Numerical Linear Algebra  MATH 5333.001
Department of Mathematics & Statistics
Fall 2017

A. COURSE INFORMATION

Course number/section:  MATH 5333.001
Class meeting time:  TR 08:00-09:15 AM
Class location:  CI-109
Course Website:  https://bb9.tamucc.edu/

B. INSTRUCTOR INFORMATION

Instructor:  Dr. Beate Zimmer
Office location:  CI 310
Office hours:  MWF 8:00 – 9:00 AM
T 9:15 PM – 11:15 PM
Telephone:  (361) 825-2682
e-mail:  beate.zimmer@tamucc.edu
Appointments:  e-mail to make appointments outside the announced office hours

C. COURSE DESCRIPTION

Catalog Course Description
A continuation of 3311, Linear Algebra, with emphasis on numerical aspects. Topics discussed include: Floating point arithmetic, Gauss Elimination, LU factorization, Cholesky factorization, Overdetermined linear systems, iterative methods, eigenvalues and eigenvectors by the power method and the QR algorithm, the singular value decomposition. 3 credit hours.

Extended Course Description
This course provides essential mathematical background for students in the Masters program in mathematics. Numerical linear algebra is crucial to scientific computing. An understanding of Numerical Analysis methods and of the possible sources of errors in large computations are a prerequisite for any research in applied mathematics. We will use MATLAB as the software package - its name comes from Matrix lab and it is particularly well suited to Linear Algebra tasks.

D. PREREQUISITES FOR THE COURSE

Prerequisites
MATH 3311 (Linear Algebra).

Corequisites
None.
E. REQUIRED TEXTBOOK(S), READINGS AND SUPPLIES

Required Textbook(s)
Numerical Linear Algebra and Applications by Biswa Nath Datta, Second Edition SIAM, 2010. All class demonstrations will be done with MATLAB.

Optional Textbook(s) or Other References
The computers in the Center for Instruction have the MATLAB software on them. All of the books listed below are available in the Bell Library.

Recommended reading for the course:


The MATCOM collection of programs is available at http://www.siam.org/books/ot116/.

Supplies
Homework is assigned weekly and may include MATLAB problems and proof type problems and hand calculations. You are expected to print out your programs, the commands you used to run them and the outputs. The notes from class will be available on BlackBoard after class. You may print them, but don’t have to. Costs for printing should not exceed $20.

F. STUDENT LEARNING OUTCOMES AND ASSESSMENT

Assessment is a process used by instructors to help improve learning. Assessment is essential for effective learning because it provides feedback to both students and instructors. A critical step in this process is making clear the course’s student learning outcomes that describe what students are expected to learn to be successful in the course. The student learning outcomes for this course are listed below. By collecting data and sharing
it with students on how well they are accomplishing these learning outcomes students
can more efficiently and effectively focus their learning efforts. This information can
also help instructors identify challenging areas for students and adjust their teaching
approach to facilitate learning.

By the end of this course, students should be able to:

1. solve linear systems by direct methods such as LU factorization, or Gauss elimina-
tion with partial or full pivoting
2. use the QR factorization for linear problems or least squares problems
3. decide when a numerical solution can be trusted
4. compute and use the Cholesky factorization
5. use iterative methods such as the Jacobi method, Gauss-Seidel, Successive Overrel-
xaxation or the conjugate gradient method to solve linear systems
6. calculate dominant eigenvalues by the Power method
7. calculate all eigenvalues by the QR iteration
8. compute the singular value decomposition (SVD) of a matrix
9. use the information given by the SVD to infer the structure of the original matrix
10. discuss the sources and types of errors arising in numerical computations
11. decide which algorithm is appropriate for a given problem
12. use existing MATLAB algorithms such as the ones in MATCOM that accompany
the book
13. generate their own codes for certain problems.

G. INSTRUCTIONAL METHODS AND ACTIVITIES

Methods and activities for instruction include: Lectures and computer demonstrations.

H. MAJOR COURSE REQUIREMENTS AND GRADING

The methods of evaluation and the criteria for grade assignments are:
Homework will be assigned weekly and is due at the start of the next week. Homework
may consist of problems from the textbook, may ask students to implement algorithms
from class in MATLAB for a given matrix or may ask students to use existing software
such as the MATCOM library to perform calculations. In addition students will be asked
to interpret the results found in their calculations in homework assignments. No late
homework is accepted. The lowest homework grade gets dropped. Office hours are a
great opportunity to ask questions about homework. Working with other students is
fine, but be sure to turn in your own product in the end. The homework assignments
are non-trivial - they are meant to take several days and it is not a good idea to wait
until the evening before the due date to start them. Late homework receives no credit.
The lowest homework grade get dropped. No exam grades get dropped.
The Final exam is comprehensive.

**Calculator policies and partial credit:**

All exams are no-calculator exams.

