BE 2550 — Numerical Methods and Programming

Course Syllabus

College of Engineering
Wayne State University, Detroit, Michigan 48202

Term: 2008 Fall Term
Class Schedule: Monday and Wednesday 10:40 am — 12:05 pm at 2359 ENGR BLDG
CRNs: LCT: 16822; LAB: 16823, 16824, 16825 (honors)
Course Website: Blackboard (http://blackboard.wayne.edu) [requires Acrobat Reader 6.0 or above]

Instructor: Dr. Chin An Tan, Professor of Mechanical Engineering
Campus Office: Room 2137 Engineering Building
E-mail Address: tan@wayne.edu
Numbers: +1-313-577-3888 (phone); +1-313-578-5932 (e-fax)
Office Hours: W 9:45-10:30 (classroom), M 12:15-2:00 (office), W 1:00-2:00 (office);
Additional appointments and Q&A by e-mail

TA/Grader: Mrs. Heather Lai (TA); Mr. Gang Li (Grader)
Campus Office: Room 2130 Engineering Building; Room 2153 Engineering Building
E-mail Address: aw5995@wayne.edu; gang_li@wayne.edu
Office Hours: Tu 9:30-10:30 (Lab), Th 9:30-11:00 (Room 2130)

Homework: Submit hard copies of all assignments (completed with the use of MATLAB).

Please write your AssessID number and the section which you have enrolled in
on all submitted assignments.

Exams: 5 Quizzes and 3 Exams
Unless otherwise specified, all quizzes and exams are in-class and closed-book
Grading: Homework (5%), 3 Projects (15%), Quizzes (15%), Exams (20%, 20%, 25%)
Grades are based on percentages scaled with respect to the highest score or 900
points (maximum 1,000 points), whichever is higher.
Guidelines for assigning grades:
(A = 95%+, A– = 90%+, B+ = 87%+, B = 83%+, B– = 80%+, C+ = 77%+, C = 73%+, C– = 70%+, D+ = 65%+, D = 60%+, D– = 55%+, E = less than 55%)

Discussion of the grading of assignments and tests is allowed within 2 weeks after
distributed. Describe the grading issues on a separate sheet, and return this sheet
with the assignment/test to the instructor or the TA, or bring grading issues to discuss
with the instructor during office hours. There will be no exception to this policy.

Prerequisites: Equivalent of BE 1200, MAT 2030, MAT 2150 (prerequisite or corequisite).
Notes: Prerequisites and co-requisites are checked automatically at the time of
registration. However, it is ultimately the responsibility of the student to make certain
that they have the prerequisites and co-requisites for a course. Students must remain
registered for a co-requisite course throughout the semester. Advisors will check
course prerequisites and co-requisites during the 5th and 6th weeks of the semester.
Any student found to be registered for a course without meeting these requirements,
and without an official waiver on file, will be administratively withdrawn from the course.

Textbooks and Software:
 Gilat, A., and Subramaniam, V., Numerical Methods for Engineers and Scientists: An Introduction
978-0-470-10877-2.
 MATLAB software, http://mathworks.com. Purchase a student version or use PCs in the labs. The
Engineering Computer Center can install a network-based copy on your laptop, and offers a useful
Use your WSU your AccessID login and password to gain access to this web site.
General Policies

1. Copying of assignments is strictly prohibited and violation will result in a course grade F (failing grade). However, discussion of lecture materials and assignments is encouraged. Students are encouraged to visit the instructor and the Teaching Assistant during the assigned office hours. Cheating in quizzes and exams will also result in a course grade F.

2. No make-up quiz or examination will be allowed. Very special circumstances will be considered for make-up examination but the instructor must be notified as early as possible.

3. Homework solutions are available at the course website. No late homework or project will be accepted, unless under unforeseen circumstances. If you cannot make it to class, please deposit into the Blackboard digital drop box by the due time and then submit a hard copy as soon as possible. Homework should be typed if your handwriting is not legible. Project reports should be typed and prepared in a professional report format.

4. University Policy: Students should activate their AccessID and either use their Wayne State email or forward it to their regular email account. The WSU account will be the email address used by the University and faculty to communicate with them.

5. Deferred and incomplete grades will only be granted to students with legitimate medical or other unforeseen excuse.

6. Photocopies of the textbooks are illegal and are violation of the U.S. copyright laws.

Course Learning Objectives:

- Utilize the computer to solve engineering problems
- Utilize programming logic, structure and syntax to develop multifunctional algorithms to solve engineering problems
- Integrate existing solutions (subroutines) into these algorithms
- Implement the designed algorithms using MATLAB
- Determine errors present in numerical solutions to engineering problems
- Integrate programming and numerical methods to solve complex engineering problems

Course Learning Outcomes:

Upon completion of this course, students will be able to solve engineering problems using scientific programming techniques (algorithm development and implementation). Specific problems that students are expected to formulate and solve include:

- Root finding; solutions for nonlinear algebraic equations
- Solving sets of linear equations
- Interpolation and curve fitting models
- Numerical Differentiation and Integration
- Numerical solution of ordinary differential equations
- Engineering applications (optimization, etc.)

