

MATH 341

Numerical Linear Algebra for Deep Neural Networks

Spring Semester 2026

TuTh 10:00AM - 11:15AM in Math & Psychology 401

Instructor: **Bedřich Sousedík**

Office: **MP427**

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Course web: Blackboard and <http://userpages.umbc.edu/~sousedik/classes/341s26/>

(Blackboard is the primary source, my www will be used only to bookmark the progress of class.)

Office Hours: TuTh: 11:30PM-12:30PM in my office.

Prerequisites: MATH 152, MATH 221 and CMSC 201 with a grade of 'C' or better.

Topics to be covered: Basics of linear algebra: matrices and vectors, four fundamental subspaces, matrix factorizations (LU, QR, SVD) and computations with large matrices, basics of probability and statistics: mean and variance, covariance and joint probability, Markov chains and randomized linear algebra, basics of optimization: methods based on gradient descent and LASSO, deep learning: topology of networks, backpropagation and hyperparameters.

Course description:

This course provides an introduction to linear algebra and related numerical aspects with an emphasis on the applications to deep neural networks. The topics include matrix factorizations (LU, QR, SVD), computation of eigenvalues, least-squares, special matrices including their use in probability and statistics, optimization algorithms such as Newton's method, (stochastic) gradient descent and ADAM, and, finally, how these techniques are used to learn from data are discussed

The main goals of the course are: By the end of the course, students will be able to:

1. **Use core linear algebra ideas for data problems** (vectors/matrices, subspaces, orthogonality, projections) and interpret what the computations mean.
2. **Solve key matrix problems using standard factorizations** (LU/QR/SVD), especially least-squares, eigenvalue/singular value ideas, and large-matrix computations at a practical level.
3. **Connect matrices to probability and statistics** through covariance/joint structure, Markov chains, and randomized linear-algebra concepts used in modern data settings.
4. **Understand optimization methods used in learning** (gradient descent/SGD, Newton-type ideas, Adam, and regularization such as LASSO) and how they behave in model fitting.
5. **Explain the mathematical core of deep learning:** how network structure, backpropagation, and hyperparameters relate to the linear algebra + optimization tools.

Recommended Textbook:

Gilbert Strang: Linear Algebra and Learning from Data, Wellesley-Cambridge Press, 2019, (<https://math.mit.edu/~gs/learningfromdata/>)

Additional materials:

Catherine F. Higham and Desmond J. Higham: Deep Learning: An Introduction for Applied Mathematicians, SIAM Review, 61(4), 2019, doi: 10.1137/18M1165748, (<https://epubs.siam.org/doi/10.1137/18M1165748>)

How you will be evaluated:

Exams: There will be two in-class one hour exams, and a comprehensive <2 hour final exam. The tentative dates of the tests and final exam are:

Midterm – Thursday, March 12 (tentative)

Final Exam – Tuesday, May 19, 10:30am-12:30pm

Homework Assignments: There will be at most 10 homework assignments. Homework for sections completed in any given week (M-W) will be due in a week unless noted otherwise. Homework assignment will be graded and will be worth 15 points each. The two lowest scores will be dropped. Please follow these guidelines in turning in homework assignments:

1. Please use only one side of paper when doing assignments.
2. All assignments should be done in pencil.
3. Show all work neatly since messy papers may not be graded.
4. Include graphs where appropriate. The graphs can either be a sketch or a computer printout with important information (axes, scale, intercepts, and important points) identified.
5. Staple your papers together.
6. Make sure that you do the assigned problems since no credit will be given for work on an incorrect problem.

Grading: HW 50%, Midterm 20%, Final 30%.

Grading Scale: Your final grade will be determined by the percentage of your points:

- A 90.0 – 100%
- B 80.0 – 89.9%
- C 65.0 – 79.9%
- D 50.0 – 64.9%
- F below 50.0%

Late Work and Exam Makeup Policy:

Makeup Tests: I expect you to take all of the in class tests. If some emergency arises that causes you to miss a test, I will deal with it in such a way that you are not penalized. We will discuss the details if this happens. If at all possible, you must make arrangements with me beforehand, and I will ask for details regarding the emergency. If you miss a test without making prior arrangements, you will in all likelihood receive a zero. No makeup will be offered after the test has been passed back to the class.

