MathWorks

Introduction to MATLAB

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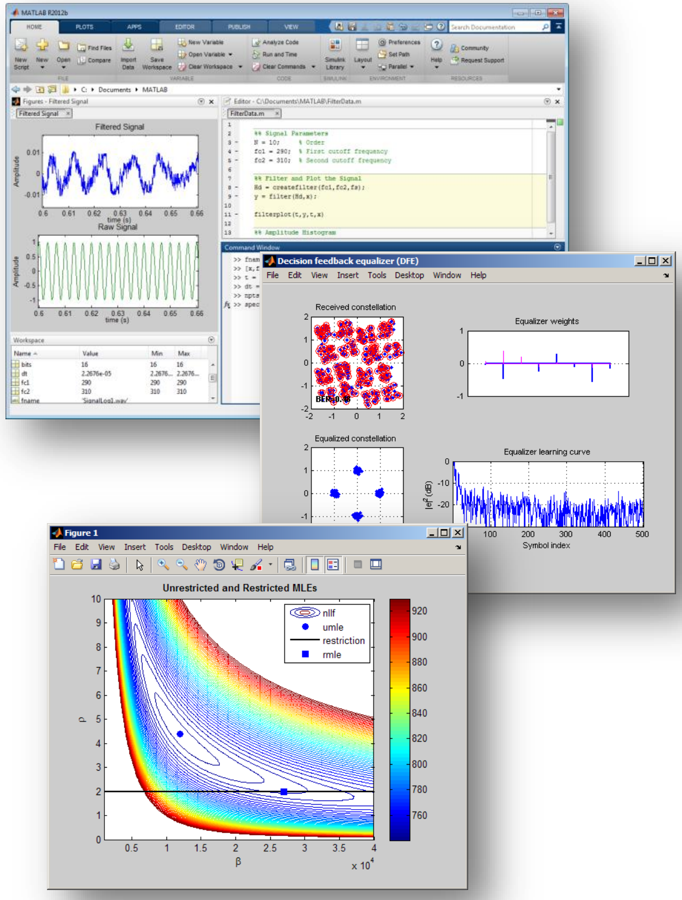
What is MATLAB?

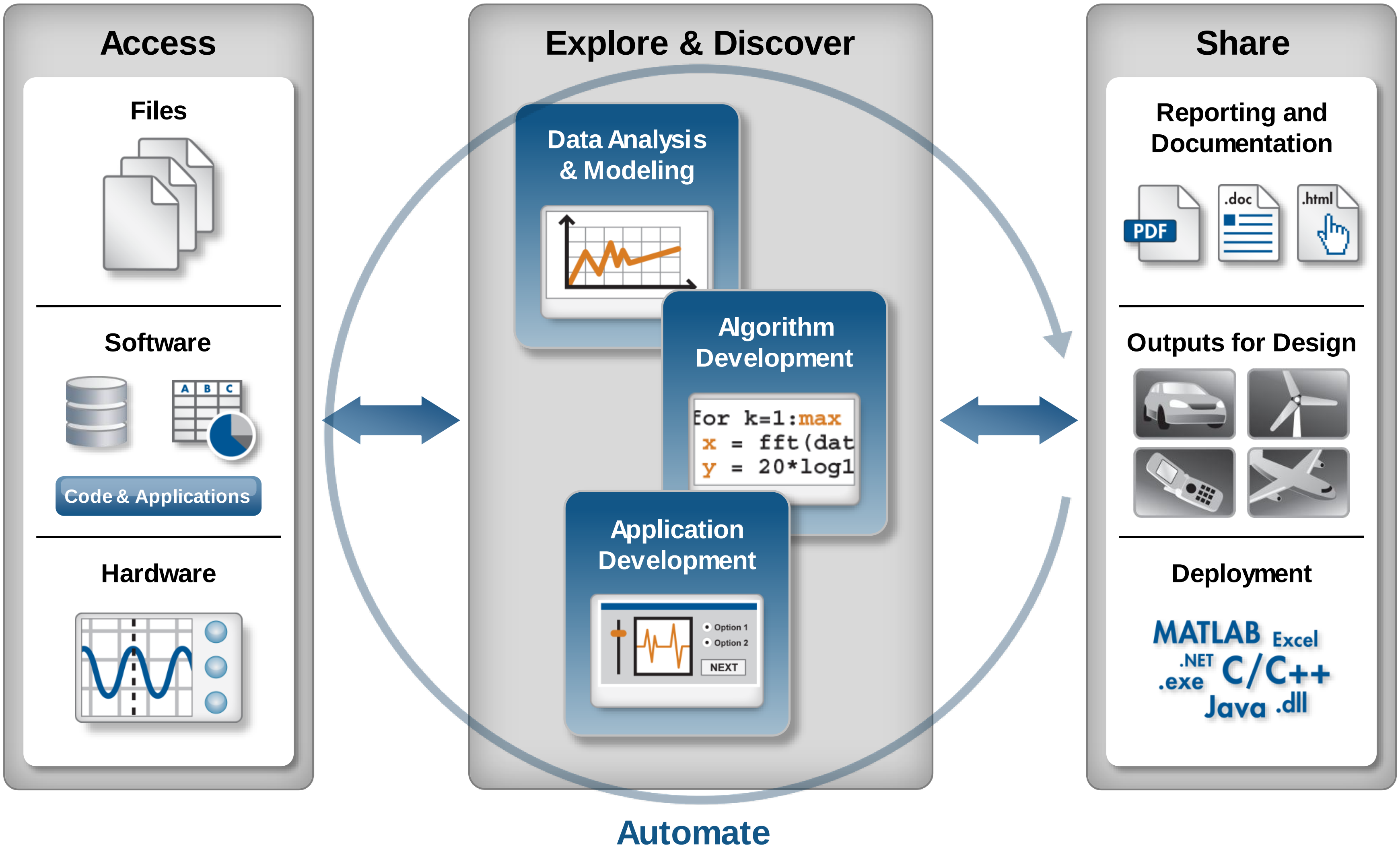
- High-level language
- Interactive development environment
- Used for:
  - Numerical computation
  - Data analysis and visualization
  - Algorithm development and programming
  - Application development and deployment



Key Industries

- Aerospace and Defense
- Automotive
- Biotech and Pharmaceutical
- Communications
- Education
- Electronics
- Energy and Power Production
- Financial Services
- Industrial Automation and Machinery
- Semiconductor