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>% of FINAL GRADE</th>
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<tbody>
<tr>
<td>Two exams</td>
<td>50%</td>
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<tr>
<td>Homework</td>
<td>20%</td>
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<tr>
<td>Final Exam</td>
<td>30%</td>
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</tbody>
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Grading Scale: Grades will be no stricter than

- A = 90.00 – 100%
- B = 80.00 – 89.99%
- C = 70.00 – 79.99%
- D = 60.00 – 69.99%
- F = below 60%

I. COURSE CONTENT/SCHEDULE

<table>
<thead>
<tr>
<th>DATE</th>
<th>TOPIC</th>
<th>CHAPTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 T 9/5</td>
<td>Review: Vectors, Matrices, Special Matrices, Vector and Matrix norms, SVD</td>
<td>2.1 – 2.4</td>
</tr>
<tr>
<td>2 R 9/7</td>
<td></td>
<td>2.5, 2.6</td>
</tr>
<tr>
<td>3 T 9/12</td>
<td>Floating Point Numbers, Calculations and Errors</td>
<td>3.1 – 3.8</td>
</tr>
<tr>
<td>4 R 9/14</td>
<td>Algorithms and their efficiency, Stability, Conditioning</td>
<td>4.1 – 4.4</td>
</tr>
<tr>
<td>5 T 9/19</td>
<td>Perturbation Theory, Condition number, Stable algorithms</td>
<td>4.5 – 4.9</td>
</tr>
<tr>
<td>6 R 9/21</td>
<td>Gaussian Elimination, LU Factorization, Partial Pivoting</td>
<td>5.1, 5.2</td>
</tr>
<tr>
<td>7 T 9/26</td>
<td>Complete Pivoting, Stability</td>
<td>5.2 – 5.4</td>
</tr>
<tr>
<td>8 R 9/28</td>
<td>Linear Systems, Existence and Uniqueness of Solutions,</td>
<td>6.1 – 6.3</td>
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<td></td>
<td>Applications leading to Linear Systems</td>
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<tr>
<td>9 T 10/3</td>
<td>LU Factorization Methods, Scaling</td>
<td>6.4 – 6.6</td>
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<tr>
<td>10 R 10/5</td>
<td>Inverses, Determinant, Sherman-Morrison</td>
<td>6.7</td>
</tr>
<tr>
<td>11 T 10/10</td>
<td>Special Systems, Cholesky</td>
<td>6.12</td>
</tr>
<tr>
<td>12 R 10/12</td>
<td>Exam 1</td>
<td></td>
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<tr>
<td>13 T 10/17</td>
<td>Iterative Methods: Jacobi, Gauss-Seidel, Convergence</td>
<td>12.1, 12.2</td>
</tr>
<tr>
<td>14 R 10/19</td>
<td>Successive Overrelaxation, Conjugate Gradient Method</td>
<td>12.3</td>
</tr>
<tr>
<td>15 T 10/24</td>
<td>Householder Matrices, QR factorization, Gives Matrices</td>
<td>7.1 – 7.4</td>
</tr>
<tr>
<td>16 R 10/26</td>
<td>Gram-Schmidt for QR factorization</td>
<td>7.5, 7.6</td>
</tr>
<tr>
<td>17 T 10/31</td>
<td>SVD and Applications , Review of QR and SVD</td>
<td>7.8, 7.9, 7.11</td>
</tr>
<tr>
<td>18 R 11/2</td>
<td>Least-Squares Solutions, Applications, Pseudoinverse</td>
<td>8.1 – 8.5</td>
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The comprehensive Final Exam is on Thursday, December 14, 8:00 AM – 10:30 AM in the usual classroom.

Note: Changes in this course schedule may be necessary and will be announced to the class by the Instructor. The exams shown are directly related to the Student Learning Outcomes described in Section F.

J. COURSE POLICIES

Attendance/Tardiness
Attendance will be taken each class. For most students attending class is a faster way of learning the material than trying to catch up on missed material solely from the book. Tardiness is often disruptive to the whole class and is not appreciated. If you are delayed and arrive late for class please do so quietly. Usually the topic/technique of the day is introduced in the first few minutes of class; missing that part usually means that you will be lost all class.

Late Work and Make-up Exams
Missed homework assignments can not be made up; the drop grade accommodates those. Make-up exams will not be given. If a student misses an exam and has a valid excuse, the final exam score will serve as the score for that exam.

Extra Credit
There is no extra credit in this class.

Cell Phone Use
Cell phones and such must be turned off before class. Each time your phone rings during class, your course grade goes down by 1%.

Laptop Use
You may use a laptop to take notes during lecture. Distracting other students by surfing the web is not acceptable behaviour.
Food in Class
No food in class (except during the final, where non-noisy foods are OK).

Missed Exam
If you have to miss an exam, it is your responsibility to contact me no later than the day of the exam. Failure to contact me on or before the exam day results in a grade of zero points for the exam. This also applies to the final exam. For missed final exams due to an acceptable excuse the university rules about I (Incomplete) grades apply and the make-up is at the instructor’s convenience early in the next long semester. Only extreme emergencies or official university business are acceptable reasons to miss exams and documentation will be required. Car trouble, routine doctor’s appointments, family reunions or graduations of siblings etc. are not valid reasons to miss exams. If your reason to miss the exam is not a valid one, your exam score is 0 points. Be sure to check before missing an exam whether your reason is acceptable.

