For a person, who only has a hammer in his or her toolbox, every problem seems to be a nail.

For a person, who only has MATLAB in his or her toolbox, every problem seems to be NUMERICAL.

YET,

except of those which are database problems ,

in a real world all real problems are numerical . . .

. . . and MATLAB is sort of SWISS KNIFE for numerical problems.

MATLAB

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Table of Contents

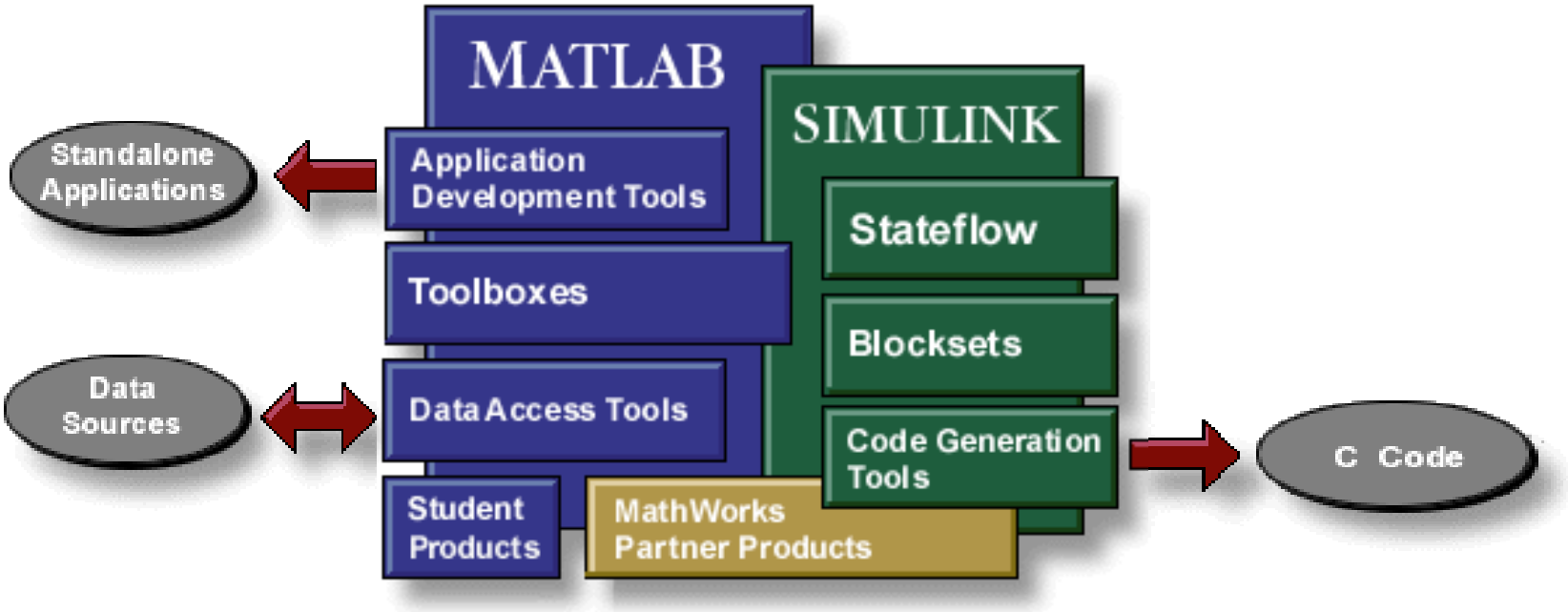
History of MATLAB

- Cleve Moler
  - LINPACK and EISPACK Documentation
  - FORTRAN Frontend for these Packages
  - The MathWorks Inc.
  - Presently CEO of the Company
- SIMULINK, Toolboxes, Code-Generation, Real-Time Applications
- Graphical Representation of Data
- Switch to C++ and LAPACK
- Numerical Package - Numerous Accessories

The MathWorks about MATLAB

„ The MathWorks offers a set of integrated products for data analysis, visualization, application development, simulation, design, and code generation."

