

# MATLAB EXPO 2017

Leveraging MATLAB and Simulink for Higher Education:  
An Overview of MathWorks Resources for Academia

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# Challenges in Teaching Engineering

- Address & solve real-world problems
- Engaging, demanding and creative courses
- Engineering practice not just science and principles

What to think ✘  
How to think ✔

## Innovation



# Disruptive Trends in Engineering Education





# Experiential Learning

# Online Learning

# Collaborative Learning



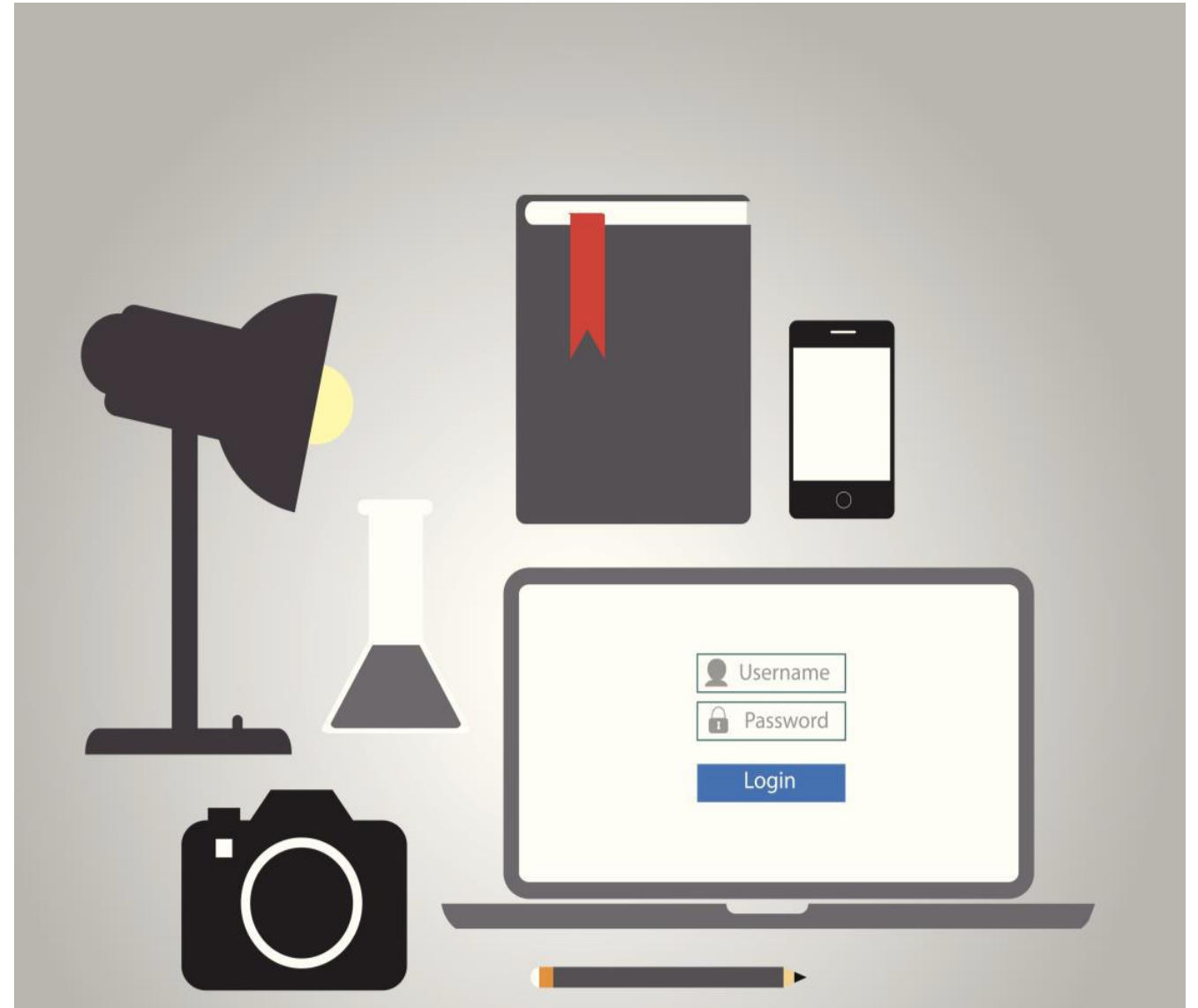
# Experiential Learning

- Focus not just on equations and theoretical examples, but also towards **real-time** implementation and **real-world** examples
- Use of hardware to demonstrate concepts
- Project-based Learning



