KOÇ UNIVERSITY  
College of Engineering  
Mechanical Engineering Department  

Course:  MECH 307 Numerical Methods for Mechanical Engineering  
(an area elective for Mechanical Engineering students)  

Semester:  Fall 2011  

Instructor:  Murat Sözer  
Office: ENG 249, Phone: 1582, e-mail: msozer@ku.edu.tr  
Office Hours: MW: 15:00-16:00 or by appointment.  
Lectures: MW: 9:30-10:45 in ENG B19.  

Teaching Assistant:  Bekir Yenilmez, Office: ENG 255 and ENG 106, Phone: 2603, e-mail: byenilmez@ku.edu.tr  
Baris Caglar, Office: ENG 255 and ENG 106, Phone: 2603, e-mail: bacaglar@ku.edu.tr  
Arda Aytekin, Office: ENG 258, Phone: 2659, e-mail: aaytekin@ku.edu.tr, OH: MW 14:00-15:00.  

Credits:  3  

Description:  
• Introduction to programming in MATLAB,  
• foundations in computing,  
• root finding,  
• solving systems of linear equations with direct and iterative methods,  
• solving nonlinear equations of multi-variables,  
• curve-fitting,  
• numerical differentiation and integration,  
• solving ODEs and PDEs using Eulerian time-marching scheme and finite difference method (FDM),  
• solving many engineering problems related with initial- and boundary-value problems, Laplace and heat equations.  

Pre-requisite:  (MATH 204 and COMP 130) or consent of the instructor.  

Motivation:  
• It is usually difficult to obtain exact analytic solutions to important problems in engineering.  
• Computers have enabled numerical solutions of a wide range of problems.  
• This course is organized to serve as an introduction to numerical methods.  
• The emphasis will be based on  
  (1) the fundamental concepts of numerical analysis, and  
  (2) hands-on experience in implementing the numerical methods.  
• MATLAB will be used in applications, projects and homework.  
Hence, at the beginning of the semester, MATLAB software will be taught.  

Contents:  
0. Introduction to MATLAB.  
1. Foundations.  
2. Solving Equations of One Variable.  
5. Nonlinear Functions of Several Variables.  
8. Interpolation.  
11. Numerical Differentiation and Integration.  
**Textbook:** No textbook. Class notes and handouts will be used.

**Reference books:**
* Applied Numerical Analysis Using MATLAB, Laurene V. Fausett, Prentice Hall
* Applied Numerical Analysis, Curtis. F. Gerald and Patrick O. Wheatley, Pearson
* Numerical Methods Using MATLAB, Mathews and Fink, Prentice Hall.
* An Introduction to Matlab, David F. Griffiths, University of Dundee.
* Numerical Methods with MATLAB, Gerald Recktenwald, Prentice Hall.

**Course Folder:**
F:\COURSES\UGRADS\MECH\MECH307
(1) lecture notes; and (2) last years’ (2003-2010) exams (problems & solutions) are available in electronic format (PDF).

**Grading:**
- Attendance: 2% (See the next page for detail.)
- Homeworks + Design Projects: 13%
- Class Assignment + Quizzes: 10% (In class and PS) *(No make-up!)*
- Midterm Exam I: 20% The date is to be announced later.
- Midterm Exam II: 20% The date is to be announced later.
- Final Exam: 35% The date is to be announced later.

**Tentative Schedule:**

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<thead>
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<th>Chapter</th>
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<td>27</td>
<td>Dec. 26</td>
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<tr>
<td>28</td>
<td>Dec. 28</td>
<td>Review for Final Exam</td>
</tr>
</tbody>
</table>

**HW Schedule:** Approximately 10 HWs will be given during the semester. To be submitted 7 days after the related chapter is studied in the class. (For example, if we finish covering Chapter 2 on Oct.12, then HW is due Oct. 19, 09:30)

**Design Project Schedule:** The due dates will be announced later.

<table>
<thead>
<tr>
<th>Design Project (DP)</th>
<th>Chapter</th>
<th>Project (details will be supplied in hand-outs)</th>
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<tbody>
<tr>
<td>1</td>
<td>9</td>
<td>Curve Fit to Experimental Data</td>
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<tr>
<td>2</td>
<td>11</td>
<td>Numerical Differentiation and Integration of Experimental Data</td>
</tr>
<tr>
<td>3</td>
<td>13</td>
<td>ODE: Initial-Value Problem (Time Marching)</td>
</tr>
<tr>
<td>4</td>
<td>14</td>
<td>ODE: Boundary Value Problems <em>(Steady Heat Equation &amp; Potential Equation in Fluid Mechanics)</em></td>
</tr>
<tr>
<td>5</td>
<td>15</td>
<td>PDE (Unsteady Heat Equation)</td>
</tr>
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</table>
Course Objectives:
This course is to have students become competent in ...
- programming in Matlab to implement numerical methods when solving many engineering problems;
- knowing the foundations of computing;
- calculating the roots of a function;
- understanding the fundamentals of linear algebra;
- knowing the direct and iterative solution techniques to solve a linear equation set;
- knowing the iterative solution technique to solve a nonlinear equation set;
- knowing the direct solution techniques (Gauss elimination and inverse matrix approach) and iterative solution techniques (Jacobian and Gauss-Seidel Iterative Methods) to solve a linear equation set;
- knowing exact polynomial curve fit;
- knowing best-curve fit;
- converting a continuous domain into a discrete domain;
- applying numerical differentiation methods;
- applying numerical integration methods;
- numerically solving initial-value problems (ODEs) of 1st and higher orders;
- numerically solving boundary-value problems (ODEs and PDEs).

