ECE 712
Matrix Computations in Signal Processing

COURSE OUTLINE
Please refer to course website for updated information.

CALENDAR DESCRIPTION

Matrix decompositions: eigen-decomposition, QR decomposition, singular value decomposition;
solution to systems of equations: Gaussian elimination, Toeplitz systems; least square methods:
ordinary, generalized and total least squares, principal component analysis.

SCHEDULE And MODE OF DELIVERY

McMaster expects to be fully in-person in the 2023/24 academic year.
Please check with Instructor and/or Avenue to Learn for Schedule and Mode of Delivery.

INSTRUCTOR

Dr. J. Reilly, PEng.
Email: reillyj@mcmaster.ca
Office: ITB-A312
Phone: 905-525-9140 ext. 22895
Office Hours: by appointment

COURSE WEBSITE/s

Primarily the class Teams website. Also http://avenue.mcmaster.ca

COURSE OBJECTIVES

By the end of this course, the student will have acquired the necessary linear algebra
background to conduct research in signal processing, machine learning and related fields.

ASSUMED KNOWLEDGE
The equivalent of an engineering undergraduate course in linear algebra. This includes
the definition of matrices/vectors, arithmetic operations on matrices/vectors, solution of
systems of equations, inverses, etc., and a knowledge of fundamental calculus,
probability and linear systems. Knowledge of a high-level programming language such
as matlab or python is also required.

COURSE MATERIALS

Textbooks:

“Fundamentals of Linear Algebra for Signal Processing”, James P. Reilly, available on the
Teams website.

Other:

"Matrix Computations", 3rd edition, Golub and Van Loan, Johns Hopkins University Press
"Linear Algebra and Its Applications", 3rd edition, G. Strang

COURSE OVERVIEW

<table>
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<tr>
<th>Week</th>
<th>Topic</th>
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<tbody>
<tr>
<td>1</td>
<td>Review of fundamental concepts of linear algebra</td>
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<tr>
<td>2</td>
<td>Eigenvalues and eigenvectors. basics, covariance matrices, principal component analysis</td>
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<td>3</td>
<td>The Singular Value Decomposition (SVD)</td>
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<td>4</td>
<td>The quadratic form and the multi—variate Gaussian probability density function</td>
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<td>5</td>
<td>Floating point number systems, Gaussian Elimination, Cholesky decomposition, condition number, and error analysis</td>
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<td>6</td>
<td>The QR decomposition: Gram-Schmidt, Householder, the QR method for computing the eigendecomposition</td>
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<td>7</td>
<td>Linear Least Squares (LS) Estimation: background, normal equations, properties, Cramer-Rao lower bound in white and coloured noise</td>
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<td>8</td>
<td>The rank deficient LS problem</td>
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<td>9</td>
<td>Model—building using Latent Variable methods</td>
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<tr>
<td>10</td>
<td>Regularization (time permitting)</td>
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<tr>
<td>11</td>
<td>Autoregressive Analysis (time permitting)</td>
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At certain points in the course it may make good sense to modify the schedule. The instructor
may modify elements of the course and will notify students accordingly (in class, on the course
website).

Course Evaluation

There will be two graded assignments of equal weight. All graded material must be submitted
no later than one week past the end of term.
CONDUCT EXPECTATIONS

As a McMaster graduate student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the Code of Student Rights & Responsibilities (the “Code”). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, whether in person or online.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students’ access to these platforms.

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, including lectures by University instructors.

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

ACADEMIC ACCOMMODATIONS OF STUDENTS WITH DISABILITIES

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University’s Academic Accommodation of Students with Disabilities policy.

ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office normally within 10 working days of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.
EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.

RESEARCH ETHICS

The two principles underlying integrity in research in a university setting are these: a researcher must be honest in proposing, seeking support for, conducting, and reporting research; a researcher must respect the rights of others in these activities. Any departure from these principles will diminish the integrity of the research enterprise. This policy applies to all those conducting research at or under the aegis of McMaster University. It is incumbent upon all members of the university community to practice and to promote ethical behaviour. To see the Policy on Research Ethics at McMaster University, please go to http://www.mcmaster.ca/policy/faculty/Conduct/ResearchEthicsPolicy.pdf.

www.eng.mcmaster.ca/ece