Final Exam: Attendance at the final exam is mandatory. Having the final rescheduled is extremely rare and is not permitted for reasons such as a plane ticket that was purchased earlier or attendance at weddings. In all cases where a makeup is requested, you MUST MAKE ARRANGEMENTS BEFOREHAND if at all possible.

Late Homework Assignments: Unless you make prior arrangements, expect a 50% reduction in grade for any item turned in late. No assignments will be accepted more than a week later after the original due date.

Attendance: Regular attendance and participation are important to your success in any college course but particularly in mathematics.

I encourage students to work together on homework. However, it is expected that you turn in your own work expressed in your own words. Never copy someone else's work and do not allow someone else to copy your work. If there are duplications of portions of homework then both parties will receive a zero on the assignment.

UMBC Academic Integrity Policy: By enrolling in this course, each student assumes the responsibilities of an active participant in UMBC's scholarly community in which everyone's academic work and behavior are held to the highest standards of honesty. Cheating, fabrication, plagiarism, and helping others to commit these acts are all forms of academic dishonesty, and they are wrong. Academic misconduct could result in disciplinary action that may include, but is not limited to, suspension or dismissal. To read the full Student Academic Conduct Policy, consult the UMBC Student Handbook, the Faculty Handbook, and the UMBC Integrity webpage <https://academicconduct.umbc.edu/> and see also [the OEI website here](#).

Technology: Access, Requirements, Resources, Support: To help ensure that UMBC students are equipped for academic success, the Division of Information Technology (DoIT) provides a wealth of resources and support, including tips for getting online and minimum specifications to consider when purchasing a computer (doit.umbc.edu/students). UMBC does require all students to be technologically self-sufficient, which entails having a reliable personal computer (preferably a laptop with webcam) and Internet access. Since UMBC requires all students to have a computer and Internet access, financial aid may be used to meet this requirement. To learn more, students should contact their financial aid counselor at financialaid.umbc.edu/contact.

Accessibility and Disability Accommodations, Guidance and Resources

Accommodations for students with disabilities are provided for all students with a qualified disability under the Americans with Disabilities Act (ADA & ADAAA) and Section 504 of the Rehabilitation Act who request and are eligible for accommodations. The Office of Student Disability Services (SDS) is the UMBC department designated to coordinate accommodations that creates equal access for students when barriers to participation exist in University courses, programs, or activities.

If you have a documented disability and need to request academic accommodations in your courses, please refer to the SDS website at sds.umbc.edu for registration information and office procedures.

SDS email: disAbility@umbc.edu

SDS phone: [410-455-2459](tel:410-455-2459)

If you will be using SDS approved accommodations in this class, please contact the instructor to discuss implementation of the accommodations. During remote instruction requirements due to COVID, communication and flexibility will be essential for success.

Sexual Assault, Sexual Harassment, and Gender Based Violence and Discrimination

UMBC Policy and Federal law (Title IX) prohibit discrimination and harassment on the basis of sex, sexual orientation, and gender identity in University programs and activities. Any student who is impacted by sexual harassment, sexual assault, domestic violence, dating violence, stalking, sexual exploitation, gender discrimination, pregnancy discrimination, gender-based harassment or retaliation should contact the University's Title IX Coordinator to make a report and/or access support and resources:

Ever Hanna, Title IX Coordinator

410-455-1026 (direct line), everhanna@umbc.edu

You can access support and resources even if you do not want to take any further action. You will not be forced to file a formal complaint or police report. Please be aware that the University may take action on its own if essential to protect the safety of the community.

If you are interested in or thinking about making a report, please use the [Online Reporting/Referral Form](#). Please note that, if you report anonymously, the University's ability to respond will be limited.