Course Outcome:
At the end of this course, the students will be able to ...
- program in Matlab;
- implement numerical methods in Matlab to solve a wide variety of engineering problems;
- understand the solution types (no-, unique, and infinitely-many solutions) of linear algebra in general;
- calculate the roots of a function using bi-section, fixed-point iteration, Newton’s methods, and also by searching for sign changes;
- calculate the unknowns of a linear equation set using direct solution techniques (Gauss elimination and inverse matrix approach) for the unique-solution case;
- calculate the unknowns of a linear equation set using iterative solution techniques (Jacobian and Gauss-Seidel Iterative Methods) for the unique-solution case;
- calculate the unknowns of a nonlinear equation set using the iterative solution technique (Jacobian Method);
- know how to fit a unique N'th order polynomial curve passing from N+1 data points;
- know how to fit a polynomial or special-function curve passing from data points using (1) least-square method and (2) over-determined system;
- apply numerical differentiation with finite-differences and calculate the 1st and higher order derivatives of analytical functions or experimental data points;
- apply numerical integration using (1) trapezoidal rule and (2) Simpson’s 1/3 rule, and calculate definite integrals of analytical functions or experimental data points;
- numerically solve initial-value problems (ODEs) of 1st and higher orders using Eulerian time-marching scheme and search for convergence of result by reducing time step;
- discretize a solution domain; and numerically solve boundary-value problems (ODEs and PDEs) using finite-difference method.

Teaching Methods:
The following items are used
- tutorial on programming in Matlab (3 weeks)
- lecture notes;
- programming in Matlab for solving many engineering problems;
- homework and project assignment;
- problem sessions;
- review for exams.
**Expected Studying Time:**

<table>
<thead>
<tr>
<th>Item</th>
<th>Approximate studying time [hours] per week</th>
<th>Approximate studying time [hours] per semester (= 14 weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>[2 \times 1.25 = 2.50]</td>
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<tr>
<td>Problem Solution Session (PS)</td>
<td>1.25</td>
<td>17.50</td>
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<tr>
<td>Review of class notes and PS</td>
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<td>28.00</td>
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<tr>
<td>HW</td>
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<td><strong>Weekly sub-total</strong></td>
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<td>Design Projects</td>
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<td>Midterm Exam 2</td>
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<td>Final Exam</td>
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<td><strong>TOTAL</strong></td>
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<td><strong>211.50</strong></td>
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**Format of Exams:**
Matlab is allowed;
Lecture notes are placed in a shared exam folder, and allowed to use them during the exam.
Your own HW and assignments are also allowed *(as hard-copy).*

**Late Assignment:**
If an assignment (HW or project) is turned in late, you lose *25% of the grade per day.*

**Attendance to class:**
You are required to attend at least two thirds (= 67%) of the classes.
Otherwise, you receive grade F.

Attendance grade (out of 2%) is calculated as follows
*(medical report or a similar excuse will not affect the grading):*

- Full attendance to the class: 5%
- 1-day-absence: 4%
- 2-day-absence: 3%
- 3-day-absence: 2%
- 4- or more-day-absence: 0%

**Attendance to PS:**
Each Friday, 09:30 – 10:45 in SOS 180.
You are strongly suggested to attend weekly Problem Sessions (PS).
1. Exercise problems will be solved by either a TA or the professor; and
2. A quiz will be given similar to the problems already solved.
Moral Expectations from Students

The students are expected to submit their own work in all exams, projects, homeworks and class assignments.

- In quizzes and exams, students show how well they have learnt the material. Therefore they should not exchange any information. All forms of information transfer between students, and any talking will be considered as cheating.

- In HWs, students enhance their knowledge and show their skills. You can give/take brief tips from others verbally on how to do things, but you are expected not to exchange papers, and not to work together, or not let others do your work (even partially).

- Please be on time when entering the classroom. The class starts at 09:30; so be seated before 09:30.

- Please turn your mobile phones off, or put them in silence mode and do not use