„ MATLAB is the foundation for all the MathWorks products."



http://www.mathworks.com/

MATLAB deals with Matrices

- **MAT**rix **LAB**oratory
- Basic Objects are 2-dimensional Arrays
- Operations are primarily defined for Matrices
  - A*B - Matrix Multiplication
  - A.*B - Element Multiplication
- Most Functions defined for Matrices (sin, log)
- Special Functions for Matrix Manipulation
  - Transposing, Diagonalisation, . . .
  - M*X=B --> X=M\B
- Cell Arrays, Structures, UINT8, . . .

Programming

- Direct Access via Command Window
- Interpreter -- 4 GL Scripting Language
- Command Scripts -- Functions
- Access to Java VM, Java-like Code
- Extension thru Compiled Code -- MEX Functions
- Backend for other Programs -- ENGINE
- ActiveX and COM
- MATLAB Compiler -- C-Code, Library

Data Exchange

- Import Wizard -- "Click and Go"
- SAVE and LOAD working environment
- High Level Ops -- TEXTREAD, DLMREAD
- Special Formats -- XLSREAD, IMREAD, . . .
- Medium Level Ops -- fscanf, fprintf
- Low Level Ops -- fread, fwrite
- C, C++ Functions -- MEX
- Outside Access -- ENGINE
- ActiveX, COM

Numerical Applications

- Most physical laws are relations between derivatives -- differential equations
- Newton's second law: $m\ddot{r} = F$
- *O*rdinary *D*ifferential *E*quations (ODE)
  - *I*nitial *V*alue *P*roblems (IVP)
  - *B*oundary *V*alue *P*roblems (BVP)
- *P*artial *D*ifferential *E*quations (PDE)
  - Static
  - Dynamic
  - Eigenmodes, Eigenvalues
  - . . .

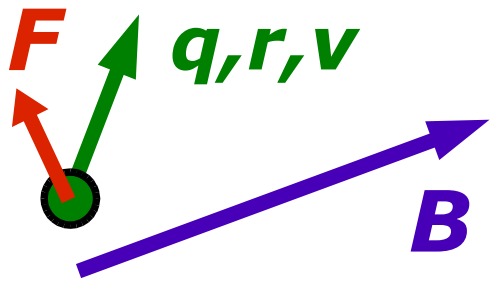
ODE: Initial Value Problem

Charged Particle in a Magnetic Field *B*

Starting Point r_0

Initial Velocity v_0

Lorentz Force $F = q\,(v \times B)$



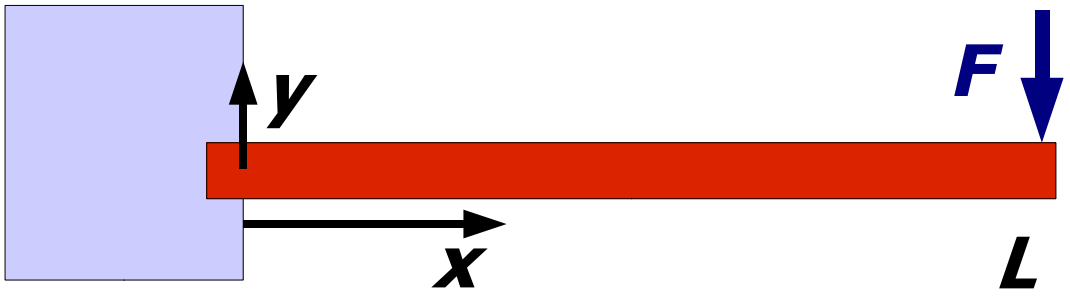
***r(t)*: 3 Coupled Second Order Linear ODEs**