Notice that Faculty are Responsible Employees with Mandatory Reporting Obligations:

All faculty members are considered *Responsible Employees*, per [UMBC's Policy on Sexual Misconduct, Sexual Harassment, and Gender Discrimination](#). Faculty are therefore required to report any/ all available information regarding conduct falling under the Policy and violations of the Policy to the Title IX Coordinator, even if a student discloses an experience that occurred before attending UMBC and/or an incident that only involves people not affiliated with UMBC. Reports are required regardless of the amount of detail provided and even in instances where support has already been offered or received.

While faculty members want encourage you to share information related to your life experiences through discussion and written work, students should understand that faculty are required to report *past and present* sexual assault, domestic and interpersonal violence, stalking, and gender discrimination that is shared with them to the Title IX Coordinator so that the University can inform students of their [rights, resources and support](#). While you are encouraged to do so, you are not obligated to respond to outreach conducted as a result of a report to the Title IX Coordinator.

If you need to speak with someone in confidence, who does not have an obligation to report to the Title IX Coordinator, UMBC has a number of [Confidential Resources](#) available to support you:

- [Retriever Integrated Health](#) (Main Campus): 410-455-2472 [Monday – Friday; 8:30 a.m. – 5 p.m.] / After-Hours Support 410-455-3230
- [Center for Counseling and Consultation](#) (Shady Grove Campus): 301-738-6273 (Messages checked hourly) [Online Appointment Request Form](#)
- Pastoral Counseling via [Interfaith Center](#): 410-455-3657; interfaith@umbc.edu [7 days a week; Fall and Spring 7 a.m. – 11 p.m.; Summer and Winter 8 a.m. – 8 p.m.]

Other Resources:

- [Women's Center](#) (for students of all genders): 410-455-2714; womenscenter@umbc.edu. [Monday – Thursday 10:00am-5:30pm and Friday 10:00am-4pm]
- [Shady Grove Student Resources](#), [Maryland Resources](#), [National Resources](#).

Child Abuse and Neglect:

Please note that Maryland law and [UMBC policy](#) require that faculty report all disclosures or suspicions of child abuse or neglect to the Department of Social Services and/or the police even if the person who experienced the abuse or neglect is now over 18.

Pregnant and Parenting Students

UMBC's [Policy on Sexual Misconduct, Sexual Harassment and Gender Discrimination](#) expressly prohibits all forms of Discrimination and Harassment on the basis of sex, including pregnancy. [Resources for pregnant, parenting and breastfeeding students](#) are available through the University's Office of Equity and Inclusion. Pregnant and parenting students are encouraged to contact the Title IX Coordinator to discuss plans and ensure ongoing access to their academic program with respect to a leave of absence or return following leave related to pregnancy, delivery, adoption, breastfeeding and/or the early months of parenting.

Pregnant students and students in the early months of parenting may be entitled to accommodations under Title IX through the Office of Equity and Inclusion.

In addition, students who are pregnant and have an impairment related to their pregnancy that qualifies as disability under the ADA may be entitled to accommodations through the [Student Disability Service Office](#).

Religious Observances & Accommodations

UMBC [Policy](#) provides that students should not be penalized because of observances of their religious beliefs, and that students shall be given an opportunity, whenever feasible, to make up within a reasonable time any academic assignment that is missed due to individual participation in religious observances. It is the responsibility of the student to inform the instructor of any intended absences or requested modifications for religious observances in advance, and as early as possible. For questions or guidance regarding religious observance accommodations please contact the [Office of Equity and Inclusion](#) at oei@umbc.edu.

Hate, Bias, Discrimination and Harassment

UMBC values safety, cultural and ethnic diversity, social responsibility, lifelong learning, equity, and civic engagement.

Consistent with these principles, [UMBC Policy](#) prohibits discrimination and harassment in its educational programs and activities or with respect to employment terms and conditions based on race, creed, color, religion, sex, gender, pregnancy, ancestry, age, gender identity or expression, national origin, veterans status, marital status, sexual orientation, physical or mental disability, or genetic information.

Students (and faculty and staff) who experience discrimination, harassment, hate or bias or who have such matters reported to them should use the [online reporting/referral form](#) to report discrimination, hate or bias incidents. You may report incidents that happen to you anonymously. Please note that, if you report anonymously, the University's ability to respond will be limited.