# Online Learning

- Connectivity – laptops, mobiles
- Anytime-anywhere learning





# Collaborative Learning

- Student Competitions and Hackathons
  - Work on design to implementation together
  - Examples: Formula Student, Robocon India, BAJA SAE India, Kaggle
  
- MOOCs
  - Run in place of traditional courses in a few colleges
  - Students use credit from MOOCs towards their coursework



## MATLAB Programming for Numerical Computation

### ABOUT THE COURSE

MATLAB is a popular language for numerical computation. This course introduces students to MATLAB programming, and demonstrate it's use for scientific computations. The basis of computational techniques are expounded through various coding examples and problems, and practical ways to use MATLAB will be discussed.

The objective of this course is to introduce undergraduate students to computational methods using MATLAB. At the end of this course, a student would:

- Learn basics of MATLAB programming
- Get introduced to numerical methods for engineering problems
- Will be able to use MATLAB to solve computational problems

### SOFTWARE USED

We will use MATLAB in this course. Course lectures, practice problems and assignments will be given using MATLAB. [With support from MathWorks, access to MATLAB Online will be provided to registered students for the duration of this course.](#) Details will be posted for enrolled students on the first day of this course (18 Jan 2016).



# Agenda

## Experiential Learning

- Interactive Live Editor and App Designer
- Hardware Connectivity and Internet of Things

## Online Learning

- MATLAB Online and MATLAB Mobile
- Cody Coursework
- MATLAB Academy
- MATLAB Courseware



# Agenda

## Experiential Learning

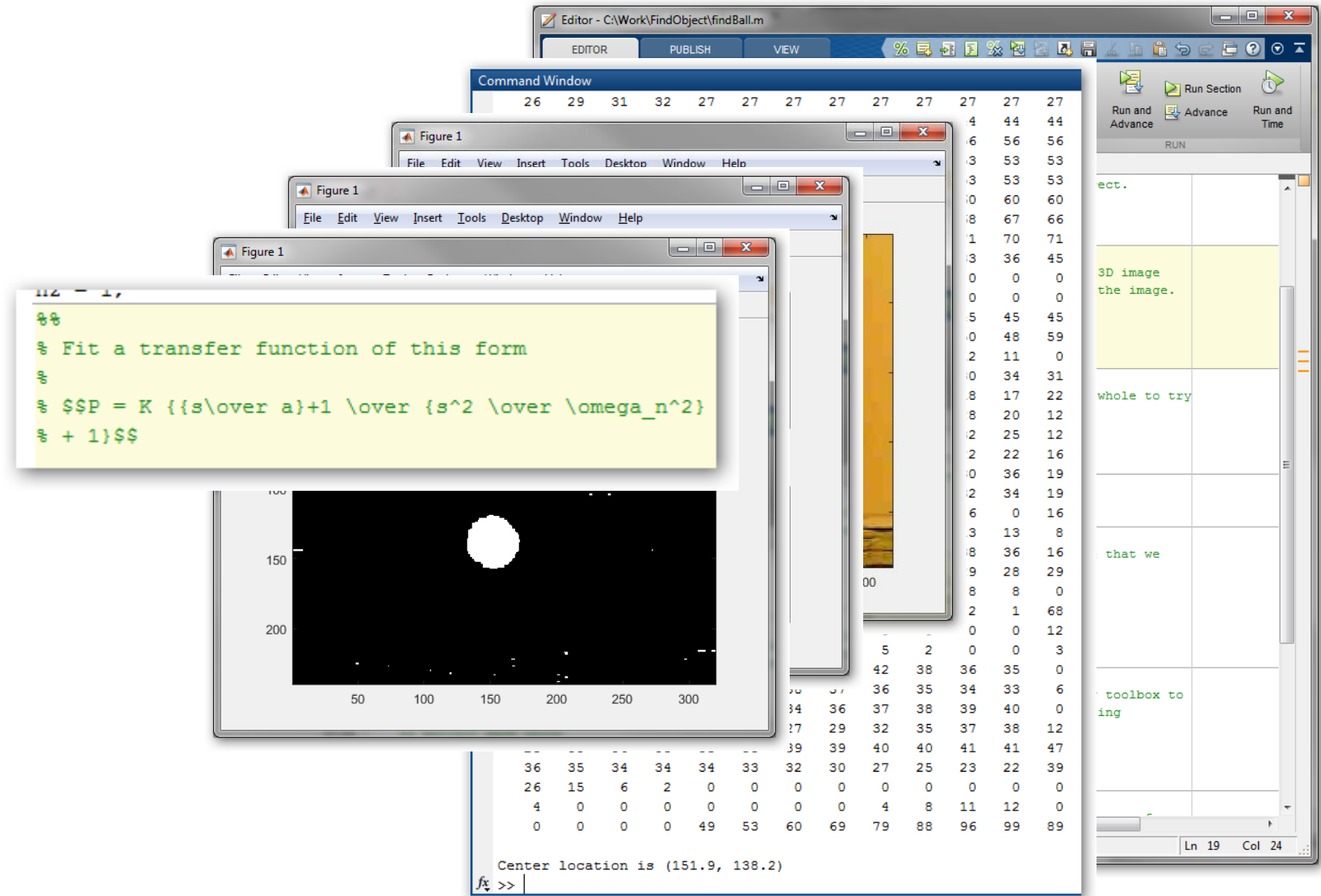
- **Interactive Live Editor and App Designer**
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# Editing and Running MATLAB Code Today