Substitution $r \Rightarrow u(1:3),\quad \dot{r} \Rightarrow u(4:6)$

6 Coupled First Order Linear ODEs for *u*

ODE: Boundary Value Problem

Bar -- One Side Clamped -- Force *F* at *L*



Torque at *x* determines curvature at *x*

$$y''(x) = G(x)\,E(x)\,F \cdot (L - x)$$

Boundary Conditions: $y(0) = 0,\ y'(0) = 0$

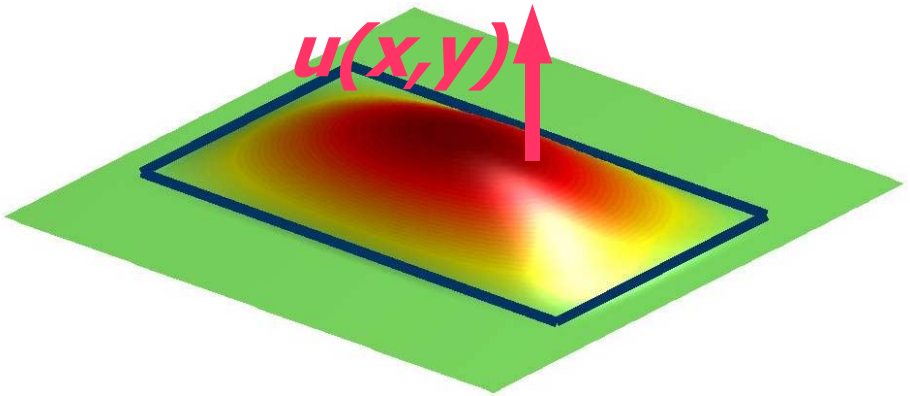
PDE -- Eigenvalue Problem

Membrane with Clamped Boundary

Laplace $\Delta u = 0$

Poisson $\Delta u = p$

Helmholtz $\Delta u = \ddot{u}$



Ansatz $u(x,y,t) = \sum u_n(x,y)\exp(j\omega_n t)$

Eigenvalue Problem $\Delta u_n = -\omega_n^2 u_n$

Discrete Laplace $-\Delta(a,b) = 4(a,b) - (a+1,b) - (a-1,b) - (a,b+1) - (a,b-1)$

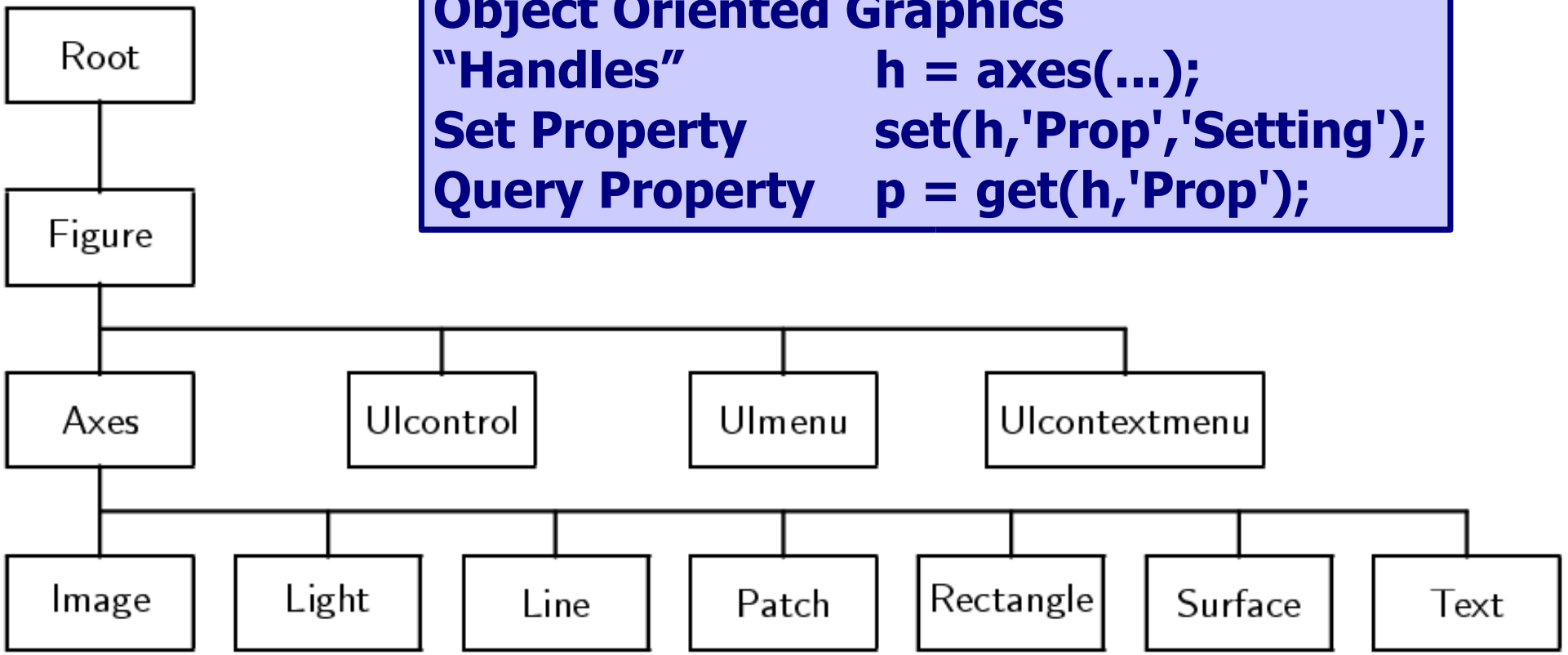
Experiment: Control and Data Acquisition