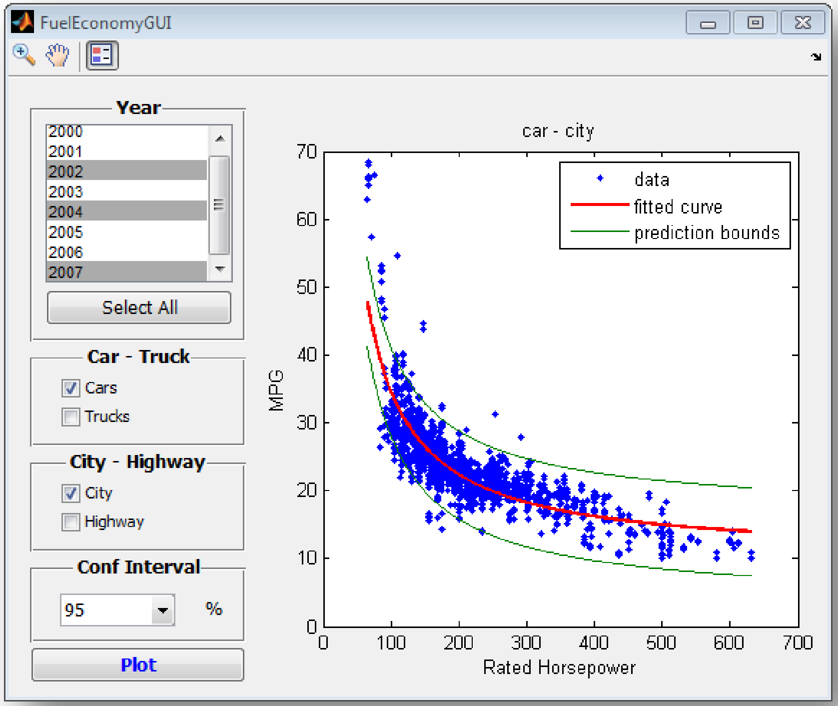
Technical Computing Workflow



Demo: Fuel Economy Analysis

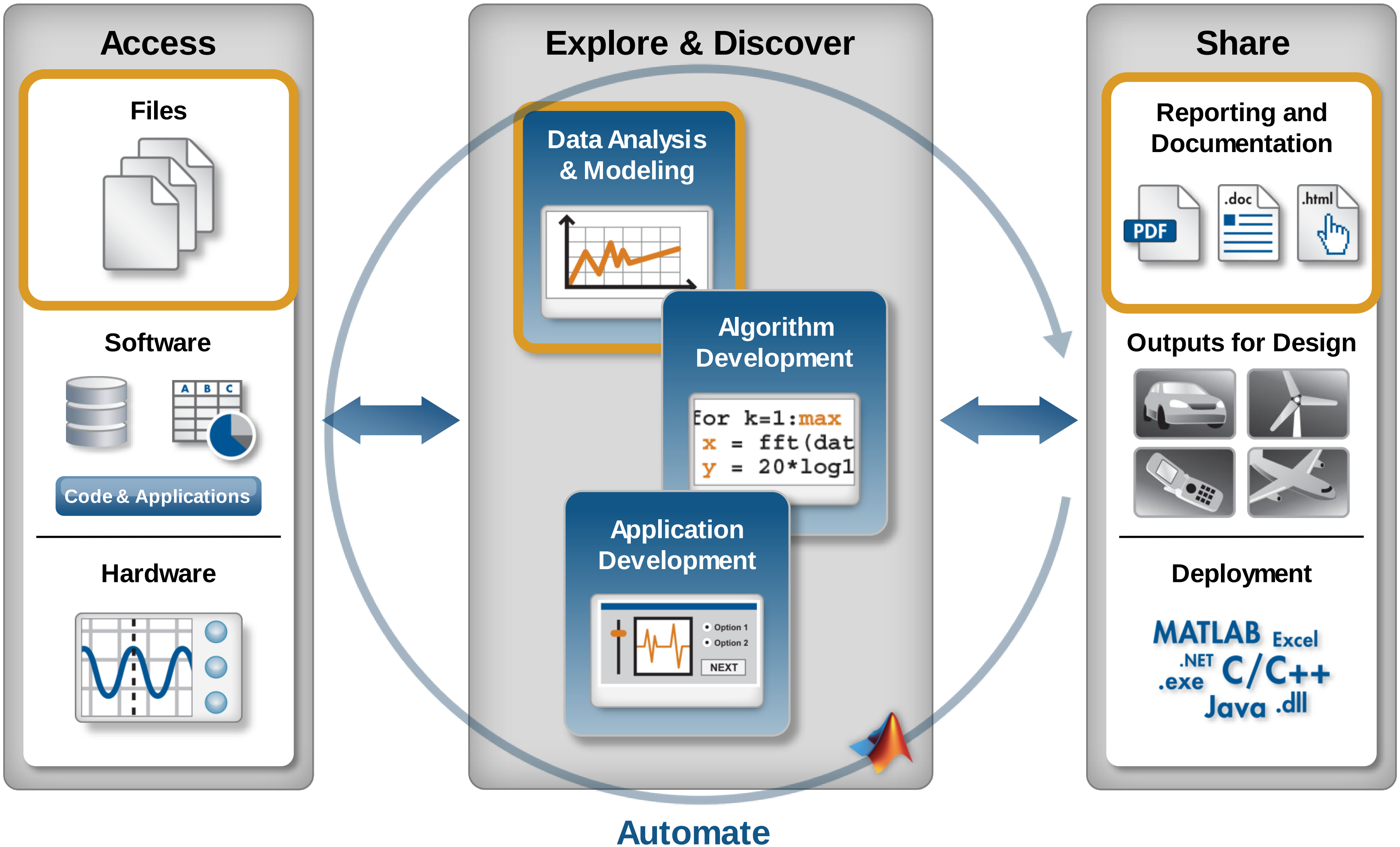
- Goal:
  – Study the relationships between fuel economy, horsepower, and type of vehicle

- Approach:
  – Access data from Excel
  – Interactively visualize and explore trends
  – Create a model
  – Document results



Demo: Fuel Economy Analysis

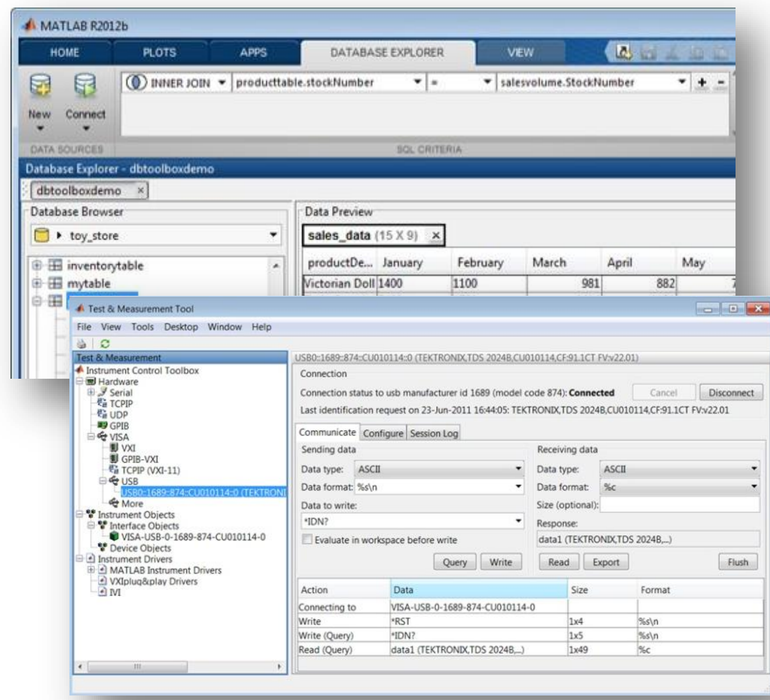
Products Used
- MATLAB
- Statistics Toolbox
- Curve Fitting Toolbox



Accessing Data from MATLAB

Access | Explore & Discover | Share

- Files
  - Excel, text, or binary
  - Audio and video, image
  - Scientific formats and XML
- Applications and languages
  - C/C++, Java, FORTRAN
  - COM, .NET, shared libraries
  - Databases
    (*Database Toolbox*)
- Measurement hardware
  - Data acquisition hardware
    (Data Acquisition Toolbox)
  - Stand-alone instruments and devices
    (Instrument Control Toolbox)

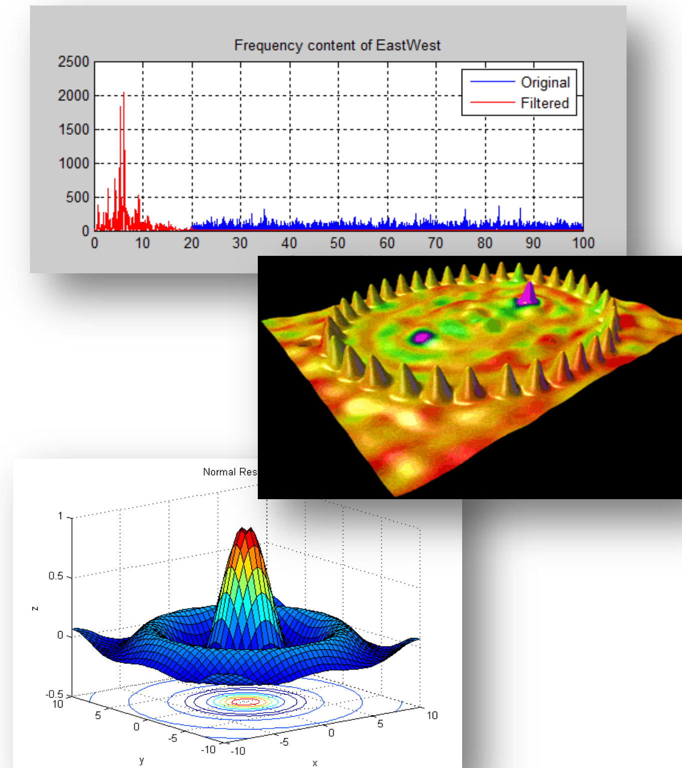


Data Analysis and Visualization in MATLAB

Access | **Explore & Discover** | Share

- Built-in engineering and mathematical functions
  - Interpolation, filtering, smoothing, Fourier analysis

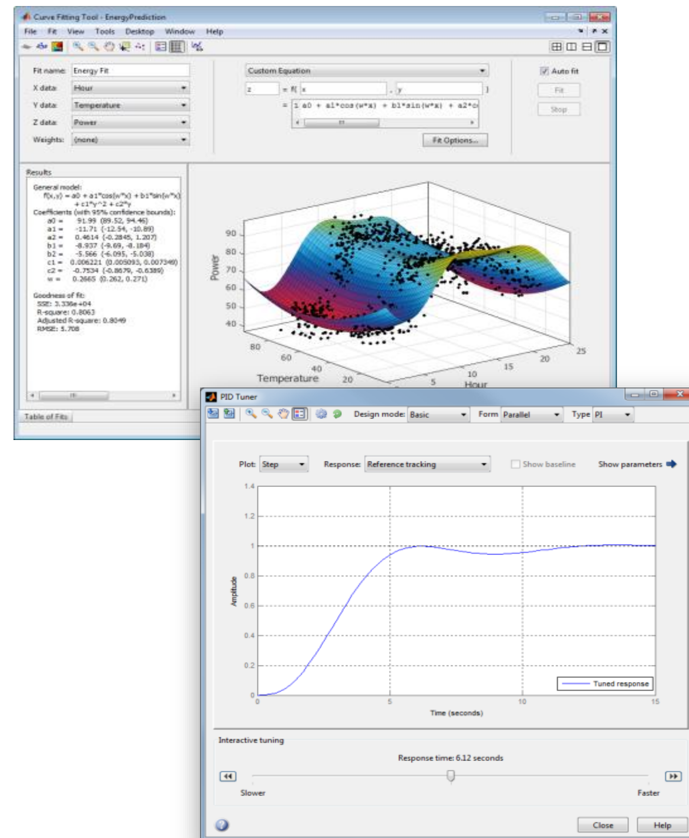
- Extensive plotting capabilities
  - 2-D, 3-D, and volume visualization
  - Tools for creating custom plots



Expanding the Capabilities of MATLAB

Access | **Explore & Discover** | Share

- MathWorks add-on tools for:
  - Math, statistics, and optimization
  - Control system design and analysis
  - Signal processing and communications
  - Image processing and computer vision
  - Parallel computing and more…

