



INTRODUCTION TO SCIENTIFIC & ENG.
COMPUTING
BIL 108E, CRN 44448



Week.1

Dr. Feyzi HAZNEDAROĞLU

Istanbul Teknik Üniversitesi - İnşaat Fakültesi
Room : 250A, e-mail : haznedar@itu.edu.tr

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COURSE SOURCES

- **Main Book:**
- William J. Palm, Introduction to Matlab 7 for Engineers, 2005, Mc Graw Hill.
- **Supplementary 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>
- Presentations will be uploaded → ninovaltu.edu.tr
- **Teaching assistant will be assigned in a few weeks**

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2



TENTATIVE SCHEDULE

Wk	Date	Topics
1	Feb. 11	Introduction to Scientific and Engineering Computing
2	Feb. 18	Introduction to Program Computing Environment
3	Feb. 25	Variables, Operations and Simple Plot
4	Mar. 04	Algorithms and Logic Operators
5	Mar. 11	Flow Control, Errors and Source of Errors
6	Mar. 18	Functions
	Mar. 20	Exam 1
7	Mar. 25	Arrays
8	Apr. 01	Solving of Simple Equations
9	Apr. 08	Polynomials Examples
10	Apr. 15	Applications of Curve Fitting
11	Apr. 22	Applications of Interpolation
	Apr. 24	Exam 2
12	Apr. 29	Applications of Numerical Integration
13	May.06	Symbolic Mathematics
14	May.13	Ord Dif.Equations (ODE) solution with Built-in Functions

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3



Course Objectives

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

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4



Course Objectives

TOOLS FOR OBJECTIVES :

- Lecturing, laboratory sessions, homework and final exam. All the activities except lecturing will be carried out in the computer labs. (depending lecturing class inivroment)

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.

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5



Course Objectives

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 :

- | | |
|---------------------------------------|-----|
| • Home works (5 assignments, 6% each) | 30% |
| • Midterms (2 exams, 15% each) | 30% |
| • Final Exam | 40% |

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Course Objectives

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

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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

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8



THE PROBLEM AND IT'S SOLUTION

Problema – A 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

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 are;

- **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

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

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 on the composition of atmosphere, global positioning system (GPS) (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)
6. Advanced composite materials, lighter, stronger and more temperature resistant materials for aircraft and spacecraft sport goods.



ENGINEERING ACHIVEMENTS

TOP TEN OUTSTANDING ENGINEERING ACHIVEMENTS (Cont'd)

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
9. Lasers, CO₂ 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.



ENGINEERING CHALLENGES

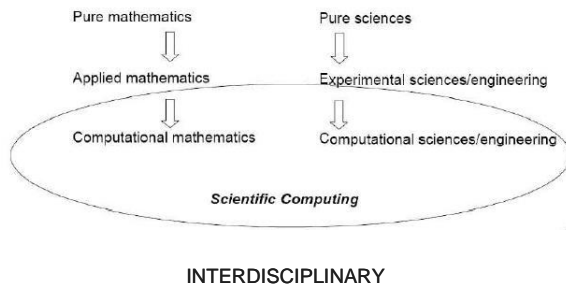
What is scientific computing ?

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



EVOLUTION OF COMPUTING

- Evolution of scientific computing from other sciences and engineering disciplines.



Why scientific computing?

- Mathematical problems that do not have closed form solutions.
Example : Solve $\Rightarrow 33 \times 5 + 8 \times 4 - 2 \times 2 + 17 = 0$
- Even if solution formula exist, it may be difficult to compute.
- To replace expensive experiments with computer simulations.



Computer Solutions & Computer Language

Computer Solutions

- executes instructions extremely fast.
- Necessary to have an effective communication channel between the user and the machine (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

1. Commercial

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

2. 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



LANGUAGE GENERATIONS

- Language Generations

1 machine language

2 Assembly

3 high level language

4 4GL have not been developed yet

5 Natural languages



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



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.



- 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 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.
$$BIL = 8.0$$
- Here the "=" symbol means in most computer languages "IS ASSIGNED" but NOT the algebraic sign "EQUAL TO".



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

Operators

- Arithmetic (+,-)
- Relational (==)
- Logical (&&)

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



Statements

Area of a circle (many statement types)

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

Libraries of functions,

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



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

So how should we organize them all ?



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.

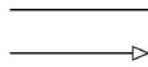
FLOWCHART

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

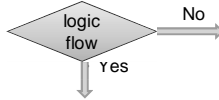


Subprogramm



FLOWCHART

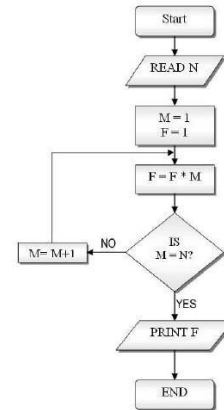
- Decision or branching box represents a point in the program where the logic flow will follow one of two paths, depending on the situation (yes or no, or true or false)



- Parallelogram for input and output.
- (not after DIN66001 1983)



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.

Have a nice Week End