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INTRODUCTION TO SCIENTIFIC & ENGINEERING COMPUTING BIL 108E, CRN 24023

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SOURCES

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- William J. Palm, 2005, Introduction to Matlab 7 for Engineers, Mc Graw Hill.

Suplementary Book :

- Cleve B. Moler, Numerical Computing with MATLAB, SIAM, 2004. An electronic edition, published by The MathWorks, is available from http://www.mathworks.com/moler/ .
- Etter, D.M., Engineering Problem Solving with Matlab, 2nd ed., Prentice Hall, NJ, 1997.
- http://www.mathworks.com

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TENTATIVE SCHEDULE

Week	Date	Topics
1	Feb. 08	Introduction to Scientific and Engineering Computing
2	Feb. 15	Introduction to Program Computing Environment
3	Feb. 22	Variables, Operations and Simple Plot
4	Mar. 01	Algorithms and Logic Operators
5	Mar. 08	Flow Control, Errors and Source of Errors
6	Mar. 15	Functions
6	Mar. 20	Exam 1
7	Mar. 22	Arrays
8	Mar. 29	Solving of Simple Equations
9	Apr. 05	Polynomials Examples
10	Apr. 12	Applications of Curve Fitting
11	Apr. 19	Applications of Interpolation
11	Apr. 24	Exam 2
12	Apr. 26	Applications of Numerical Integration
13	May 03	Symbolic Mathematics
14	May 10	Ordinary Differential Equation (ODE) Solutions with Built-in Functions

COURSE OBJECTIVES

Course Objectives

- To familiarize students with the fundamentals of scientific computing concepts
- To develop problem solving skills
- To develop skills in constructing an algorithm,
- To train students how to use Matlab in scientific and engineering calculations
- To train students to visualize their results and prepare written reports

TOOLS FOR OBJECTIVES

TOOLS FOR OBJECTIVES :
Lecturing, laboratory sessions, homework and final exam. All the activities except lecturing will be carried out in the computer labs.

Homework :
Six homework assignments will be handed out and best five out of six will be considered.

Laboratory Sessions :
Laboratory sessions will be based on the material covered in the lectures. If one did not attend the lecture, they will most likely not be able to contribute an effort to solve the assigned problems, therefore only the ones who attend the lecture will be admitted to the laboratory.

GRADING

Exams :
All exams will be conducted in computer labs unless otherwise stated. Only your ITU accounts and course web page will be available in exams.
final exam (limited access to internet)

Grading :

Homeworks (5 assignments, 6% each)	30%
Midterms (2 exams, 15% each)	30%
Final Exam	40%

COURSE OUTCOMES

Course Outcomes
Students succeeding the course will be able to,

- Analyze a problem and develop an algorithm
- Test, debug, and verify the program
- Understand and do both pre- and post- processing of raw data (input) and produced data (output) for scientific and engineering problems
- Prepare scientific report

OUTLINE, WEEK# 1

- THE PROBLEM AND IT'S SOLUTION
- TOP TEN OUTSTANDING ENGINEERING ACHIVEMENTS AND GRAND CHALLENGES FOR THE FUTURE
- PROOF AND SIMULATIONS
- COMPUTER LANGUAGES
- FLOWCHART

THE PROBLEM AND IT'S SOLUTION

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Problema-Greek word(something thrown forward)

The modern definition is :

- a question raised for inquiry, consideration or solution.

Problem solving can be described as the process of arriving at solutions to a problem, question or situation, which involves the use of mathematical, physical or logical reasoning.

Problems can be classified according to their type of solution as

- algorithmic(step by step approach computes) or
- heuristic

SOLUTION TECHNIQUES

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Algorithmic problems(deterministic)

- usually quantitative in nature
- require numerical computation

Heuristic solution approach:

- Does not follow step-by-step approach.
- Based on reasoning built on practice, knowledge and experience.
- In many cases the method is trial and error

Heuristic solutions

- Qualitative in nature
- Based on human judgment, values, principles and experience
- Some examples, (buying a car, choosing a college)
- Uncertain unpredictable, impossible to estimate

SAMPLE ANALYSIS PROCESS

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Phases of a sample numerical analysis implementation:

- State the problem clearly.
- Describe the input and output information.
- Work the problem by hand (or with a calculator) for a simple set of data.
- Develop a solution code.
- Test the solution with a variety of data.

COMPUTER SIMULATION

Simulation can also be very useful in analyzing a given problem and finding a solution using the power of the computer.