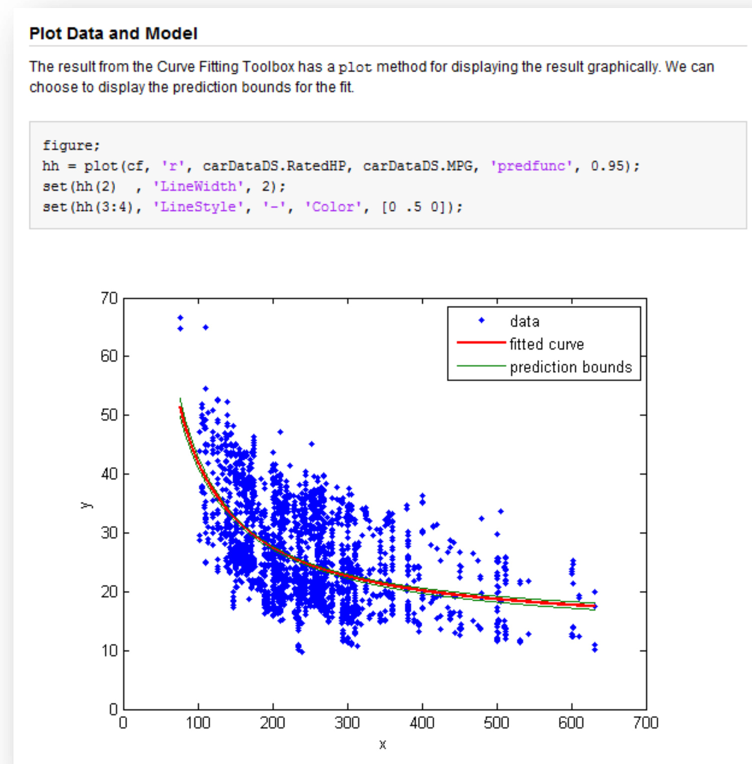


- Partner products provide:
  - Additional interfaces
  - Domain-specific analysis
  - Support for niche applications

Sharing Results from MATLAB

Access　　Explore & Discover　　**Share**

- Automatically generate reports
  - Publish MATLAB files
  - Customize reports using MATLAB Report Generator



Plot Data and Model

The result from the Curve Fitting Toolbox has a `plot` method for displaying the result graphically. We can choose to display the prediction bounds for the fit.

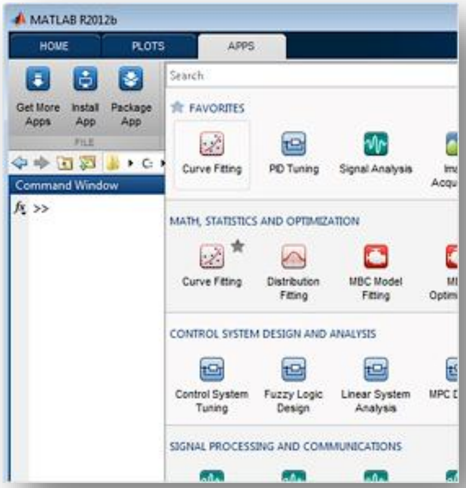
```
figure;
hh = plot(cf, 'r', carDataDS.RatedHP, carDataDS.MPG, 'predfunc', 0.95);
set(hh(2)  , 'LineWidth', 2);
set(hh(3:4), 'LineStyle', '-', 'Color', [0 .5 0]);
```


- Package as an app

- Deploy applications to other environments

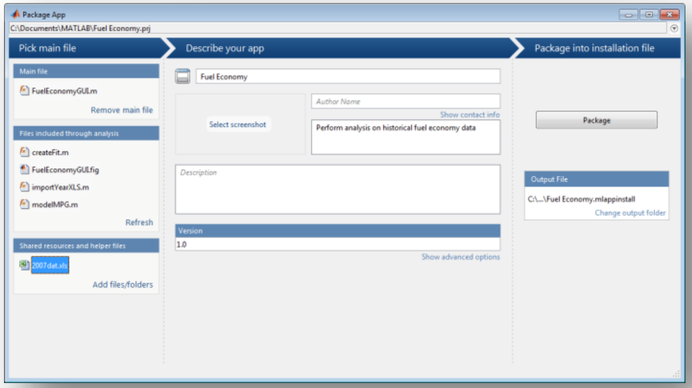
Packaging and Sharing MATLAB Apps

- MATLAB apps
  - Interactive applications to perform technical computing tasks
  - Displayed in apps gallery



- Included in many MATLAB products

- Package your own app
  - Create single file for distribution and installation into gallery
  - Packaging tool:
    - Automatically includes all necessary files
    - Documents required products



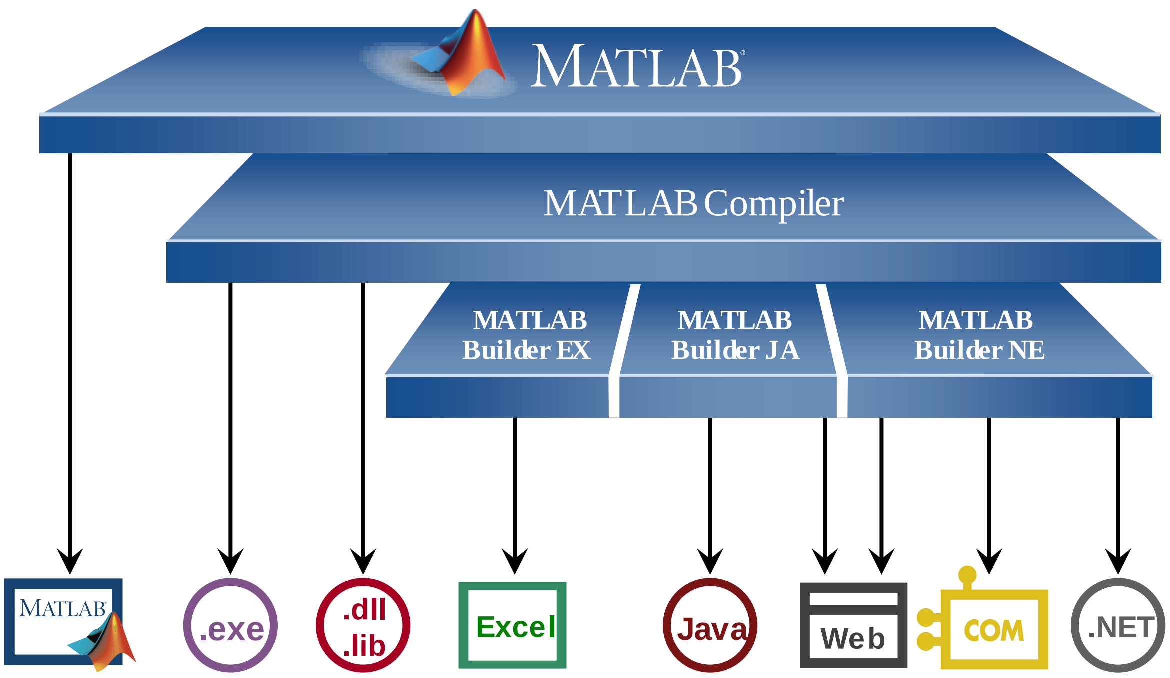
Deploying Applications with MATLAB

Access | Explore & Discover | **Share**

- Give MATLAB code to other users
  - MATLAB apps
  - MATLAB files

- Share applications with end users who do not need MATLAB
  - Stand-alone executables
  - Shared libraries
  - Software components

- Royalty-free distribution

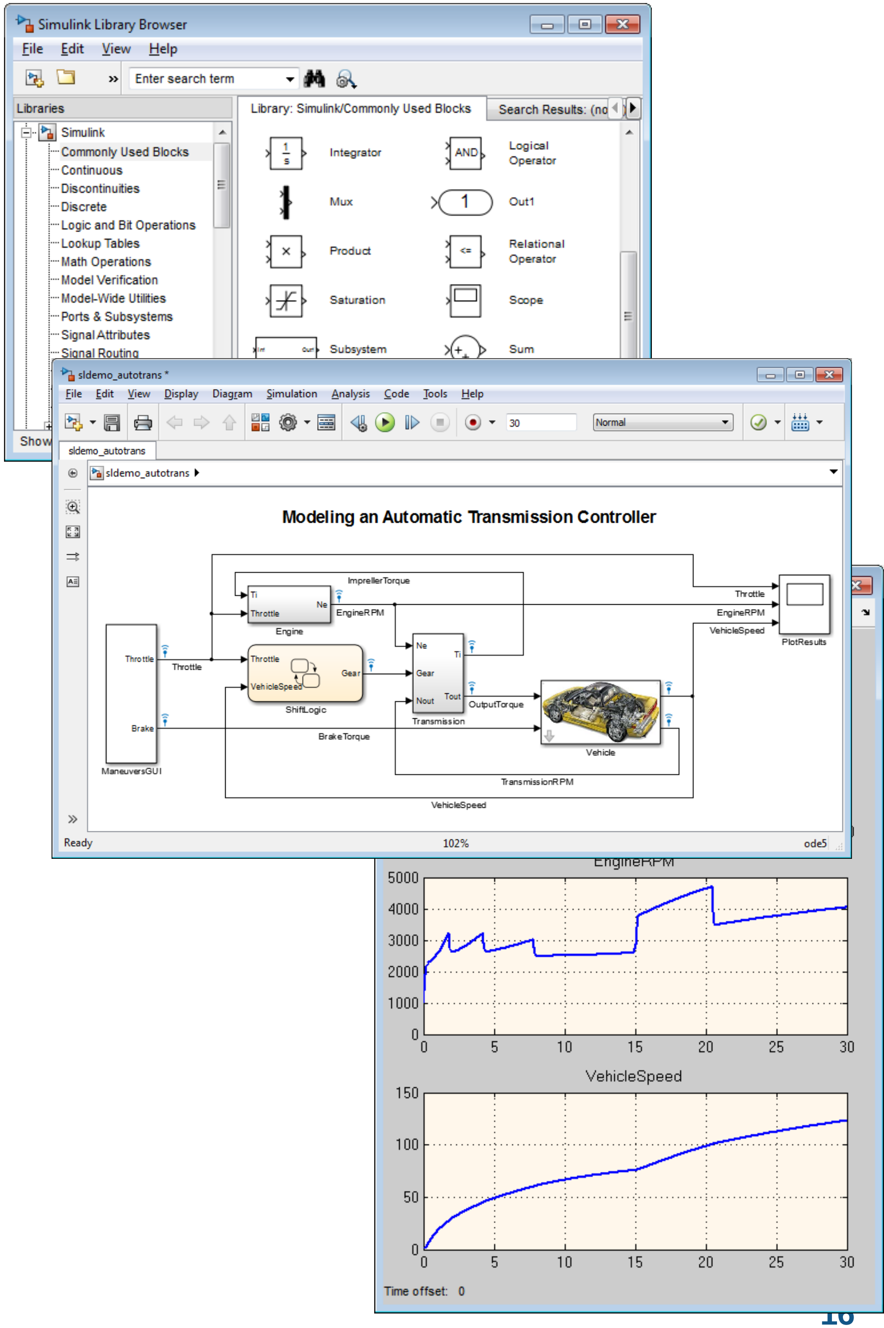


Using MATLAB

- High-level language
  - Native support for vector and matrix operations
  - Built-in math and visualization functions
- Development environment
  - Interactive and easy to get started
  - Ideal for iterative exploration and design
- Technical computing platform
  - Add-on products for a range of application areas
    (e.g., signal processing and communications, image and video processing, control systems, test and measurement)