- Plain-text editing
- Output goes to Command Window
- Multiple figure windows appear
- Equations, images, and hyperlinks only appear if published



C:\MATLAB\SymbolicOverview.mlx

LIVE EDITOR VIEW

FILE NAVIGATE FORMAT INSERT TEXT STYLE RUN

+ New    Open    Save    Find Files    Compare    Go To    Find    **B I U M**    Equation    Hyperlink    Image    AaBbCc Normal    AaBbCc Heading    AaBbCc Title    Run All    Run Section

## Calculus I, II and III

Multivariate integration, differentiation, series, limits, 3D curves and surfaces

Find the derivative, integrand and Taylor series of  $\log(x)$ .

```

syms a x
f = log(1/x)

f = log(1/x)

df = diff(f)

df = -1/x

F = int(f)

F = x (log(1/x) + 1)

T = taylor(f,x,'ExpansionPoint', 1)

T = (x-1)^2/2 - x - (x-1)^3/3 + (x-1)^4/4 - (x-1)^5/5 + 1

```

Plot 3D surfaces

```

syms f(t) x(u,v) y(u,v) z(u,v)

```

# Using the Live Editor

- Accelerate Exploratory Programming
- Create an Interactive Narrative
- Teach with Live Scripts

Live Editor - C:\MATLAB\Live Editor\RootsOfOne.mlx

LIVE EDITOR VIEW

## The Roots of One

What does it mean to find the  $n^{th}$  root of 1?

Today we're going to talk about finding the roots of 1. What does it mean to find the  $n^{th}$  root of 1? The  $n^{th}$  roots of 1 are the solutions to the equation  $x^n - 1 = 0$ .

For square roots, this is easy. The values are  $x = \pm \sqrt{1} = \pm 1$ . For higher-order roots, it gets a bit more difficult. To find the cube roots of 1 we need to solve the equation  $x^3 - 1 = 0$ . We can factor this equation to get

$$(x - 1)(x^2 + x + 1) = 0.$$

So the first cube root is 1. Now we can use the quadratic formula to get the second and third cube roots.

