SYLLABUS - MATH 373: INTRODUCTION TO NUMERICAL ANALYSIS

(3-0) 3 credits. Prerequisite: MATH 321 and CSC 150 or permission of instructor. This course is an introduction to numerical methods. Topics include elementary discussion of errors, polynomial interpolation, quadrature, non-linear equations, and systems of linear equations. The algorithmic approach and efficient use of the computer will be emphasized. Additional topics may include: calculation of eigenvalues and eigenvectors, numerical differentiation and integration, numerical solution of differential equations.

TEXT

Applied Numerical Methods with MATLAB® for Engineers and Scientists, 3rd ed., Steven C. Chapra
A free, online text is available at http://showard.sdsmt.edu. The student may also wish to purchase an optional additional numerical analysis or applied numerical methods book to provide supplementary and alternative explanations of the methods used in this course. Such books are typically available for under $10 on EBay or Amazon; however, they usually do not include the material on all of the covered topics, most particularly:

1) Modeling Engineering Systems with Differential Equations,
2) Solution of Partial Differential Equations (PDQ's) using Spreadsheets and MATLAB

Material will be accompanied with handouts but in all cases there is no substitute for thorough class notes, questions during class for clarification, and getting individual help when you need it. Handouts will be posted to the course web site.

INSTRUCTOR

Dr. S. M. Howard MI 114 Ph. 394 -1282
Stanley.howard@sdsmt.edu Open Door Office Policy

REQUIRED/ELECTIVE

MATH 373 is required for all B.S. Metallurgical Engineering and Mechanical Engineering students. It is a required course for B.S. Environmental Engineering students taking the Metallurgical Engineering emphasis.

COURSE OBJECTIVE

Students who complete this course successfully will be able to solve numerically a wide range of problems encountered in science and engineering that

- are described by ordinary differential equations
- are described by parabolic and elliptical partial differential equations,
- are described as a linearly bounded systems having a linear objective function,
- require integration of incrementized data, and
- require optimization.

COURSE OUTCOMES

1. Students will be able to write **finite approximations** of the first and second derivatives.
2. Students will able to explain the **Mean Value Theorem** and its relationship to error estimation.
3. Students will be able to derive the **LaPlace Equation** in rectilinear, cylindrical, and spherical coordinates with a generation term.
4. Students will be able to solve on a spreadsheet
   - **1D SS HT problems**
     Explicitly
   - **1D USS HT problems**
     Explicitly, by Saul'yev, by Frankel-DuFort, and by Crank-Nicolson all with fixed, zero-flux, gradient, and convection BC's.
   - **2D SS HT problems**
     Explicitly by relaxation with fixed, zero flux, gradient, and convection BC's.
   - **2D USS HT problems**
     Explicitly and Implicitly by ADI methods with fixed, zero flux, gradient, and convection BC's.
5. Students will be able to perform numerical integration by
   Rectilinear Rule, Trapezoid Rule, Simpson's 1/3 and 3/8 Rules, Gaussian Quadrature
6. Students will be able to solve a system of Ordinary Differential Equation of any order by **Runge-Kutta Methods** including the Fourth Order form by hand and by using MathCad.

7. Students will be able to find roots by the following methods
   - **Interval Halving**
   - **False Position**
   - **Secant**
   - **Newton-Raphson**
   - **One-point Iteration**
8. Students will be able to construct objective functions necessary for **LP** and **Data Adjustment** problem solutions solved by **Excel Solver**.
9. Students will submit a written **project report** and orally present the numerical solution to an engineering problem.

TOPICS

The following is intended to be an approximate guide to the topics we will cover and the amount of time that will be devoted to each topic. The topics or the time on each may vary somewhat to accommodate the class but the exams will be given when scheduled.