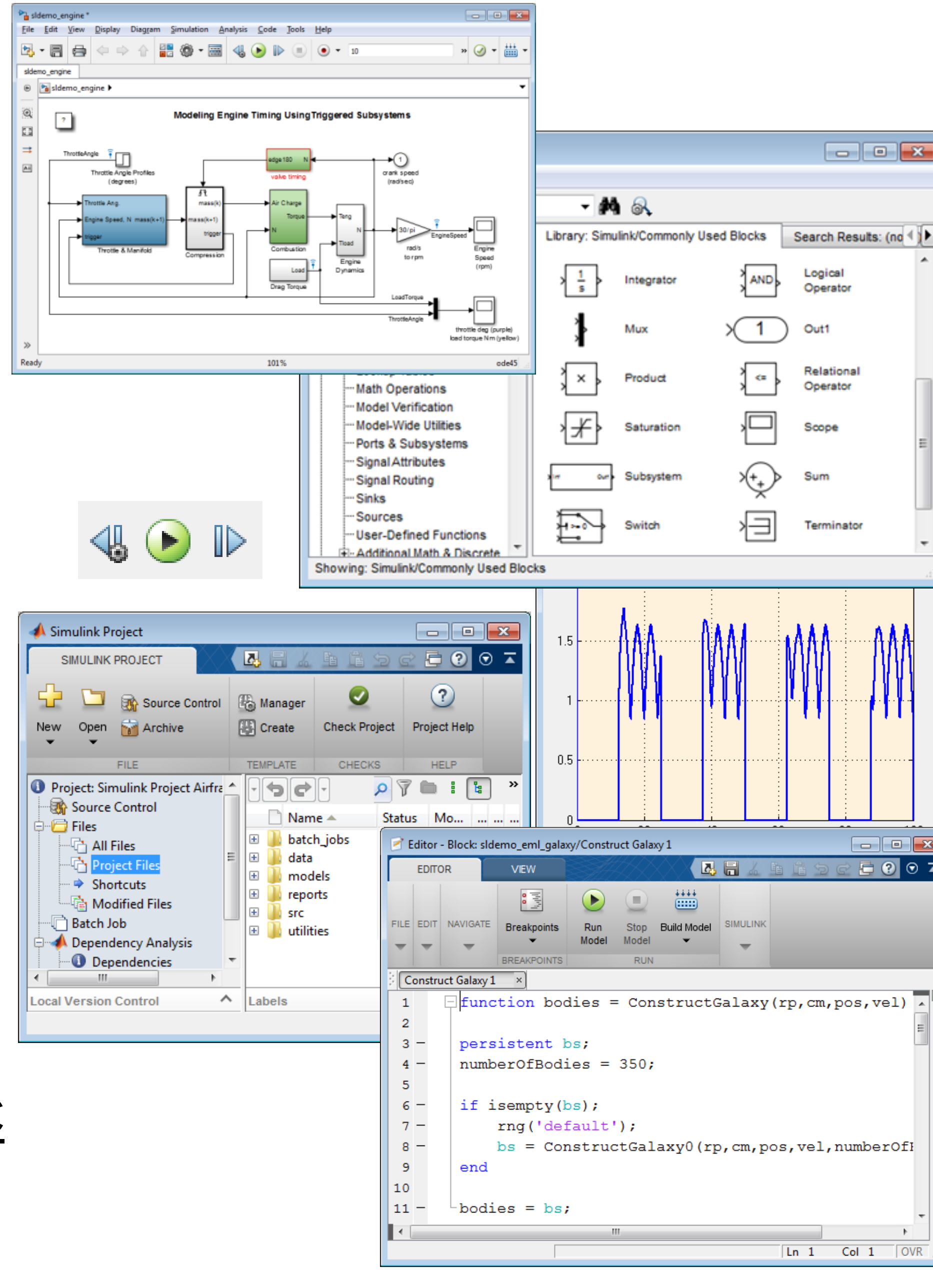
What is Simulink?

- Block-diagram environment
- Model, simulate, and analyze multidomain systems
- Design, implement, and test:
  - Control systems
  - Signal processing systems
  - Communications systems
  - Other dynamic systems
- Platform for Model-Based Design

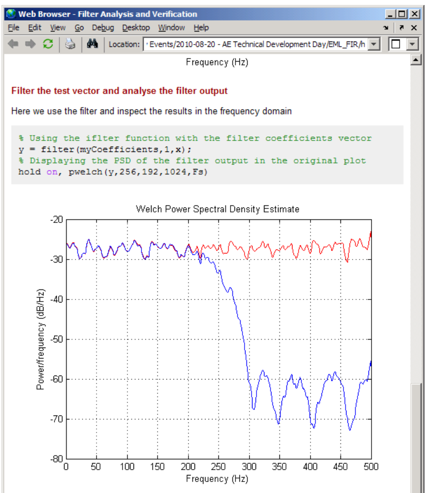


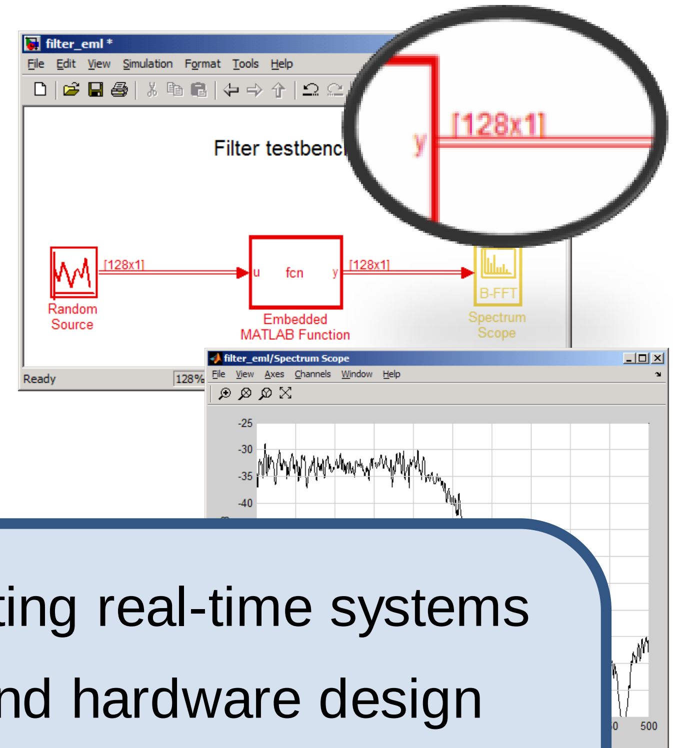
Simulink Key Features

- Graphical editor for building hierarchical block diagrams
- Libraries of continuous-time and discrete-time blocks
- Simulation engine with fixed-step and variable-step ODE solvers
- Scopes and data displays for viewing simulation results
- Project and data management tools
- MATLAB Function block for importing MATLAB algorithms
- Legacy Code Tool for importing C and C++ code into models



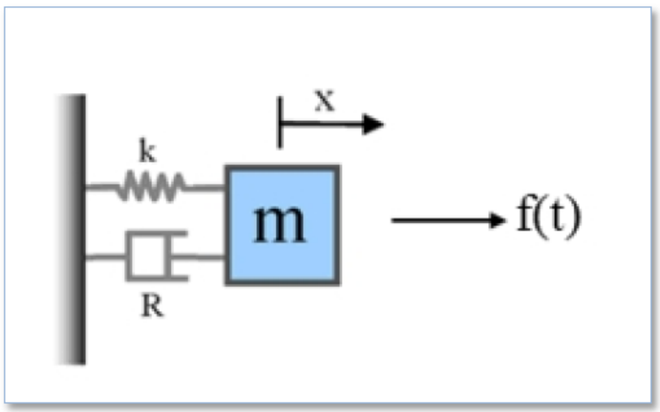
From MATLAB to Simulink – why?