Here to paraphrase Mario Salvadori.

An engineer is a fool who can build for one dollar what fool can build for two dollars.
(Don't forget : Computer usage increases cost)

ENGINEERING ACHIVEMENTS

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TOP TEN OUTSTANDING ENGINEERING ACHIVEMENTS(25 year period)
(National Academy of Engineering(1989))

1. The development of microprocessor
2. Moon landing(Apollo spacecraft, lunar landing, three stage Saturn V rocket, spacesuit(190 pounds = 86 kg), etc.)
3. Application satellites weather information communication signals map uncharted terrain environmental updates an th ecomposition of atmosphere global positioning system (position velocity, and time constellation of 24 satellites, requires min 4 satellites)
4. Computer aided design and manufacturing, CAD CAM
5. Jumbo Jet (originated Air Force C-5A cargo plane, 1969) high bypass fanjet(less fuel consumption, less noise)

ENGINEERING ACHIVEMENTS

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cont'd.

6. Advanced composite materials lighter stronger and more temperature resistant materials for aircraft and spacecraft sport goods
7. Computerized axial tomography medicine and bioengineering CAT scanner machine (generates 3D images or 2D slice using X-Ray) used for tumors, blood clots and brain abnormalities.
8. Genetic engineering insulin growth hormones infection resistant vegetables

ENGINEERING ACHIVEMENTS

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cont'd.

9. Lasers CO_2 lasers drilling for composite to ceramics medical usage, weld detached routines, seal leaky blood vessels, vaporize brain tumors, inner ear surgery. 3D holograms
10. Optical fibers fiber-optic communication (thinner than human hair) better than radio or electric waves in copper telephone wires. does not produce electromagnetic waves(cause interference)

ENGINEERING CHALLENGES

Grand challenges for the future

- The prediction of weather, climate and global change
- Computerized speech understanding
- Human genome project
- Improvements in vehicle performance
- Enhanced oil and gas recovery
- etc., etc.

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WHAT IS SCIENTIFIC COMPUTING?

What is scientic computing?

- Design and analysis of algorithms for solving mathematical problems in science and engineering numerically
- Traditionally called
  - numerical analysis

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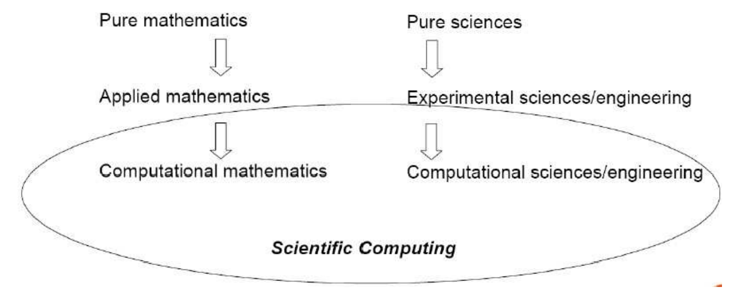
EVOLUTION OF COMPUTING

Evolution of scientific computing from other sciences and engineering disciplines



INTERDISCIPLINARY

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WHY SCIENTIFIC COMPUTING?

Why scientific computing?

- Mathematical problems that do not have closed formsolutions.
  Example : Solve $33x^5 + 8x^4 - 2x^2 + 17 = 0$
- Even if solution formula exist, it may be difficult to compute.
- To replace expensive experiments with computersimulations.

COMPUTER SOLUTIONS

Computer Solutions

- executes instructions extremely fast.
- necessary to have an effective communication channel between the user and the machine (computer language)

COMPUTER LANGUAGE

Computer Language

Similar to the human language,

- set of well defined syntax and semantic rules
- syntax rules govern
  - grammar
  - format
  - punctuation
- semantic rules provide the meaning

In this lecture we will use the MATLAB interface language

COMPUTER LANGUAGE

A computer program is a set of instructions, written in a computer language
Syntax rules are strict grammar rules.
Any variation of the rules causes errors(FATAL ERROR, from fortran 77 time).

An error is called :

- a bug(this definition comes from the ancient computer time with huge computers and real bugs).

Debugging - correcting the errors.

SOFTWARE FOR COMPUTATION

Mathematical Computation

Commercial

- Matlab, Mathematica, Mathcad, Maple, Mupad, etc.

