Linear Algebra and Matrix Computation (LAMC)
DA109
Suggested reading materials

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Contents

Lecture 1

Motivation, Prerequisites, Syllabus and Resources

1.1 Class schedule:

- Monday: 10:30AM - 12:30 PM (MB207)
- Thursday: 10:30AM - 12:30 PM (MB207)

1.2 Teaching Assistant (TA):

We have a TA in this course:

- TA: Rajdeep Mondal (2nd yr. PhD student) (IH412)
- Email: `rajdeep.mondal@tcgcrest.org`

1.3 Motivation:

Why linear algebra?

1.4 Prerequisites:

Student should have some knowledge in

- Basic concept on algebra, vectors and co-ordinate geometry
- Computer programming: Any one from C/C++/Python(recommended for the class assignments)/MATLAB/Octave

1.5 Course url:

`https://xlms.rkmvu.ac.in/course/view.php?id=85`

1.6 Credit : 4 (four), approximately 60 credit hours

1.7 Tentative syllabus:

- Introduction to vectors: Vectors and its geometry, operation on vectors (addition, multiplication by a scalar, dot production, length)
- Vector space: Vector space, Subspace, Basis and dimension, Change of basis
- Linear transformations: Introduction to linear transformation, Rank-Nullity theorem, Matrix of a linear transformation, Linear operators and isomorphism, Linear functionals
- Matrix algebra: Matrix addition and multiplication, transpose, inversion, Special matrices, Row rank and column rank of a matrix, Determinant of a matrix and its geometric interpretation, Cramer's rule to solve system of linear equations, Various matrix decompositions
- Eigenvalues and Eigenvectors: Introduction to eigenvalues and eigenvectors of matrices, Characteristic polynomial, Cayley-Hamilton theorem, Algebraic and geometric multiplicities of eigenvalues, Matrix diagonalization, Positive (semi-) definite matrices, Solving linear recurrences

- Normed linear spaces: Normed spaces, Cauchy-Schwarz inequality and triangle inequality, Projection, Gram-Schmidt orthogonalization, Hermitian operators, The Spectral theorem
- Matrix Computations: Floating point numbers and operations, Error Analysis, Solving system of linear equations - Direct (Gaussian elimination, LU factorization) and Iterative methods (Jacobi method, Gauss-Seidel method), Solving least square problems - QR decomposition, Gram-Schmidt orthogonalisation, Singular value-decomposition (SVD), Solving Eigenvalue problems - Tridiagonal QR iteration, Jacobi method
- Some practical applications (if time permit)

1.8 Related books:

We will follow these books:

[1] A. Ramachandra Rao and P. Bhimasankaram. *Linear algebra*. Hindustan Book Agency (india), 2nd Edition, 2000. [library]

[2] Sheldon Axler. *Linear Algebra Done Right*. Springer, 3rd edition, 2015. [sample chapter online] [library]

[3] Kenneth Hoffman and Ray Kunze. *Linear Algebra*. Prentice Hall of India, 2nd edition, 1971. [library] or [online]

[4] Gilbert Strang. *Introduction to linear algebra*. Wellesley-Cambridge Press, 5th/6th edition, 2016/2023. [sample chapter online] and [library]

1.9 Evaluation:

Approximate weightage of different components in evaluation are as follows:

Midterm Exam	20%
Final Exam	50%
Assignment and Class test	30 (20+10)%

1.10 Assignments:

There will be both theoretical and programming assignments. For the theoretical assignment, I am encouraging you all to use LaTex tool to prepare your assignment and submit as *pdf* file formal. For the programming assignment, you can use any programming language (Python/C/C++/MATLAB/Octave) you want, we will prefer Python for this course. For those of you who are not familiar with LaTex, here are some resources that might help you to prepare your document:

- A quick user guide/tutorial on latex: `https://www.overleaf.com/learn/latex/Learn_LaTeX_in_30_minutes`
- LATEX: `https://www.latex-project.org//`
- For Linux(Ubuntu, Fedora..): TeX Live (`https://www.tug.org/texlive/`)
- For Mac: MacTex (`https://tug.org/mactex/`)

The assignment submission deadline is strict and you can utilize extra/buffer two days after the deadline for the entire semester. We will consider 11.59PM as our day end.

1.11 Academic ethics:

We will follow some academic ethics:

- Your grade should reflect your own work.
- Copying or paraphrasing someone's work (code included), or permitting your own work to be copied or paraphrased, even if only in part, is strictly forbidden, and will result in an automatic grade of zero for the entire assignment or exam in which the copying or paraphrasing was done.
- So, ask yourself before copying from others.
- If you are going to have trouble completing an assignment, talk to the instructor and TA before due date.

1.12 Computational tools:

Here are some popular LAMC tools:

- Numpy (python) - https://numpy.org/
- Octave - https://octave.org/
- CLAPAC (C) - https://netlib.org/clapack/
- Matlab - https://in.mathworks.com/
- PyTorch (Python and GPU support) - https://pytorch.org/
- ...

1.13 Datasets repository:

You can find some datasets to evaluate yous programming assignment in UCI Machine Learning Repository (https://archive.ics.uci.edu/datasets)

1.14 Journals and other resources:

For recent updates on LAMC you can follow journals and the arXiv.

- SIAM Journal on Matrix Analysis and Applications - https://epubs.siam.org/journal/sjmael
- You can go to Mathematics section in arXiv and under that you can find Numerical Analysis (NA) - https://arxiv.org/list/math.NA/recent, where you can find some recent works on linear algebra from NA point of view.

Lecture 2

Vector space, Subspace, Span, Linearly dependent & independent, Basis and Dimension

2.1 Suggested reading

Please read *Chapter-1 & 2* of Axler's book [1] and *Chapter-1, Section 1.1 - 1.5* of Rao and Bhimasankaram's book [3] or *Chapter-2, Sections 2.1 - 2.3* of Hoffman and Kunze's [2] book.

Try to solve the corresponding exercises.

Bibliography

[1] Sheldon Axler. *Linear Algebra Done Right*. Springer, 3rd edition, 2015.

[2] Kenneth Hoffman and Ray Kunze. *Linear Algebra*. Prentice Hall of India, 2nd edition, 1971.

[3] A. Ramachandra Rao and P. Bhimasankaram. *Linear Algebra*. Hindustan Book Agency (india), 2nd edition, 2000.