- Intrinsic time management – simulating real-time systems
- Greater capabilities for fixed-point and hardware design
- Solid embedded code generation (C / HDL) infrastructure
- Dataflow-style diagram – easily document and reuse
- Integration with Analogue / Mixed Signal models

Case study: damped oscillation



$$m\ddot{x} + R\dot{x} + kx = f(t)$$

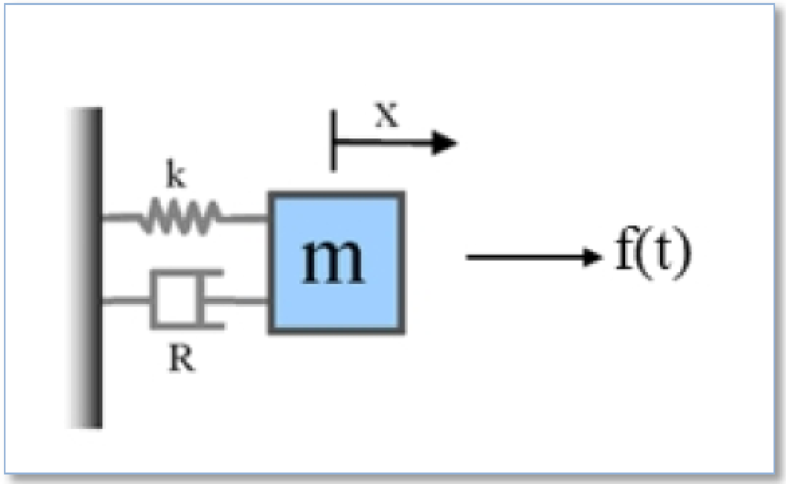
$$x(0) = x_0 ; \dot{x}(0) = \dot{x}_0$$

$$\Rightarrow \ddot{x} + 2\varsigma\omega_n\dot{x} + \omega_n^2 x = \frac{1}{m} f(t)$$

$$\omega_n = \sqrt{\frac{k}{m}} = natural\ frequency$$

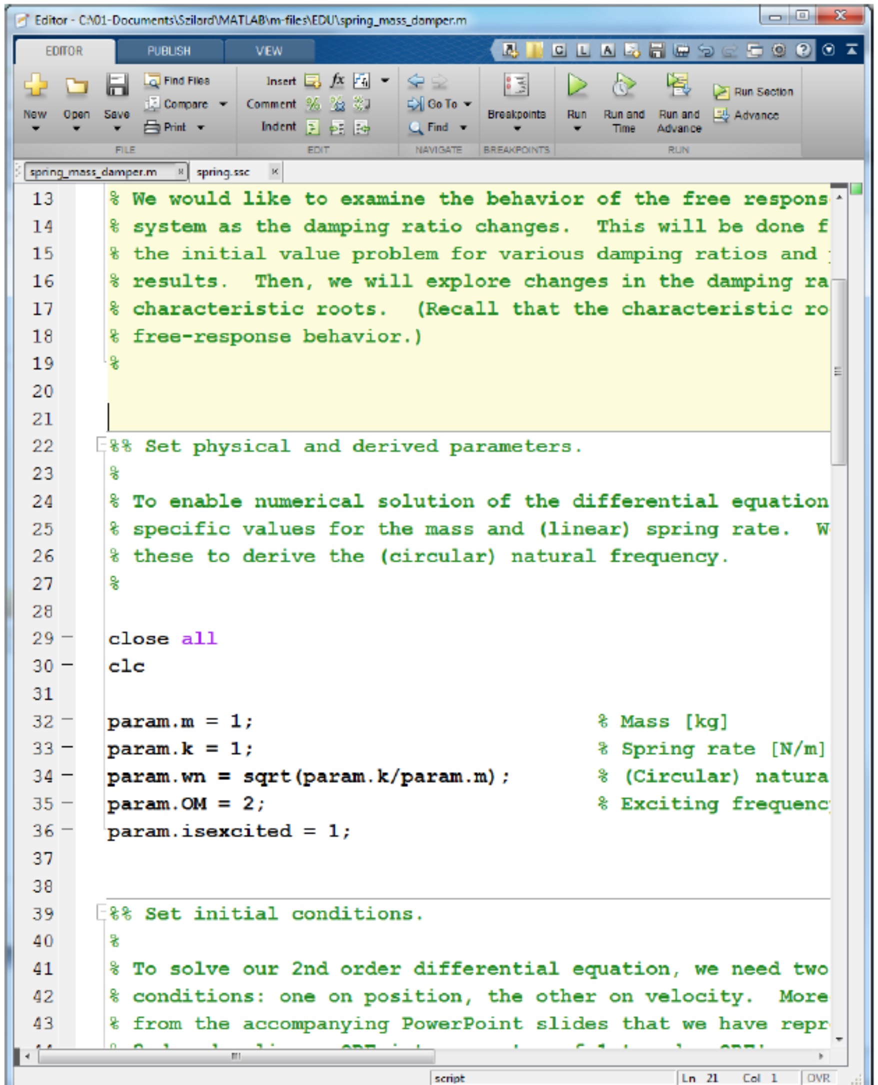
$$\varsigma = \frac{R}{2\sqrt{km}} = damping\ ratio$$

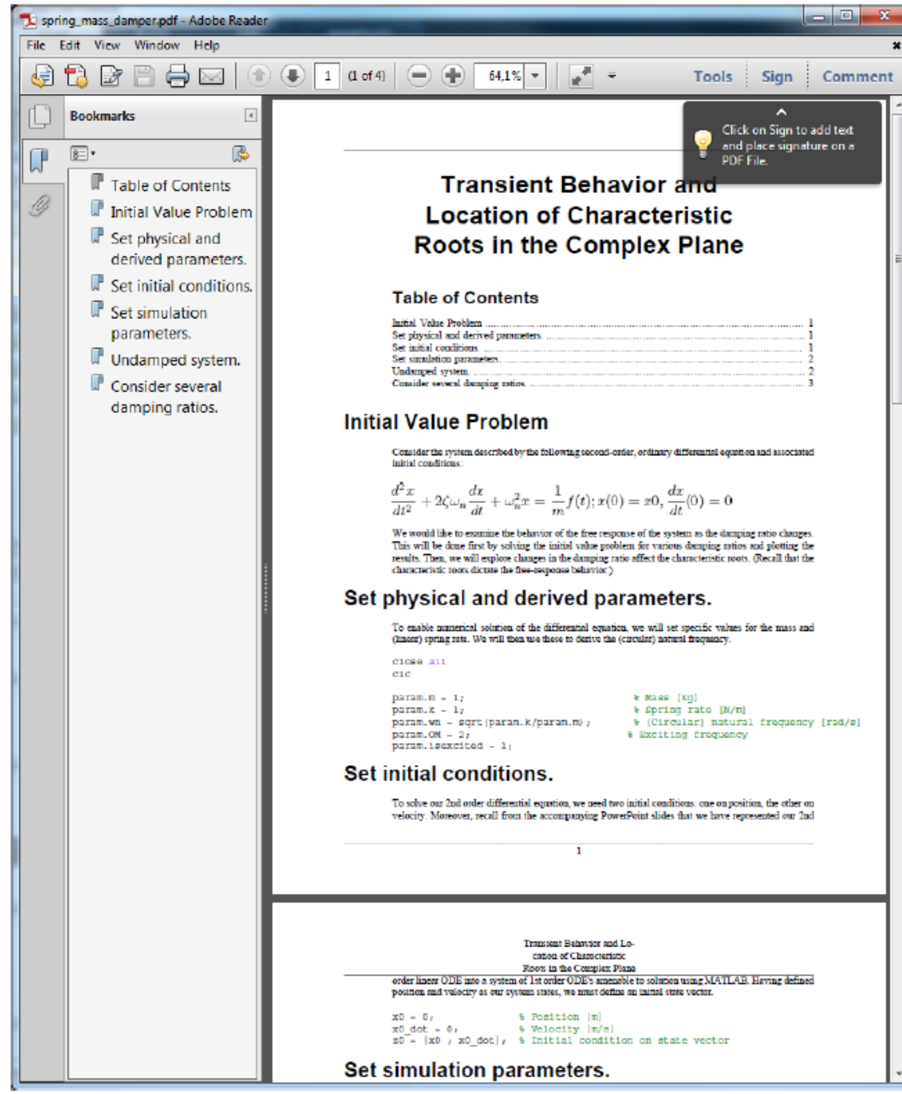
Methods



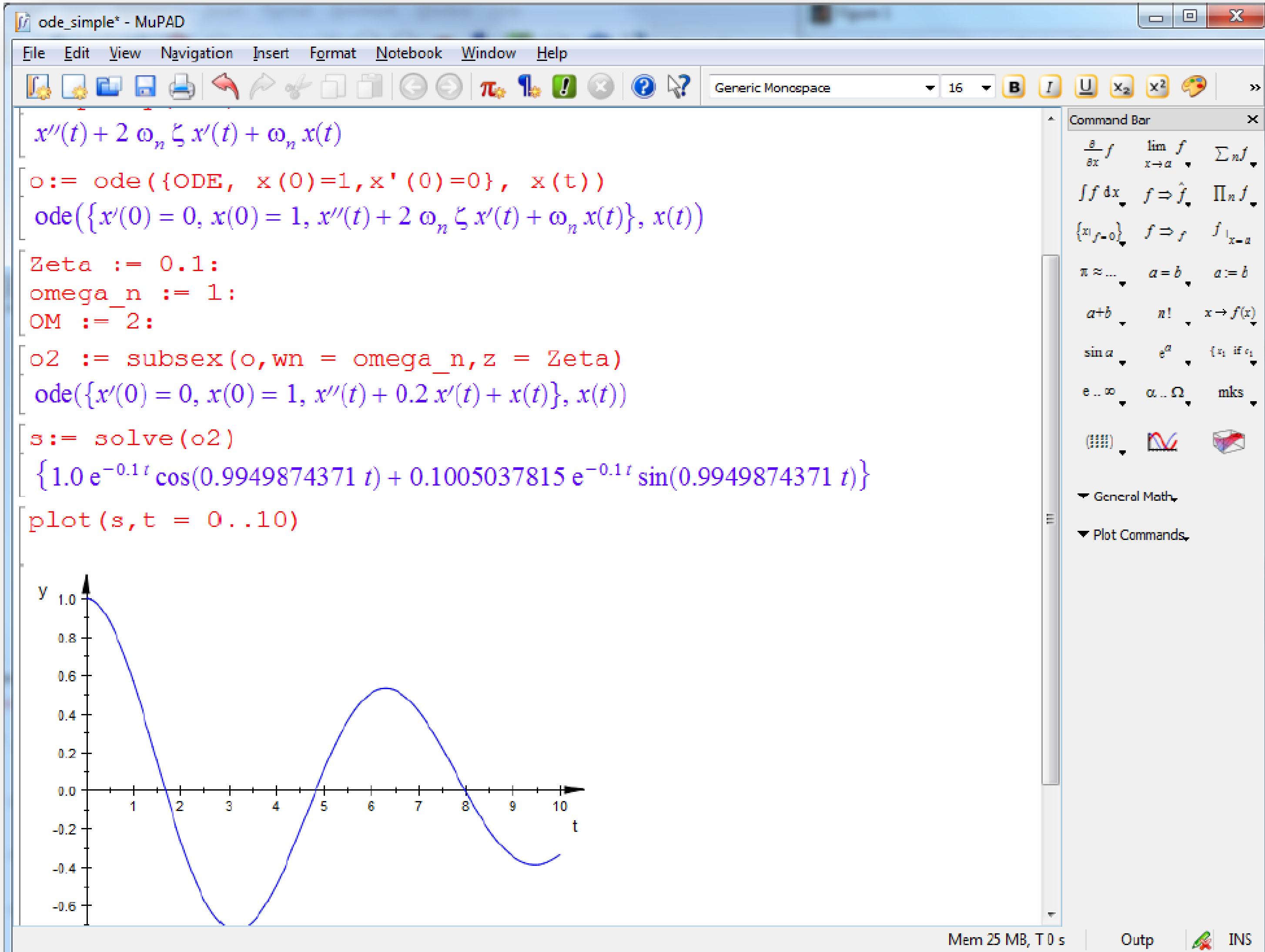
- Handling a system with warious methods
  - Numeric – ***MATLAB***
  - Symbolic – ***Symbolic Math Toolbox***
  - Dynamic system – ***Simulink***
  - Physical Modeling – ***Simscape***

