Information sheet for Math 504 Winter 2026

Class meets: MTRF noon in BH 201

Credits: four credits

Teacher: Branko Ćurgus, Proofessor of Mathematics

Office: BH 184A

Office Hour: MTRF 11 am or by appointment

Email: curgus@wwu.edu

Course website: https://faculty.curgus.wwu.edu/Courses/504_202610/504.html

Text: **Linear Algebra Done Right** by Sheldon Axler

Material covered: We plan to cover most of the first eight chapters of the textbook. The emphasis will be on finite dimensional *complex* vector spaces.

Student learning outcomes: By the end of this course, a successful student will demonstrate: (1) Knowledge of the following definitions: an abstract vector space over an arbitrary field, a subspace of a vector space, a sum and a direct sum of subspaces, a span of a set of vectors, a finite dimensional vector space, linear independence of a set of vectors, a basis and the dimension of a finite dimensional vector space. (2) Knowledge of the basic theorems and their rigorous proofs involving the concepts in (1); for example, the Steinitz exchange lemma, the Basis theorem. (3) Knowledge of the definitions of a linear operator and the definitions of the following related concepts: the null space, range, invertibility and the matrix of a linear operator relative to given bases. (4) Knowledge of the basic theorems and their rigorous proofs involving the concepts in (3); for example the Rank-nullity theorem. (5) Ability to prove the existence of an eigenvalue and a fan basis for a linear operator on a complex vector space. (6) Knowledge of the definitions of a positive definite inner product and a norm and the basic theorems involving these concepts: the abstract Pythagorean theorem, parallelogram low, Cauchy-Bunyakovsky-Schwarz inequality, polarization identities. (7) Understanding of the importance of orthonormal bases and Gram-Schmidt orthogonalization process in inner product spaces, the Bessel inequality, the proof of orthogonal complement theorem. (8) Knowledge of the definitions of a linear functional, an adjoint operator, a self-adjoint operator, a normal operator, a unitary operator and an isometry. (9) Knowledge (with a rigorous proof) of the spectral theorem for normal operators on finite dimensional inner product complex vector spaces and of the applications of the spectral theorem to positive operators, isometries, polar and singular-value decomposition. (10) Knowledge of the following definitions: a characteristic polynomials of an operator, a generalized eigenvector, a Jordan chain, a Jordan basis of a vector space relative to an operator. (11) Knowledge of the basic theorems and their rigorous proofs involving the concepts in (10); for example, Cayley-Hamilton theorem, the Primary Decomposition theorem, the existence of Jordan basis. (12) Ability to use concepts and theorems covered in the course to solve related problems and prove new related propositions.

Homework: Your daily homework should consist of studying the material covered in class. Proofs that I will present in class will often differ from the proofs in the textbook. Study both: your class notes and the book. Analyze the similarities and the differences. This will help you to internalize the concepts and the methods that are being studied. Exercises in the book are there to enhance and challenge the learning process. Use them. You should try to do all the exercises in the textbook. Report those exercises that you find difficult in **Discussions on Canvas**.

Assessment. There will be two "mid-term" exams and a comprehensive final exam. The "mid-term" exams are scheduled as follows: Monday, February 2, 2026 and Thursday, February 26, 2026. The final exam is scheduled for **three hours** on Monday, March 16, 2026 from 1 to 4 pm. (Notice that the final exam time is set by the school. I did my best to copy it right from the schedule. Please verify that I did it right.) Notice that I extended the duration of the final by one hour. If you are unable to take an exam for a very serious reason verified in writing, please see me beforehand. This does not apply to the final exam which cannot be taken neither early nor late.

On each exam I will assign one or two questions related to the theory presented in class (a proof of an important theorem for example) and two or three problems. One of these problems might be a problem discussed in class or an exercise from the book.

There will be one written homework assignments. The assignment will be handed out in class one week before they are due. This assignment will be graded and the grade will count towards the final grade.

