



Wrocław University of Science and Technology

Department of Cybernetics and Robotics



Scientific & Engineering Programming

Lecture I

Introduction. Tools

Krzysztof Arent, Robert Muszyński

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Some facts

- course home page:
<https://kcir.pwr.edu.pl/~mucha/SciEng>
- lecture instructors: Krzysztof Arent, Robert Muszyński
 - office: room 106/331, building C-3
 - contact and office hours: refer to the lecturers' home pages
- rest of the crew: Joanna Ratajczak, Katarzyna Zadarnowska
 - office: room 330, building C-3
 - contact and office hours: refer to the lecturers' home pages
- final tests: will be, for details refer to the CHP
- credit: pass the final tests and complete the laboratory classes
- contents – soon



Scientific & Engineering Programming

Scientific – related to science

science – knowledge about or study of the natural world based on facts learned through experiments and observation (Merriam-Webster Dict.)

scientist – some of you (if not now, in near future, hopefully:)

Engineering – a function of an engineer

but also: the application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to people (Merriam-Webster Dict.)

engineer – some of you, again (let's hope:)

- a designer of engines (Merriam-Webster Dict.)

- a person who designs, builds, or maintains engines, machines, or structures (Oxford Dict.)



Scientific & Engineering Programming

Scientific – related to science

science – knowledge about the natural world

Engineering – related to design

engineering – application of science and mathematics in nature

Programming – related to programs

programming – the act of creating computer programs



Scientist & Engineer Needs

- acquire knowledge
- describe nature
- predict behaviors
- invent machines
- design machines
- analyze machines
- build machines
- test machines
- keep machines running



Scientist & Engineer Process Cycle & Tasks

the cycle:

- pre-processing — defining the model and environmental factors
- analysis – understanding, verification
- post-processing of results – visualization

tasks:

- modelling
- simulation
- visualization



Scientist & Engineer Programming Tools

- programming languages
 - programming environments
 - libraries
 - general purpose
 - linear algebra https://en.wikipedia.org/wiki/List_of_computer_algebra_systems
 - physic engines
 - differential equations solvers
 - motion planning and automatic control
 - optimization
 - curve fitting
 - signal processing
 - machine learning
 - ...
 - simulation environments
-
- all these CAE, CASE, CAD, CAS, FEA/FEM, MBD, ETC stuff



Scientist & Engineer Programming Tools

they should be

- effective
- efficient
- impressive



Scientist & Engineer Programming Tools

- GNU Scientific Library, Intel Math Kernel Library, AMD Core Math Library
 - BLAS, LAPACK, UMFPACK, Eigen, uBLAS, GSL, Armadillo, MKL, ACL
 - Bullet, ODE, Box2D, OpenTissue, PhysicsJS, Havok, PhysX, Newton Dynamics
 - Gazebo, v-rep, Microsoft Robotics Developer Studio, LabVIEW Robotics Module, Webots, USARsim, SystemModeler, Octave, WolframAlpha
 - SUNDIALS, IPOPT, MPK, OMPL, OOPSMP, MSL, SIMOX, ACADO Toolkit, OpenDX, ParaView, Gnuplot
-
- **MATLAB** [▶ Link](#), **MATHEMATICA** [▶ Link](#)



MATHEMATICA

a mathematical symbolic computation program, sometimes termed
a computer algebra system

- core technologies

- Wolfram language
- Wolfram notebook interface
- Wolfram algorithm base
- Wolfram knowledge base
- Wolfram engine
- Wolfram cloud

- coverage

- symbolic language
- numerics
- math computation
- algebraic manipulation
- differential equations
- control systems
- robotics
- data analysis
- signal processing
- computer vision
- visualization



MATHEMATICA

● features

- libraries of mathematical elementary functions and special functions
- support for complex number, arbitrary precision arithmetic, interval arithmetic, and symbolic computation
- matrix and data manipulation tools including support for sparse arrays
- 2D and 3D data, function and geo visualization and animation tools
- solvers for systems of equations, Diophantine equations, ordinary differential equations (ODEs), partial differential equations (PDEs), differential algebraic equations (DAEs), delay differential equations (DDEs), stochastic differential equations (SDEs), and recurrence relations
- finite element analysis including 2D and 3D adaptive mesh generation
- numeric and symbolic tools for discrete and continuous calculus including continuous and discrete integral transforms
- constrained and unconstrained local and global optimization
- multivariate statistics libraries including fitting, hypothesis testing, and probability and expectation calculations on over 160 distributions
- support for censored data, temporal data, time series, and unit based data
- calculations and simulations on random processes and queues
- supervised and unsupervised machine learning tools for data, images and sounds including artificial neural networks
- tools for text mining including regular expressions and semantic analysis
- data mining tools such as cluster analysis, sequence alignment and pattern matching
- computational geometry in 2D, 3D and higher dimensions
- libraries for signal processing including wavelet analysis on sounds, images and data
- linear and non-linear control system libraries
- tools for 2D and 3D image processing and morphological image processing including image recognition
- tools for visualizing and analyzing directed and undirected graphs
- tools for combinatoric problems
- number theory function library
- tools for financial calculations including bonds, annuities, derivatives, options etc.
- group theory and symbolic tensor functions
- import and export filters for data, images, video, sound, computer-aided design (CAD), geographic information systems (GIS), document and biomedical formats
- database collection for mathematical, scientific, and socio-economic information and access to Wolfram Alpha data and computations
- technical word processing including formula editor and automated report generator
- programming language supporting procedural, functional, and object-oriented constructs
- toolkit for adding user interfaces to calculations and applications
- tools for creating and deploying cloud based computational applications and services
- tools to connect to dynamic-link library (DLL), Structured Query Language (SQL), Java, .NET, C++, Fortran, CUDA, OpenCL, and Hypertext Transfer Protocol (HTTP) based systems
- tools for parallel programming
- using both "free-form linguistic input" (a natural language user interface) and Wolfram Language in notebook when connected to the Internet



MATHEMATICA

How to begin?

- get a version of Mathematica to work with [▶ Link](#) [▶ Link](#) [▶ Link](#)
- work with Wolfram Cloud [▶ Link](#)
- download CDF Player to view documents [▶ Link](#)
- work with Wolfram Alpha [▶ Link](#)