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$


---

### Calculate the Cube Roots

In our case  $a$ ,  $b$ , and  $c$  are all equal to 1. The other two roots are calculated from these formulas:

Live Editor - C:\MATLAB\Live Editor\SolarPower.mlx

LIVE EDITOR VIEW

## Air Mass and Solar Radiation

As light from the sun passes through the earth's atmosphere, some of the solar radiation will be absorbed. The [air mass](https://en.wikipedia.org/wiki/Air_mass) is a function of solar elevation ( $\alpha$ ). As shown in the diagram below, it is a measure of the length of the path of light through the atmosphere (Y) relative to the shortest possible path (X).

[https://en.wikipedia.org/wiki/Air\\_mass](https://en.wikipedia.org/wiki/Air_mass)  
Ctrl+Click to follow link

The larger the air mass, the less radiation reaches the ground. The air mass can be calculated from the equation

$$AM = \frac{1}{\cos(90 - \alpha) + 0.5057(6.0799 + \alpha)^{-1.6364}}$$

Then the solar radiation (in Kw/m<sup>2</sup>) reaching the ground can be calculated from the empirical equation

$$sRad = 1.353 * 0.7^{AM^{0.678}}$$

```
AM = 1 / (cosd(90 - alpha) + 0.50572 * (6.07955 + alpha)^-1.6354);
sRad = 1.353 * 0.7^(AM^0.678); % kW/m^2
disp(['Air Mass = ' num2str(AM) ' Solar Radiation = ' num2str(sRad) ' kW/m^2'])
```

Air Mass = 1.0688 Solar Radiation = 0.93164 kW/m<sup>2</sup>

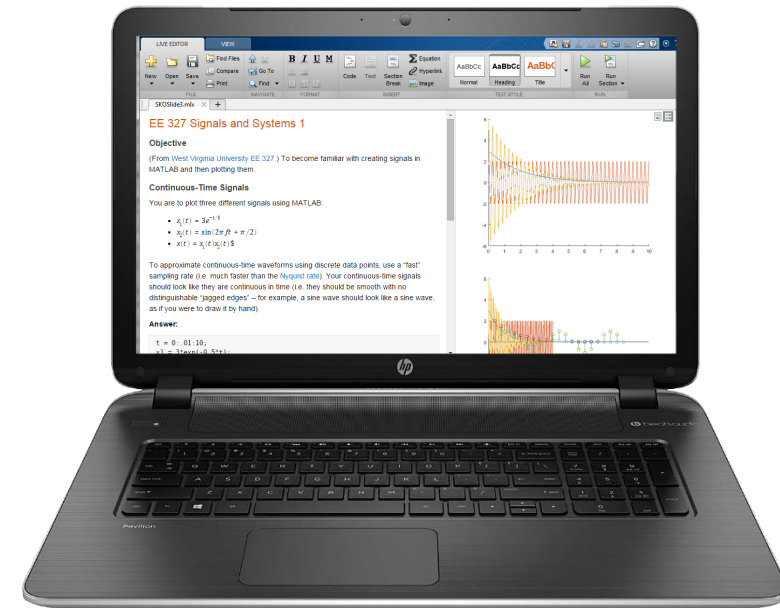
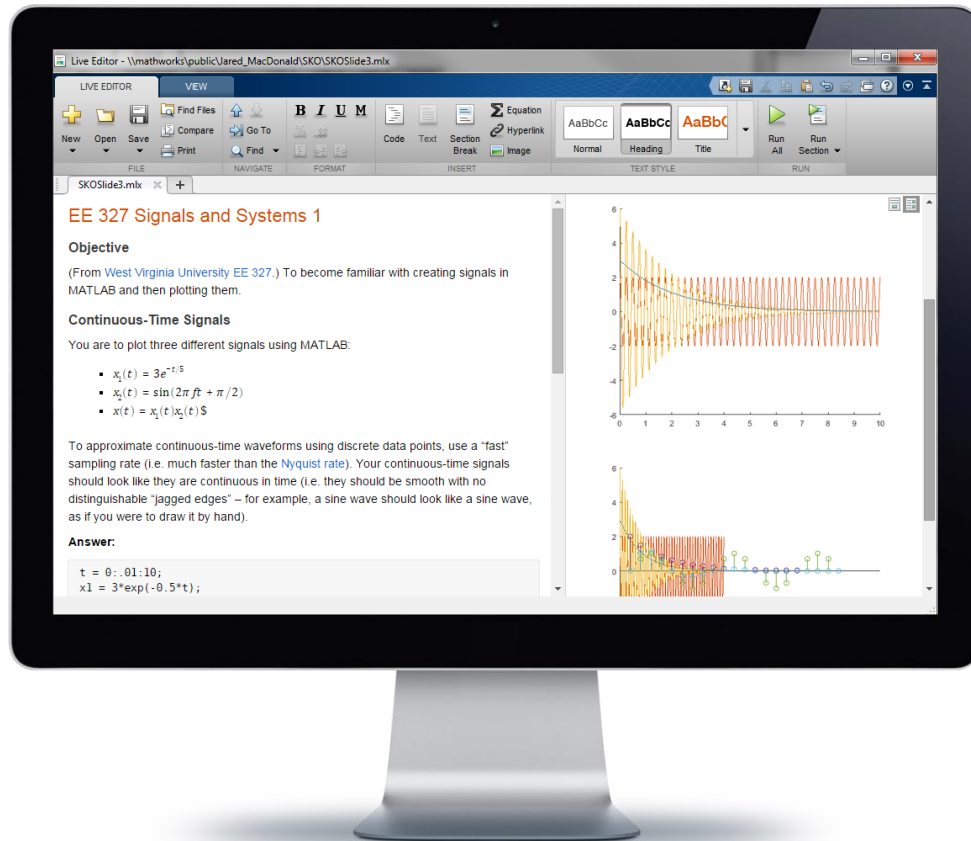
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## Solar Radiation on Fixed Panels