- Direct Access to Computer Hardware
  - Serial Interface (Fully Programmable)
  - Printer Interface (Logical File)
- Java VM
  - Socket Connection to the Ethernet
- Data Acquisition Toolbox
  - Analog Input and Output
  - Digital Input and Output
- Additional Software
  - MEX, ENGINE, ActiveX, COM

Graphics in MATLAB – Hierarchy of Objects

Object Oriented Graphics

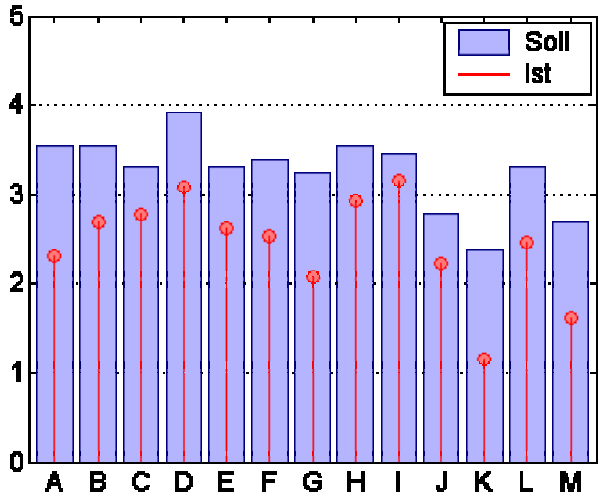
"Handles"	**h = axes(...);**
Set Property	**set(h,'Prop','Setting');**
Query Property	**p = get(h,'Prop');**

