a fast pace.

## Brief outline of topics:

- fields; systems of linear equations; matrices; row-reduced echelon form; matrix algebra; invertible matrices
- vector spaces; subspaces; bases and dimension; coordinates; row equivalence
- algebra of linear maps; isomorphism; representations by matrices; dual space; transpose of a linear map
- algebra of polynomials; Lagrange interpolation; polynomial ideals; prime factorization of polynomials
- commutative rings; existence and uniqueness of determinants; multilinear maps; the exterior algebra
- eigenvalues; annihilating polynomials; invariant subspaces; simultaneous triangulation and diagonalization
- direct sum decompositions; invariant direct sums; the primary decomposition theorem

**Textbook:** There really is only one textbook which is ideally suited for this course:

“*Linear Algebra: Second Edition*” by Kenneth Hoffman and Ray Kunze; Prentice Hall, 1971.

It is in my opinion the best written, most complete textbook on advanced linear algebra in existence. *But this book is extremely expensive.* Therefore, I feel that I cannot make it a compulsory textbook, although I will be following it quite closely. A copy will be put on reserve in the Davis library. Other useful texts for this course are:

- “*Finite-Dimensional Vector Spaces*” by Paul Halmos; Springer, 1987.
- “*Linear Algebra: Fourth Edition*” by Friedberg, Insel, and Spence; Prentice-Hall, 2003. (This text was used in recent years and many used copies should be readily available.)

The above two books will also be put on reserve in the Davis library. If you attend all the lectures (*and you should*) then you can get by without needing to purchase a textbook.

**Marking Scheme:** Your course mark will be determined as follows:

- Assignments: 30% (twelve assignments, *one every week*, worth 2.5% each)
- Midterm test: 15% (Date, time, and location TBD)
- FINAL EXAM: 55% (Date, time, and location TBD)

You may use calculators/computers to do the assignments, but you will not be permitted to use them for the midterm or the final exam. Please note that you are strongly encouraged to work together with your classmates on the assignment problems, but you must write up and turn in your own solutions to the problems. The assignments are an integral part of your evaluation in this course and I encourage everyone to take them very seriously. I will not be sympathetic to requests for leniency after the exam if you have not done the assignments. *There will not be an opportunity to base your entire course mark on the final exam. This course will cover a large amount of difficult material at a fast pace. If you do not work hard in this course from day one, you will not do well.*

There will be no opportunity for a make-up midterm test. A student who misses the midterm test without a valid, acceptable excuse (accompanied by documented proof, such as a medical note) will receive a score of zero on the test. Students who miss the midterm for valid reasons will have the 15 points missed transferred to the final exam.

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