Approximations of Derivatives
Mean Value Theorem and Approximation Errors
    Modeling Engineering Systems with Differential Equations
    Heat Conduction in Solids
    Velocity Gradients in Laminar Flow, Well Draw Down Profiles
Solution of Partial Differential Equations (PDQ's) using Spreadsheets
    Explicit Methods: Steady State
    Gradient and other Boundary Conditions
    Explicit Methods, Unsteady State, Implicit Methods
Excel® Solver and Linear Programming Problems
    Optimization & Objective Functions and Excel® Solver
    Linear Programming
    Data Adjustment
    Curve Fitting by Least Squares Regression
Root Finding Methods: Bisection, False Position, Secant, Newton, One-Point Iteration
Gauss Elimination: Systematic Solution of Linear Equations
Numerical Integration: Rectangular Rule, Trapezoid Rule, Simpson's 1/3 Rule, Gauss Quadrature
Numerical Solutions to Ordinary Partial Differential Equations
    One Step Methods: Milne's Method, Runge-Kutta Methods
    MathCad
    MathCad Solutions of Ordinary Differential Equations (ODE's)
Student Projects
Student Reports

CLASS SCHEDULE

11:00 – 11:50 MWF	Spring	MI 222
02:00 – 02:50 MWF	Fall	MI 222

RELATION OF COURSE OUTCOMES TO PROGRAM OUTCOMES

a) Apply Knowledge of Math, Science, and Engineering
b) Design and Conduct Experiments and Analyze and Interpret Data and Information
e) Identify, Formulate, and Solve Engineering Problems
k) Use Engineering Techniques, Skills, and Tools

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT

This course provides the fundamental concepts required to solve engineering problems numerically.

LABORATORY

none

EXPECTATIONS

College Calculus, Chemistry, Physics

COMPUTER USAGE

Advanced Excel including Macros, MathCad

ASSESSMENT AND EVALUATION

One Final Exam
Three Hour Exams
Homework
Project Report

GRADES

Homework	10 points each	150*
Short Quizzes	10 points each	50*
Hour Exams	100 points each	300 to 400*
Final Project		100
Final exam		~150*

* These are approximate numbers.

The final grade is based directly on the total points achieved. There is no additional weighting. On rare occasions a student's grade may be raised (but never lowered) for subjective considerations such as an excellent homework file. The final grade section average is normally between 2.9 and 3.2.

COURSE WEB SITE

Important supplemental course information will be posted at this address: http://webct.sdsmt.edu:8900/webct/public/home.pl. Student have access to email groups and threaded discussions on the web site. The site also contains exam review information, a calendar, and interactive modules for enhanced learning.

ADA STATEMENT

Students with special needs or requiring special accommodations should contact the instructor, Dr. Howard at 394-1282 or the campus ADA coordinator at the **earliest** opportunity.

POLICIES

Illness Students who are ill should not attend class or come to the instructor's office to report illness. Go home and call (394-1282) to limit the risk of exposing others. Leave a message.

Office hours are posted on my door (MI 114). If no office hours are specifically listed then all unscheduled hours are available to students for help. Students are encouraged to get help from the instructor. Students are welcome to call the instructor (394-1282) or email him (showard@silver.sdsmt.edu). Phone messages might not be replied to punctually. If there is a need to contact the instructor on an urgent matter (including help on course content) and you have not received a reply call the secretary at 394-2341 and have her leave a message on my door to call you.

Assignments will be announced in class

Late Assignments. Assignments are made one week in advance so that there is plenty of time to complete them. **No assignments will be accepted if they are more than one week late. Assignments not submitted on time are given a maximum of ½ credit.**

Short quizzes will be announced in class at least two days in advance and on the web site at least one day in advance.

Short quizzes will cover only material from the lecture or web site for the course and the topic will generally be described in class.

Format of all submitted work. All exam, quiz, and homework sheets provided by the instructor MUST be stapled on top of each student submittal. If no sheet is provided, staple an entire sheet of paper on top of the homework with your name, date and assignment topic **CLEARLY PRINTED** (by hand is ok) on the sheet.

Homework is graded. None is disregarded in grade computation.

Attendance. Students are expected to attend class unless otherwise excused.

Excused absences from short quizzes will result in the assignment of an estimated grade for the missed quiz. Unexcused absences will result in a zero. All quizzes, homework, and exams count towards the final grade. Short quizzes cannot be made up. However, if your absence is excused the replacement grade will be estimated based on your normal performance and your peers' performance on the missed quiz.

Missed exams. Students who miss an hour exam for an excused reason will be given a make-up exam that will be designed to be more difficult and longer than the missed exam. Unexcused exam absences will result in an exam grade of zero. Students must make arrangements on the first day of class after their return to take the missed exam.

Final Exam. The final exam will be required unless otherwise stated in class and posted on the class web site before the last class period.

PREPARED BY

S. M. Howard