Assignment: The work that you submit in your assignments must be your own. You can ask clarifying questions about the assignment problems in **Discussions on Canvas**. If your question involves a part of your solution, you can ask me during office hours. You can discuss problems on the assignment with other students in general terms only. You should not share your solutions with others.

The due date for the assignment will be given in the class one week after the assignment has been handed out.

Grading: The exams and the assignment will be graded by an integer between 0 and 100. Your final grade will be determined using the following formula

$$\texttt{FG} = \left\lceil\, 0.18 * \texttt{E1} + 0.18 * \texttt{E2} + 0.36 * \texttt{FE} + 0.28 * \texttt{A} \,\right\rceil,$$

where E1, E2 are the grades for mid-term exams, FE is the grade for the final exam and A is the grade for the assignment. In the above formula the symbol $\lceil x \rceil$ denotes the ceiling of a real number x. Your letter grade will be assigned according to the following table:

F : 0 - 49	D : 50 - 54	C− : 55 - 59	C : 60 - 64	C+ : 65 - 69
B− : 70 - 74	B : 75 - 79	B+ : 80 - 84	A− : 85 - 89	A : 90 - 100

On Your Written Work: LaTeX is free software designed for typesetting high-quality mathematical documents. I encourage you to learn LaTeX and use it when you write mathematical work that you share with others. If you submit handwritten work, please write neatly and in a reader-friendly way.

Since you will have enough time to work on the homework and assignments, your papers should be well-written. Presenting calculations alone without the context in which they occur and explanations of your reasoning is not sufficient for the full credit. I believe that writing mathematics in complete sentences organized in meaningful paragraphs enhances the learning process. As a guide for writing, you can use examples in the textbook or my writing on the class website.

This course is a fast-paced course. It builds on the concepts that you learned in undergraduate linear algebra courses and some ideas from calculus. It is essential that you keep up with the material presented every day. Do the exercises at the end of each chapter. Look for help if you encounter difficulties.

How to succeed: Doing well in mathematics builds on understanding, not memorizing. To understand, practice critical thinking in all mathematical activities and question everything until clarity has been achieved. Put your questions in writing, share with the class in **Discussions on Canvas**.

Diversity, Equity, Inclusion: Welcome to my class. I promise to keep my mind open for all the diverse mathematical experiences you bring to this class. I want to help each of you use those personal experiences creatively to build your own understanding of the content studied in this class. I will bring diverse approaches to most concepts. For example, to make this class more diverse, I looked into the history of linear algebra. Amazingly, the first known system of linear equations appears on the old Babylonian tablet VAT 8389, which is between 3600 and 4000 years old (2000-1600 BC). The second oldest one is from ancient Egypt in the Rhind papyrus, dating back to around 1550 BC. This system involves five unknowns, but the solution in the papyrus is cryptic. The oldest treatment of systems of linear equations from antiquity which uses a method that resembles matrices is in Chapter 8 of the Chinese textbook *Nine Chapters of the Mathematical Art* which is at least 1800 years old.

My celebration of the history of mathematics in one short paragraph: Throughout history, human civilizations have developed and shared mathematical knowledge. Successive civilizations have recognized and admired the contributions of those who came before. Earlier discoveries have provided both a foundation and an inspiration for further advances, giving mathematics the spirit of a collective endeavor of humanity across the past, the present, and the future.

I understand that each of you comes to this class with a diverse mathematical background. I believe that mathematics is so universally diverse that it offers a path to understanding to everybody. The only prerequisite is to be open to the human worth of rigorous thinking, which is practiced in Mathematics. I want to help you build your own understanding of Linear Algebra. The goal is to create an environment where you can succeed in Mathematics and be proud of your achievement.

Academic Honesty Policy: Academic dishonesty is not tolerated at Western Washington University. Representing the work of another as one's own is an act of academic dishonesty. For a full description of the academic honesty policy and procedures at Western, see Appendix D in the University Catalog.

Flexibility Statement: This syllabus is subject to change. Changes, if any, will be announced in class or online. Students will be held responsible for all changes.

Syllabi@WWU Please also check `https://syllabi.wwu.edu/`