Participation
Participation is not part of the grade, but you learn more by interacting, than by watching passively.

K. COLLEGE AND UNIVERSITY POLICIES

- Academic Integrity (University)
  University students are expected to conduct themselves in accordance with the highest standards of academic honesty. Academic misconduct for which a student is subject to penalty includes all forms of cheating, such as illicit possession of examinations or examination materials, falsification, forgery, complicity or plagiarism. (Plagiarism is the presentation of the work of another as one’s own work.) In this class, academic misconduct or complicity in an act of academic misconduct on an assignment or test will result in a failing grade.

- Classroom/Professional Behavior
  Texas A&M University–Corpus Christi, as an academic community, requires that each individual respect the needs of others to study and learn in a peaceful atmosphere. Under Article III of the Student Code of Conduct, classroom behavior that interferes with either (a) the instructor’s ability to conduct the class or (b) the ability of other students to profit from the instructional program may be considered a breach of the peace and is subject to disciplinary sanction outlined in article VII of the Student Code of Conduct. Students engaging in unacceptable behavior may be instructed to leave the classroom. This prohibition applies to all instructional forums, including classrooms, electronic classrooms, labs, discussion groups, field trips, etc.

- Statement of Civility
  Texas A&M University–Corpus Christi has a diverse student population that represents the population of the state. Our goal is to provide you with a high quality educational experience that is free from repression. You are responsible for following the rules of the University, city, state and federal government. We expect that
you will behave in a manner that is dignified, respectful and courteous to all people, regardless of sex, ethnic/racial origin, religious background, sexual orientation or disability. Behaviors that infringe on the rights of another individual will not be tolerated.

- **Deadline for Dropping a Course with a Grade of W (University)** I hope that you never find it necessary to drop this or any other class. However, events can sometimes occur that make dropping a course necessary or wise. *Please consult with your academic advisor, the Financial Aid Office, and me, before you decide to drop this course.* Should dropping the course be the best course of action, you must initiate the process to drop the course by going to the Student Services Center and filling out a course drop form. Just stopping attendance and participation WILL NOT automatically result in your being dropped from the class. Please consult the Academic Calendar ([http://www.tamucc.edu/academics/calendar/](http://www.tamucc.edu/academics/calendar/)) for the last day to drop a course.

- **Grade Appeals (College of Science and Engineering)** As stated in University Procedure 13.02.99.C2.01, Student Grade Appeal Procedures, a student who believes that he or she has not been held to appropriate academic standards as outlined in the class syllabus, equitable evaluation procedures, or appropriate grading, may appeal the final grade given in the course. The burden of proof is upon the student to demonstrate the appropriateness of the appeal. A student with a complaint about a grade is encouraged to first discuss the matter with the instructor. For complete details, including the responsibilities of the parties involved in the process and the number of days allowed for completing the steps in the process, see University Procedure 13.02.99.C2.01, Student Grade Appeal Procedures. These documents are accessible through the University Rules website at [http://www.tamucc.edu/provost/university_rules/index.html](http://www.tamucc.edu/provost/university_rules/index.html) and the College of Science and Engineering Grade Appeals webpage at [http://sci.tamucc.edu/students/GradeAppeal.html](http://sci.tamucc.edu/students/GradeAppeal.html)

For assistance and/or guidance in the grade appeal process, students may contact the chair or director of the appropriate department or school, the Office of the College of Science and Engineering Dean, or the Office of the Provost.

- **Disability Services**

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please call (361) 825-5816 or visit Disability Services in Corpus Christi Hall 116. If you are a returning veteran and are experiencing cognitive and/or physical access issues in the classroom or on campus, please contact the Disability Services office for assistance at (361) 825-5816.
http://disabilityservices.tamucc.edu/

- **Statement of Academic Continuity** In the event of unforeseen adverse event, such as a major hurricane and classes could not be held on the campus of Texas A&M University–Corpus Christi this course would continue through Blackboard and/or e-mail. In addition the syllabus and class activities may be modified to allow continuation of the course. University Facilities (i.e. e-mail, web sites, and Blackboard) will be operational within two days of closing the physical campus. However, students need to make certain that the course instructor has a primary and secondary way of contacting each student.

L. **OTHER INFORMATION**

- **Academic Advising** The College of Science & Engineering requires that students meet with an Academic Advisor as soon as they are ready to declare a major. The Academic Advisor will set up a degree plan, which must be signed by the student, a faculty mentor, and the department chair. Meetings are by appointment only; advisors do not take walk-ins. Please call or stop by the Advising Center to check availability and schedule an appointment. The Colleges Academic Advising Center is located in Center for Instruction 350 or can be reached at (361) 825-3928.

**GENERAL DISCLAIMER**

I reserve the right to modify the information, schedule, assignments, deadlines, and course policies in this syllabus if and when necessary. I will announce such changes in a timely manner during regularly scheduled lecture periods.