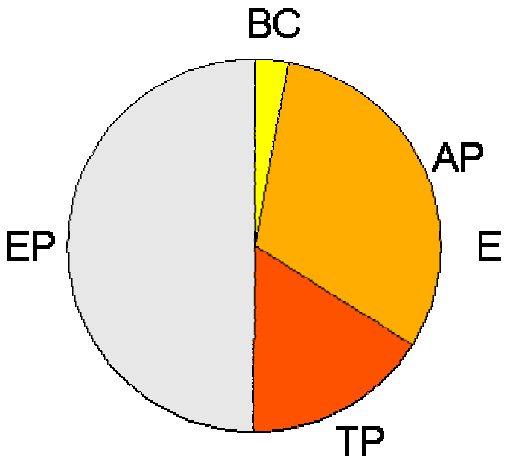


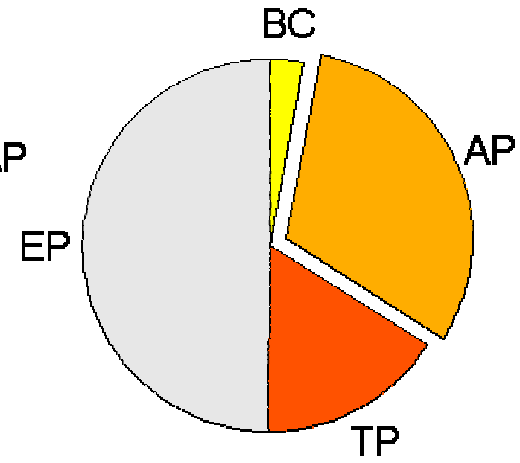
Graphical Data Representation – 2D

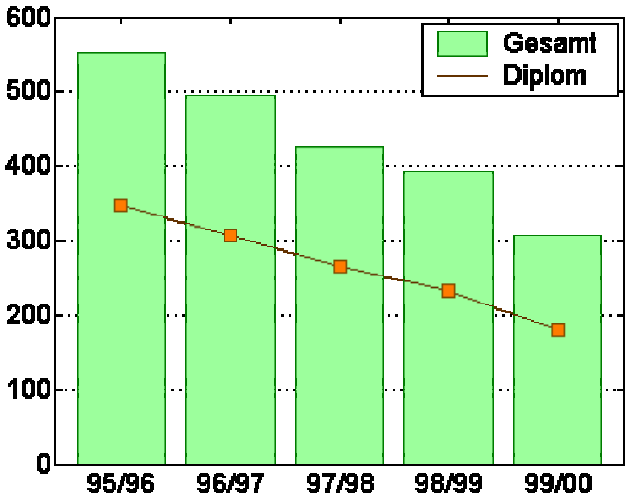
- plot, plotyy, semilogx, loglog, . . .
- title, xlabel, ylabel
- line, axes, text
- All these commands create one or more objects
- All object properties are settable thru handles
- Command Script
- Property Editor

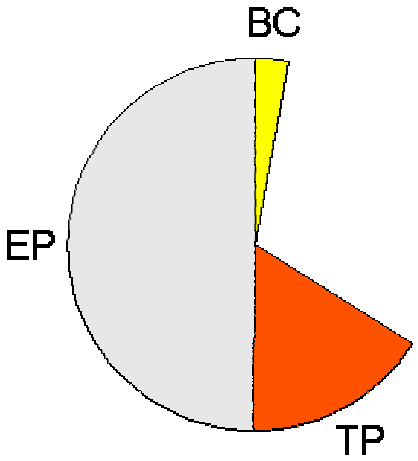
Bar and Pie Graphics

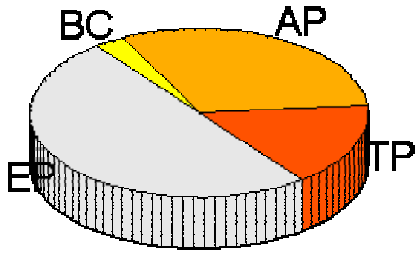












Graphical Representation of Matrix Data

- 2-dimensional array of data
- u = f(x,y), x and y any (physical) variables
- general case: x, y, u arrays of the same size
- simple case: x, y monotone, often equidistant
- example: 6th eigenmode
  - pcolor, colormap
  - contour, vectors
  - mesh, waterfall
  - surf, contour3, light

Fitting of Data

- Parameters of the Physical Description ('Law')
- Interpolation Rule ('Table Lookup')

- Polynomial Fit $y = \Sigma a_n x^n$ polyfit
- Parameter-Linear Fit $y = \Sigma a_n f_n(x)$ mldivide
- Arbitrary Function Fit $y = F(a_n, x)$ fminsearch

Filtering of Measured Data

- **Noise Reduction**
- **Bandwidth Reduction**
- **MATLAB Functions filter and filter2**
- **Convolution conv , conv2 , and convn**

- **Example: RTM Data**

Animation, Video Clips

- Dynamics of Processes
- Parameter --> Time (Slider)
- Video Sequences (Web Cam)
- Image Sequences (Experiment)
- Simulations (MATLAB)

```
for k = 1:N,
    <<  Establish Frame <k> >>
    F(k) = getframe;
end;
movie2avi(F, 'fname.avi', 'quality', 90, ...);
```

If you should still dislike NUMERICS . . .

. . . there is also a SYMBOLIC MATH TOOLBOX available with MATLAB.

The End