Non-Commercial

- GNU-Octave, Scilab, Euler, Maxima

LANGUAGES

- high level (BASIC, MATLAB, FORTRAN)
  - easier to write
- mid level (C, C++)
- low level
  - assembly(not binary)
  - machine lang.(binary)
  - differs from hardware to hardware

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LANGUAGE GENERATIONS

Language Generations

1. machine language
2. Assembly
3. high level language
4. 4GL have not been developed yet
5. Natural languages

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CHRONOLOGY ON LANGUAGES

- Fortran 1950's, scientific and engineering
- COBOL 1950's, business problems
- BASIC 1960's educational tool
- PASCAL 1970's computer science students intro
- ADA 1970's
- C 1970's Bell Laboratory, Hardware Independent, Dennis Ritchie, Brian C. Kernighan
- C++ 1980's Bjarne Stroustrup, Object oriented design and programming

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MATLAB SOFTWARE

Historical Facts about Matlab

- Matrix-based numeric computation
- MATrix LABoratory
- The language was invented by Cleve Moler in the late 1970's
- He designed it to give his students access to LINPACK and EISPACK without having to learn Fortran.
- MATLAB is rewritten in C and founded The Mathworks is founded in 1984 to continue its development by Cleve Moler and Steve Bannert.

MATLAB SOFTWARE

- Calculations done by Arithmetic Logic Unit (ALU)
- results are stored in memory
- and control unit manages the flow of instructions
- information stored in memory as a variable.

What is a variable?

VARIABLE

Variable is a name that can represent the data, numbers or strings. (may change during the execution of the program)

The following expression means that the variable BIL is ASSIGNED THE VALUE 8.0 and its stored in MEMORY LOCATION BIL.

$BIL = 8.0$
$KNOW = 9.0$

- Here the "$=$" symbol means in most computer languages "IS ASSIGNED" but NOT the algebraic sign "EQUAL TO".

CONSTANT

A Constant takes a specific value and does not change

$PI = 3.14...1592654$
$e = 2.71...8281828$

(euler number, Leonhard Euler, 1707-1783)

- Good naming techniques

OPERATORS

Operators used to implement and//or model expressions, algorithms or equations
Software processes them by a given hiearchy.
Operators

- arithmetic($+, *$)
- relational($==$)
- logical(&&)

the shortest correct sequence leading to the correct result constitutes the best or the most efficient program.

STATEMENTS

statements

Area of a circle

```
area=PI/4.0*D**2
area=PI/4.0*D^2
area=PI/4.0*SQU(D)
```

FUNCTIONS

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Libraries of functions,

- Instructions that are frequently used in the solution of problems defined by keywords $sin(x)$, $max(x)$..., etc.

FLOWCHART

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- variables
- constants
- operators
- functions
- expressions
- and equations

So how should we organize them all?

FLOWCHART

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Construction of a flowchart(heuristic)

(Flow Diagram)

Graphical or pictorial representation of an algorithm showing the steps involved as well as the interrelations of these steps in the solution of a problem.

- Defines known and unknown variables and constants
- Indicates sequence of steps and decisions, program operations, principles and equations used.

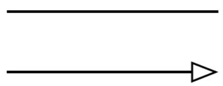
With a flowchart the computer program writing is an easy translation.

FLOWCHART

Algorithm process is defined by a box with a specific shape(identifies the action or process.)

Start, stop or other end points

Flow line indicates the direction or sequence in which data flows or the instructions are executed



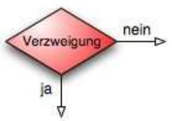
FLOWCHART

Process or instruction box, use for data manipulation, computation, or movement of data

Subprogramm

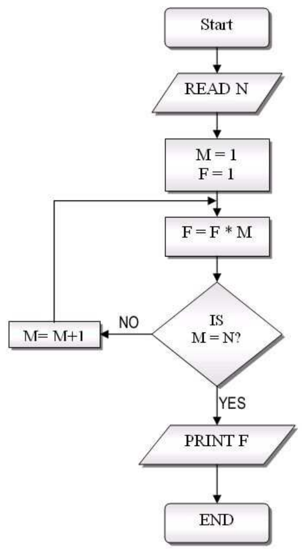
FLOWCHART

Decision or branching box represents a point in the program where the logic flow will follow one of two paths, depending on the situation (yes or no, or true or false)



Parallelogramm for input and output.
(not after DIN66001 1983)

SAMPLE FLOWCHART



References for Week 1

1. Misza Kalechman, Practical Matlab Basics for Engineers, CRC Press, 2009.
2. Etter, D.M., Engineering Problem Solving with Matlab, 2nd ed., Prentice Hall, NJ, 1997.