Student Conduct:

It is the responsibility of each student to adhere to the principles of academic integrity. Academic integrity means that a student is honest with him/herself, fellow students, instructors, and the University in matters concerning his or her educational endeavors. Thus, a student should not falsely claim the work of another as his/her own, or misrepresent him/herself so that the measures of his/her academic performance do not reflect his/her own work or personal knowledge. In this regard, cheating will not be tolerated. Cheating includes (but is not limited to) any communication (written or oral) during examinations and sharing of work, such as using the same models or computer programs or copying work. All homework and projects must be an individual effort unless specifically noted.
WHO CHEAT ON ANY ASSIGNMENT OR DURING ANY EXAMINATION WILL BE ASSIGNED A FAILING GRADE FOR THE COURSE. Therefore avoid all appearance of improper behavior! Students who witness cheating should report the incident to the instructor as soon as possible. Students are also welcome to discuss any concerns related to cheating with Dr. Michele Grimm, Associate Dean for Academic Affairs.

Policy on Classroom Attendance:

All students are expected to attend all lectures, quizzes, and examinations with enthusiasm. Although classroom attendance does not mathematically contribute to the final course grade, active class participation is expected of all students and may help to boost up the course grade in those “borderline” cases between failing and passing.

It is recognized that students may be required to miss classes on occasions as a result of their participation in approved University activities. Examples of such activities include formal participation on University sports teams, debate teams, and performing arts groups. These activities are generally directed by a University official, such as a coach, and usually have a set schedule of events.

Students participating in approved University activities should consult instructors prior to registration, but no later than the end of the second week after the start of classes, to determine the class attendance policy. At this time, the student should provide the instructor with a schedule of planned absences, preferably signed by the University official directing the activity (e.g., Athletic or Program Director or his/her designee), in order to allow the instructor to evaluate and advise the student on the possible impact of the planned absences. In this case, the instructor will consider absences due to participation in approved University activities, as outlined above, to be excused absences, on par with those due to other unavoidable circumstances such as illness and work-related travel.

It is the student’s responsibility to learn the course material. When classes are missed, for whatever reason, it is the obligation of the students to obtain copies of the class materials and students are responsible for all materials covered in the lectures. An excused absence does not excuse the student from completing assigned work, including exams.

University and College Policy on Withdrawal:

1. The LAST day to drop a class with a tuition refund is Monday, September 15, 2008.
2. Beginning with the fifth week of the term, students will need permission from instructors to withdraw from a class, and will receive one of the following grades on their records:
   - WP  Withdrawal with a passing grade earned to date
   - WF  Withdrawal with a failing grade earned to date
   - WN  Withdrawal never attended, or no graded work to date
3. All W’s will count towards a student’s allowed number of substandard grades. Thus, students should make withdrawal decisions before the end of Week 4 to avoid any W-grade recorded. [ENG Policy]
4. If a student feels that there are extenuating circumstances (medical, family emergency, change in work schedule) that justify the withdrawal without it counting towards the allowed number of repeats, he/she must submit a petition to the Associate Dean for Academic Affairs before the end of the semester. [ENG policy]
5. The LAST day to drop a class is Thursday, December 11, 2008. Students who do not withdraw by this date will be assigned grades according to their performance. For instance, a student who has never submitted any work and does not withdraw will receive a grade F.

Policy on Incomplete Grade:

A grade of “I” (incomplete) can only be assigned if all of the following criteria are met:
1. the student is not currently failing the class and,
2. there is not a substantial quantity of work yet to be completed,
3. there is no extra work required of the instructor beyond the normal duties of grading the paper/exam,
4. there is no need for the student to attend the class in subsequent terms.

The final decision to assign an incomplete grade rests with the instructor. An incomplete grade MUST be made up within one year of assignment of the grade. Incompletes will revert to a failing grade after one calendar year.

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**Policy on Examination:**

The examination schedule is published in the syllabus. If you have any conflicts with any of the examination dates, please notify the instructor as soon as possible. The following documentation is required for rescheduling of an examination:

- **Medical Excuse:** A signed letter from a physician from the day of the examination indicating that the student had a valid medical reason for missing school. This letter must be on the physician’s letterhead and the name and phone number of the physician must be legible. (Note: For cases of extended medical treatment, the letter can be dated prior to the examination, if the physician’s recommendation for leave extends beyond the examination date.)