MATLAB Environment

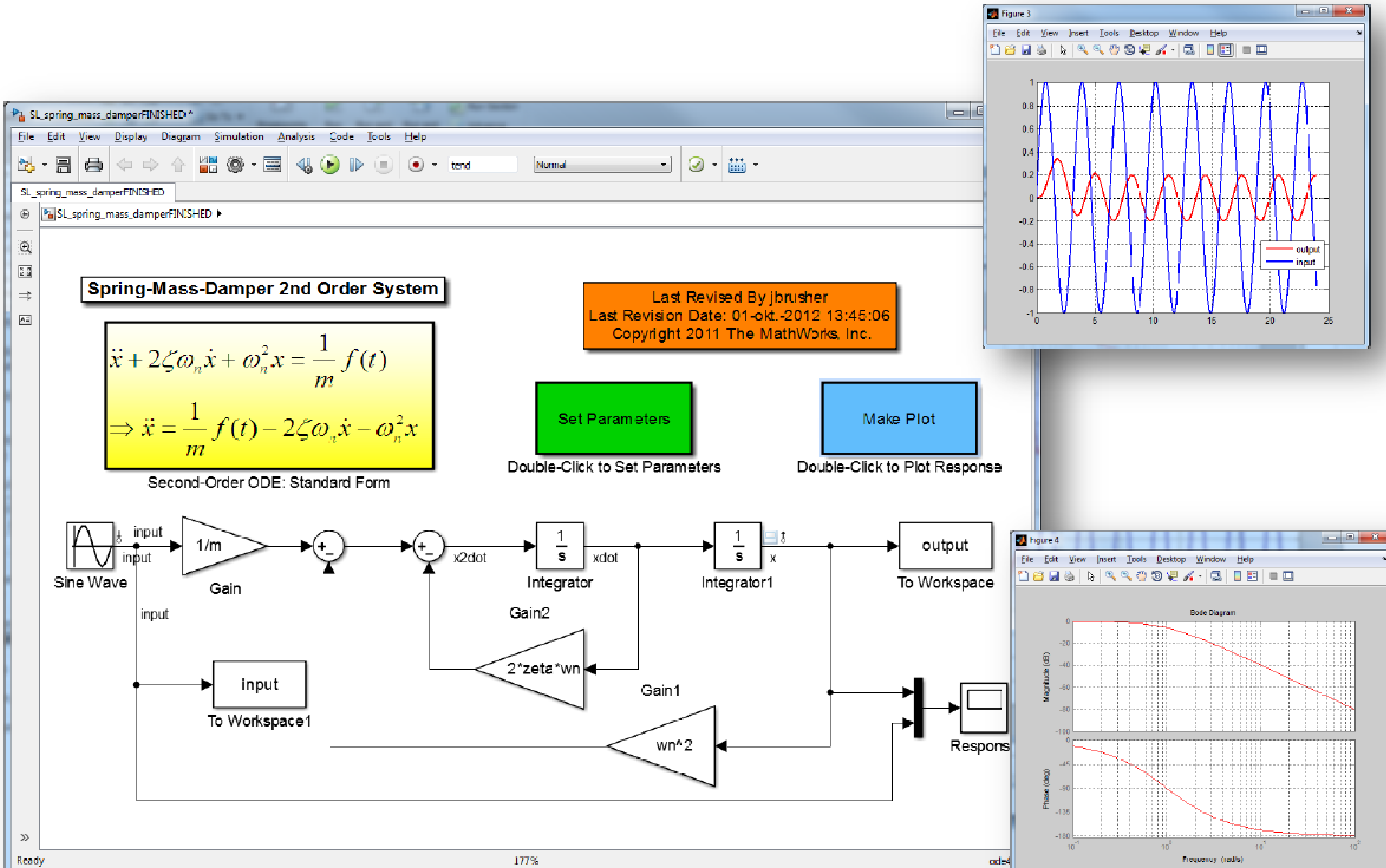




Symbolic Math - MuPAD



Simulink



SL_spring_mass_damperFINISHED *
File Edit View Display Diagram Simulation Analysis Code Tools Help
Spring-Mass-Damper 2nd Order System
$\ddot{x} + 2\zeta\omega_n\dot{x} + \omega_n^2 x = \frac{1}{m} f(t)$
$\Rightarrow \ddot{x} = \frac{1}{m} f(t) - 2\zeta\omega_n\dot{x} - \omega_n^2 x$
Second-Order ODE: Standard Form
Last Revised By jbrusher
Last Revision Date: 01-okt.-2012 13:45:06
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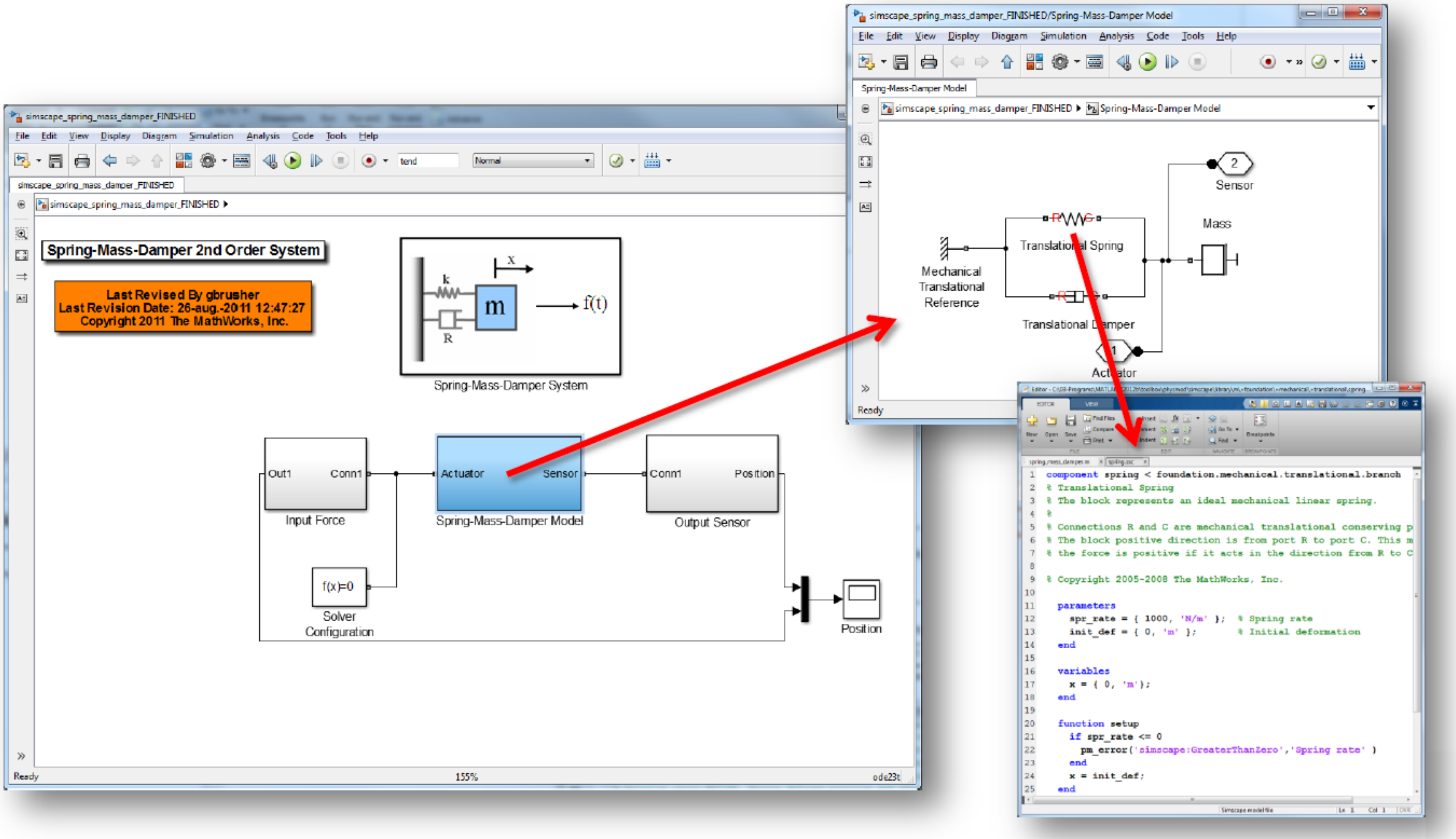
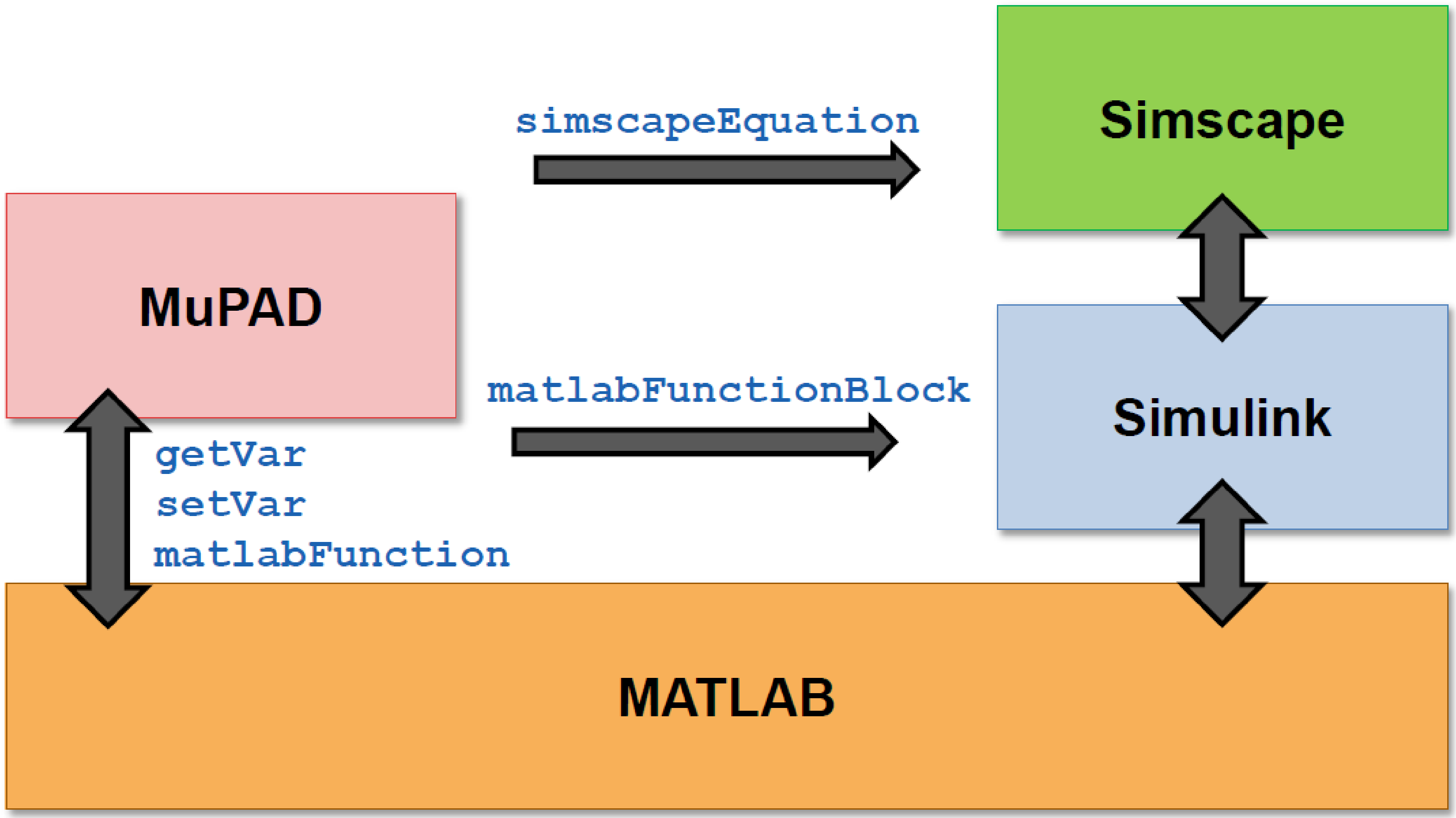
Set Parameters
Double-Click to Set Parameters