- **Employment Conflict:** A signed letter from the student’s direct supervisor indicating that an absence from the Detroit-area is required for the student’s employment for the dates surrounding the examination.

- **Death in the Family or Family Illness:** A copy of the death certificate or obituary for the family member who has died. For illness of a family member for whom a student is the primary caregiver, a signed letter from the family member’s physician for the day of the examination.

- **Transportation Problem:** In the event that a student is prevented from arriving on campus due to a transportation delay, the following should be provided:
  - A copy of the police report concerning a traffic accident
  - A copy of the receipt for towing from a towing service
  - A signed letter from the Customs and Immigration Officials at the Detroit/Windsor border indicating that a student was delayed for questioning

The final determination of the validity of an excuse is the jurisdiction of the faculty member. In all of the above instances, all reasonable attempts must be made to contact the faculty member to notify them of the problem BEFORE the examination. This can be done via email or via phone. If notice is not provided before the examination, no documentation will be accepted.

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**Exam Scheduled During the Final Exam Week:**

Examination No. 3 (25% of course grade) may be considered as the Final Examination and is scheduled during the Final Exam Week. Students who have three or more exams scheduled for that day have the right to request relief. Please consult the instructor as soon as possible if that is the case.

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**Educational Accessibility Services:**

If you feel that you may need an accommodation based on the impact of a disability, please feel free to contact me privately to discuss your specific needs. Additionally, the Office of Educational Accessibility Services (EAS) coordinates reasonable accommodations for students with documented disabilities. The office is located at 5155 Gullen Mall, 1600 Undergraduate Library. Numbers: (313) 577-1851 (Phone), (313) 577-3365 (TTY), (313) 577-4898 (Fax). Email: eas@wayne.edu, Website: http://eas.wayne.edu.

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**Useful Resources:**

University academic calendar at http://sdcl.wayne.edu/RegistrarWeb/Calendars/academic
University registration schedule at http://sdcl.wayne.edu/RegistrarWeb/Calendars/registration
University final exam schedule at http://sdcl.wayne.edu/RegistrarWeb/Calendars-finals or http://sdcl.wayne.edu/RegistrarWeb/Calendars-finalsF08
BE 2550 Course Outline and Assignments

Note 1: Notations used below:
M = Gilat — MATLAB, N = Gilat & Subramaniam Numerical Methods; h = honors students
Note 2: Chapter 2 of Numerical Methods book provides mathematical background and review of basics of Calculus and Linear Algebra. This will not be covered in class, but may be a useful resource throughout the term.
Note 3: Homework solutions will be posted on Blackboard. Homework is due on Wednesday of the following week. We might revise the homework problems — please check the final posting on Blackboard.
Note 4: Projects will be assigned during the course of the term.
Note 5: Always start EARLY on homework assignments and projects.