Make Plot
Double-Click to Plot Response
Sine Wave
input
1/m
Gain
x2dot
Integrator
xdot
Integrator1
x
output
To Workspace
Gain2
2*zeta*wn
Gain1
wn^2
input
To Workspace1
Respons
Ready
177%
Figure 3
output
input
Figure 4
Bode Diagram
Frequency (rad/s)

Simscape

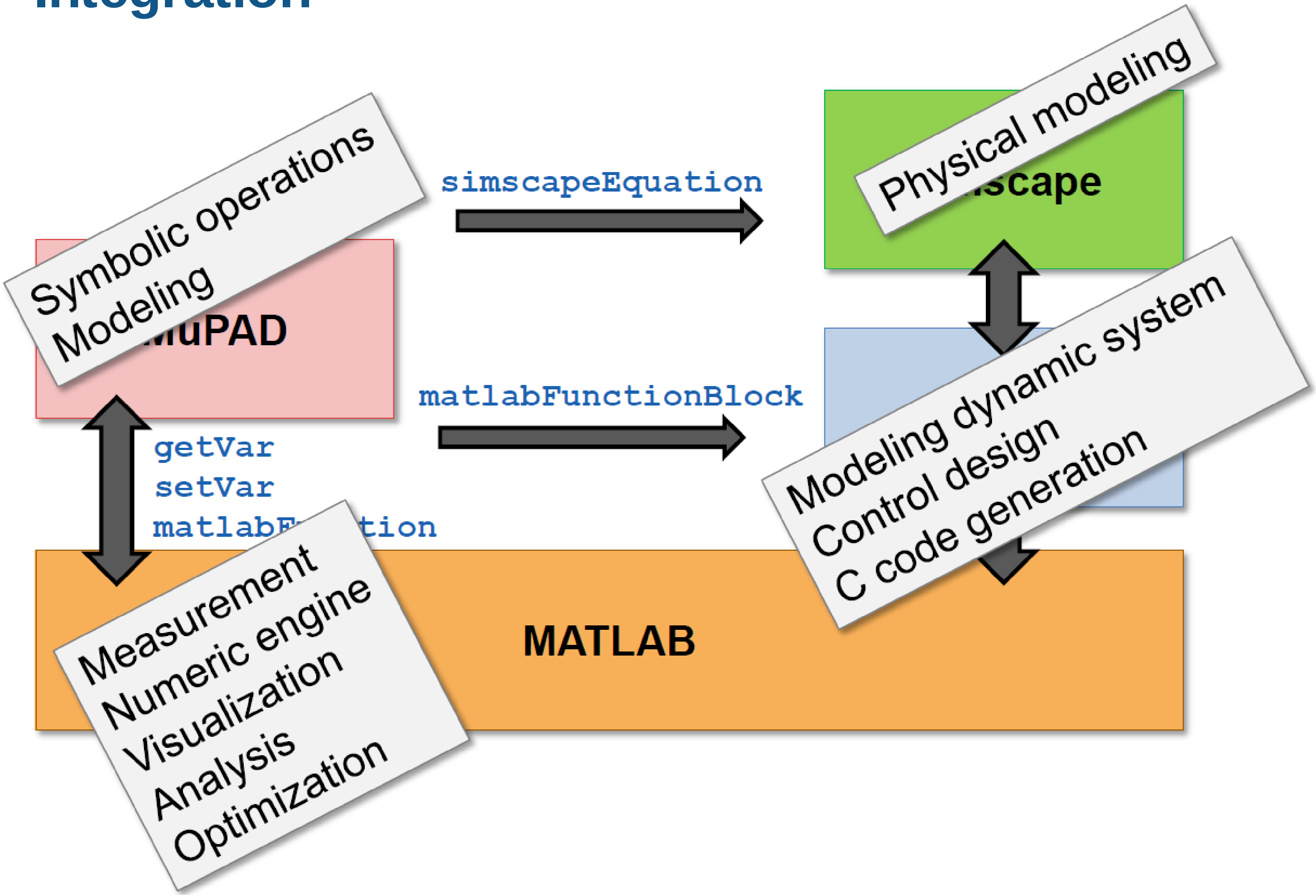


Spring-Mass-Damper 2nd Order System
Last Revised By gbrusher
Last Revision Date: 26-aug.-2011 12:47:27
Copyright 2011 The MathWorks, Inc.
Spring-Mass-Damper System
Input Force
Spring-Mass-Damper Model
Output Sensor
Solver Configuration
Position
Sensor
Mass
Translational Spring
Mechanical Translational Reference
Translational Damper
Actuator