<table>
<thead>
<tr>
<th>WEEK</th>
<th>OUTLINE OF TOPICS</th>
<th>READING</th>
<th>HOMEWORK</th>
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<tbody>
<tr>
<td>1</td>
<td>COMPUTATIONS AND BASICS OF MATLAB</td>
<td>Sept. 1 is Labor Day — no class</td>
<td>M§1-3; MATLAB Tutorials (Blackboard)</td>
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<td>Course administration</td>
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<td></td>
<td>Introduction to scientific computations and MATLAB environment; Data arrays</td>
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<td></td>
<td></td>
<td>M§3-4</td>
<td>3.6, 3.12, 4.7, 4.8(h), 4.12</td>
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<td>M§5</td>
<td>5.3, 5.5, 5.10, 5.11, 5.13(h)</td>
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<td></td>
<td></td>
<td>M§6</td>
<td>6.5, 6.7</td>
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<tr>
<td></td>
<td></td>
<td>MATLAB Tutorials</td>
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<td>2</td>
<td>Mathematical operations and use of script files in MATLAB</td>
<td>M§6</td>
<td>6.10, 6.13, 6.14(h), 6.17, 6.20</td>
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<td>Plotting in MATLAB</td>
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<td>User-defined functions and function files in MATLAB</td>
<td>M§7</td>
<td>7.4, 7.7, 7.9, 7.14, 7.21(h)</td>
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<td>Programming in MATLAB</td>
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<td>Introduction to numerical methods; Round-off and truncation errors</td>
<td>N§1</td>
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<td>3</td>
<td>SOLVING NONLINEAR ALGEBRAIC EQUATIONS</td>
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<td>Round-off and truncation errors</td>
<td>N§1</td>
<td>1.5, 1.17, 1.26(h)</td>
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<td>Bisection method; Regula Falsi method</td>
<td>N§3.1-3.4</td>
<td>3.3, 3.6, 3.14, 3.17, 3.18(h)</td>
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<td>Newton-Raphson and Secant methods</td>
<td>N§3.5-3.6</td>
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<td>4</td>
<td>Fixed-point iteration; Use of built-in MATLAB functions fzero, roots</td>
<td>N§3.7-3.8</td>
<td>3.9, 3.26, 3.29</td>
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<td>Solutions of sets of nonlinear equations; Multiple solutions</td>
<td>N§3.9-3.10</td>
<td>3.12, 3.33</td>
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<td>5</td>
<td>SOLVING SYSTEMS OF LINEAR ALGEBRAIC EQUATIONS</td>
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<td>Gaussian elimination method; Gaussian elimination with pivoting</td>
<td>N§4.1-4.4</td>
<td>4.1+ pivoting, 4.5+4.8, 4.23, 4.24, 4.32(a,c)</td>
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<td>Exam No. 1 on October 8</td>
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<td>6</td>
<td>LU Decomposition method</td>
<td>N§4.5</td>
<td>4.9, 4.10</td>
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<td>Inverse matrix algebra</td>
<td>N§4.6</td>
<td>4.13</td>
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<td>Iterative methods for nonlinear systems; Use of MATLAB built-in functions</td>
<td>N§4.7</td>
<td>4.32(b)+Jacobi Method</td>
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<td>N§4.8</td>
<td>4.34, 4.38</td>
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<td>Week</td>
<td>Date</td>
<td>Topics</td>
<td>Sections</td>
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<td>8</td>
<td>10/20, 22</td>
<td>Tridiagonal systems of equations; Ill-conditioned systems&lt;br&gt;Eigenvalues and eigenvectors</td>
<td>N§4.9-4.11&lt;br&gt;N§4.12</td>
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<td><strong>CUVER FITTING AND INTERPOLATION</strong>&lt;br&gt;Linear least-squares regression;&lt;br&gt;Linearized nonlinear regression models</td>
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<td>9</td>
<td>10/27, 29</td>
<td>Linearized nonlinear regression models&lt;br&gt;Curve fitting with higher-order polynomials&lt;br&gt;Curve fitting with nonlinear functions&lt;br&gt;Interpolation techniques&lt;br&gt;Use of MATLAB built-in function</td>
<td>N§5.3&lt;br&gt;N§5.4&lt;br&gt;N§5.8&lt;br&gt;N§5.5-5.6&lt;br&gt;N§5.7</td>
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<td><strong>NUMERICAL INTEGRATION AND DIFFERENTIATION</strong>&lt;br&gt;Trapezoidal and Simpson’s rules&lt;br&gt;Gauss quadrature&lt;br&gt;Multiple integrals</td>
<td>N§7.1-7.4&lt;br&gt;N§7.5&lt;br&gt;N§7.6</td>
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<td>10</td>
<td>11/3, 5</td>
<td>Multiple integrals; Use of built-in functions&lt;br&gt;Richardson extrapolation; Romberg integration; Improper integrals</td>
<td>N§7.6-7.8&lt;br&gt;N§7.9-7.11</td>
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<td>Exam 2 on November 12</td>
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<td>11</td>
<td>11/10, 12</td>
<td>Finite differences, difference formulas&lt;br&gt;Differentiation using Lagrange polynomials; Use of built-in functions&lt;br&gt;Richardson extrapolation&lt;br&gt;Errors in numerical differentiation</td>
<td>N§6.1-6.4&lt;br&gt;N§6.5-6.7&lt;br&gt;N§6.8&lt;br&gt;N§6.9</td>
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<td><strong>ORDINARY DIFFERENTIAL EQUATIONS</strong>&lt;br&gt;Euler’s Method&lt;br&gt;Modified Euler’s method&lt;br&gt;<em>Nov 26 is scheduled as Friday—no class</em></td>
<td>N§8.1-8.4</td>
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<td>14</td>
<td>12/1, 3</td>
<td>Runge-Kutta methods&lt;br&gt;Multiple-step methods; Predictor-corrector methods&lt;br&gt;Systems of first-order equations</td>
<td>N§8.5&lt;br&gt;N§8.6-8.7&lt;br&gt;N§8.8</td>
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<td><strong>Systems of first-order equations and higher-order initial value problems</strong>&lt;br&gt;Use of built-in MATLAB functions&lt;br&gt;<em>ode23/ode45</em>&lt;br&gt;Stability; Stiff ODEs&lt;br&gt;Wrap-up and Course Review</td>
<td>N§8.8-8.9&lt;br&gt;N§8.10&lt;br&gt;N§8.13-8.14</td>
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<td>16</td>
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<td>Exam No. 3 on December 18&lt;br&gt;(Thursday, 8:00-10:30 am)</td>
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