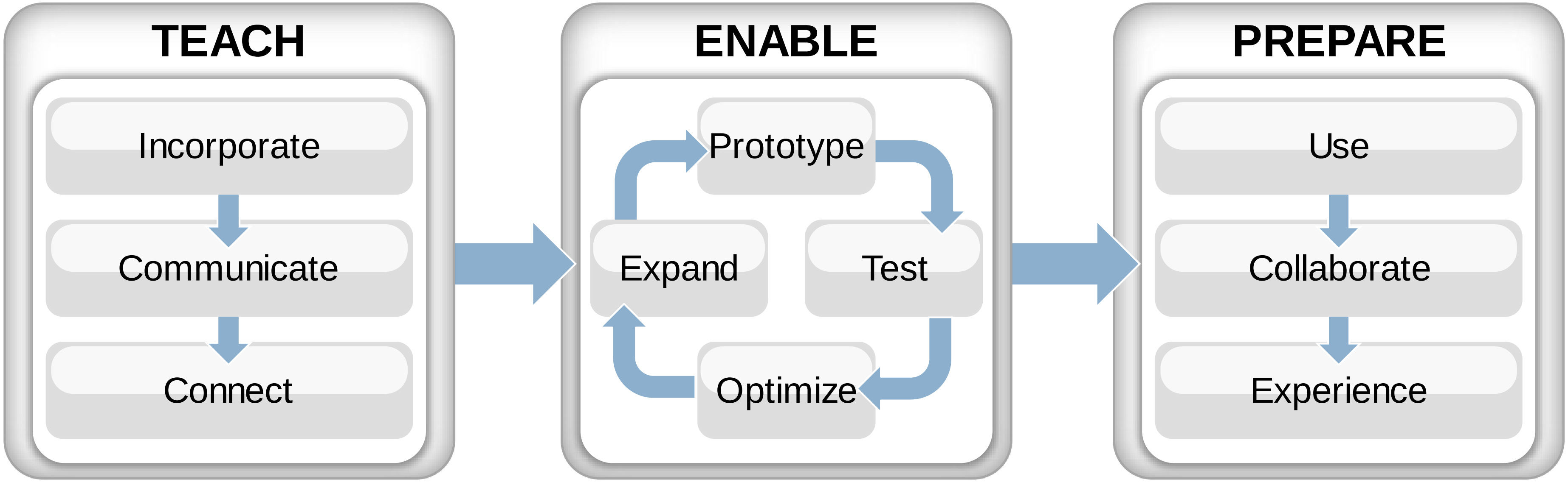
Integration



Integration



Engage Students with Modeling and Simulation



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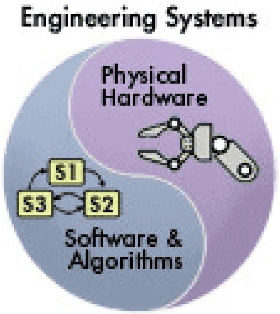
Physical Modeling Key Messages For Classrooms and Labs



Teach

1. Incorporate realistic and engaging examples
2. Communicate concepts using best available method
3. Connect theory to real systems

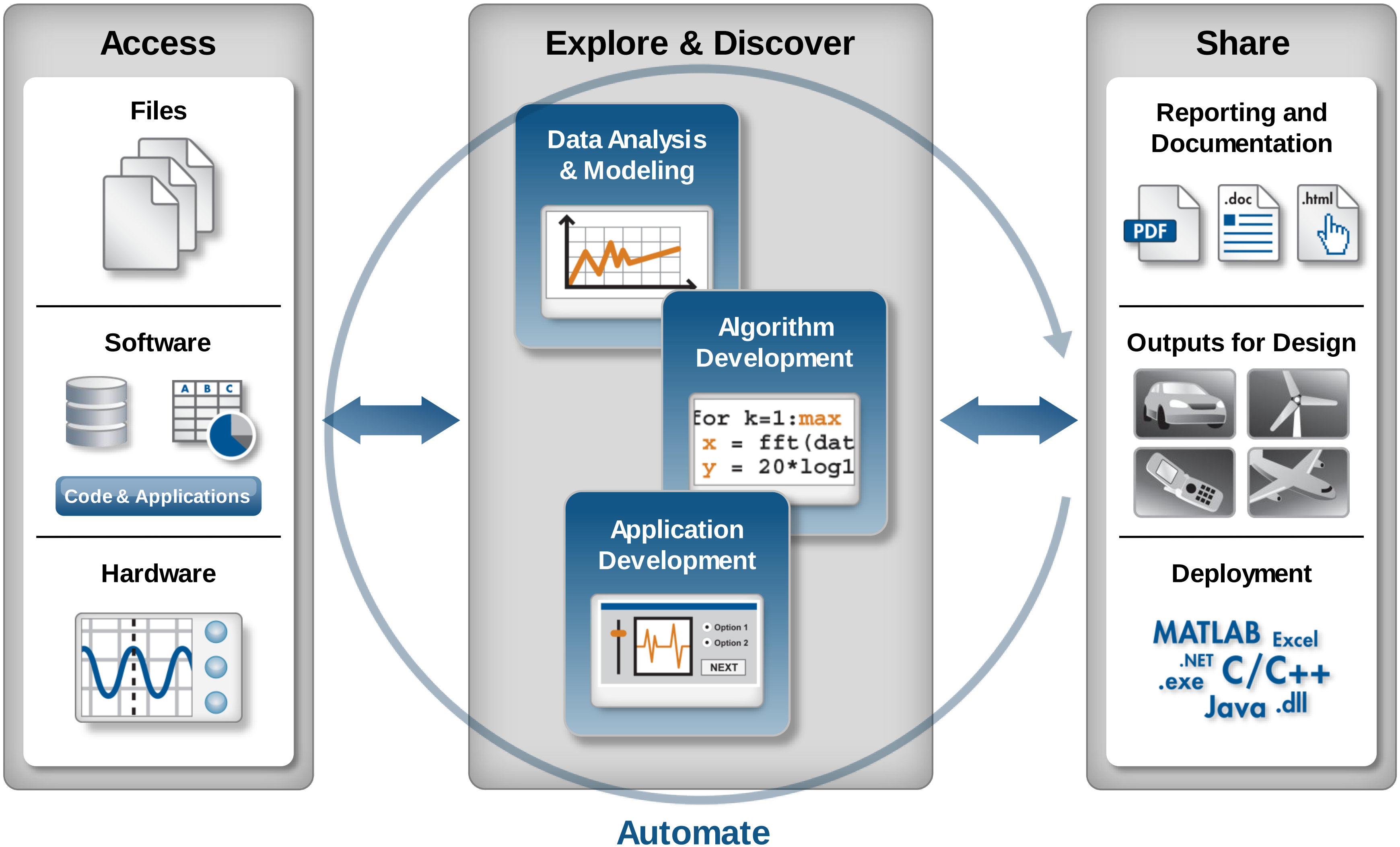
Enable

4. Expand learning to adjacent disciplines
5. Prototype new designs rapidly
6. Test designs completely
7. Optimize designs

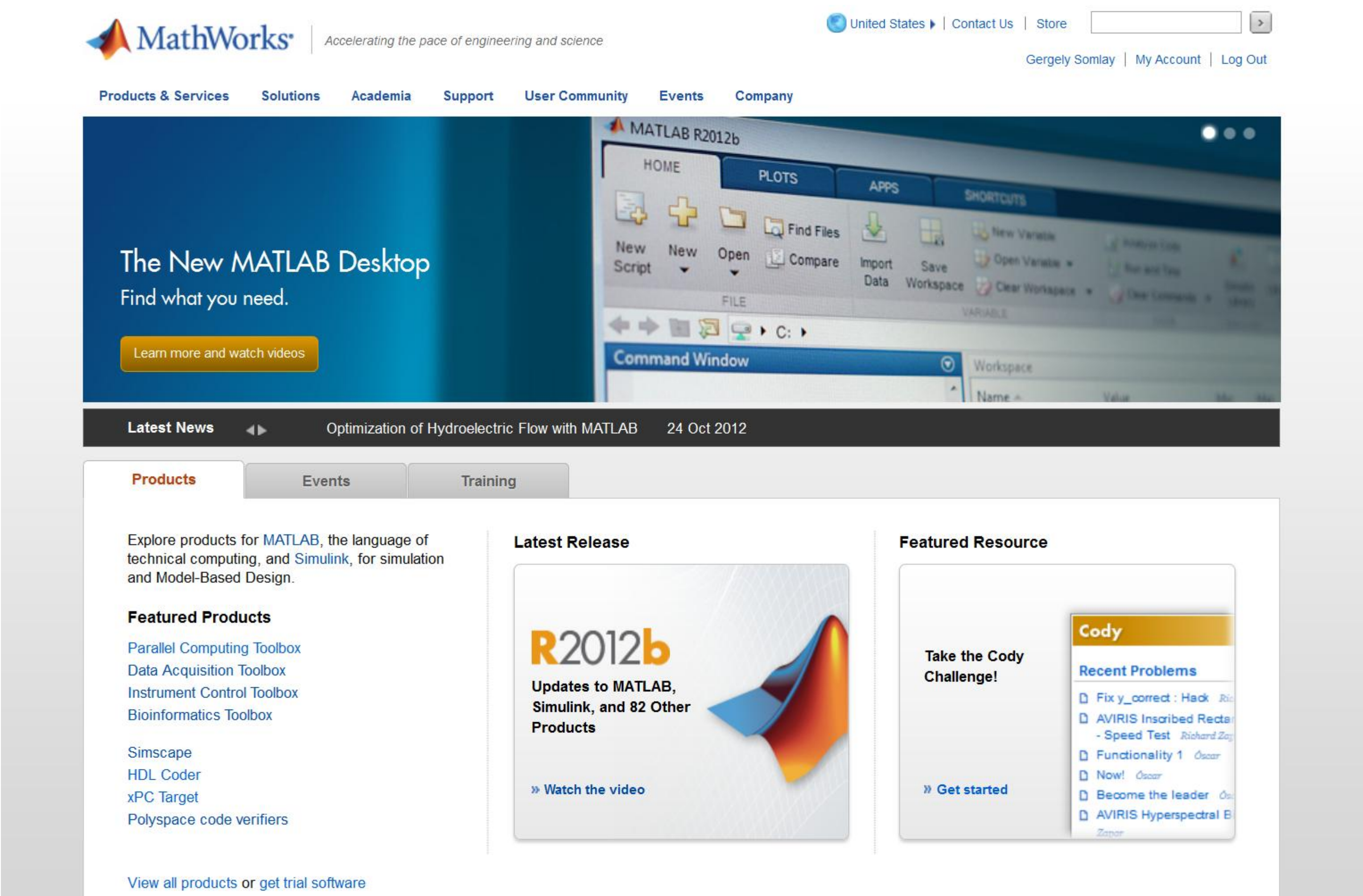
Prepare

8. Use industry-standard tools
9. Collaborate with other floors
10. Experience Model-Based Design

Technical Computing Workflow



Further Information



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Next steps

- Trials, license and price informations:

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Questions and Answers

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