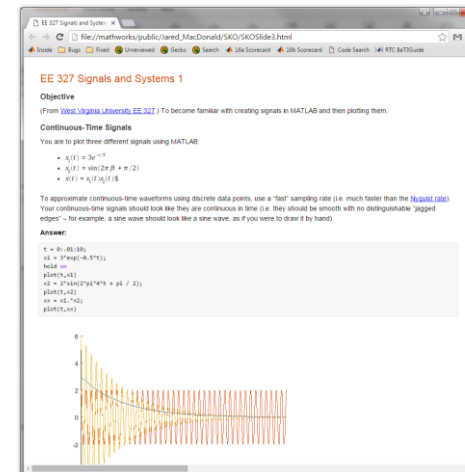
Panels installed with a [solar tracker](#) can move with the sun and receive 100% of the sun's radiation as the sun moves across the sky. However, most [solar cell](#) installations have panels set at a fixed azimuth and tilt. Therefore the actual radiation reaching the panel will also depend on the sun's



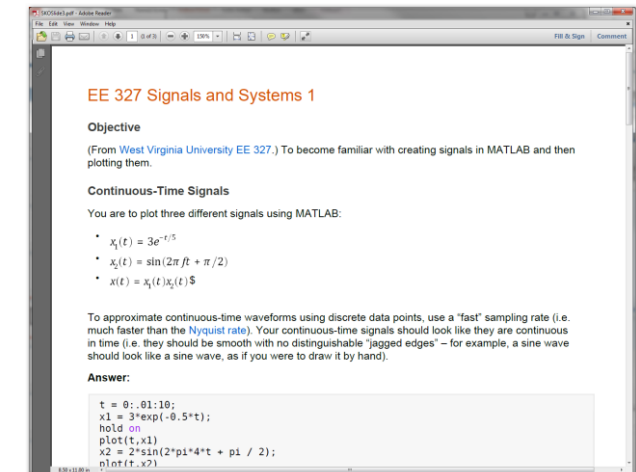
# Sharing Live Scripts



Colleague with MATLAB



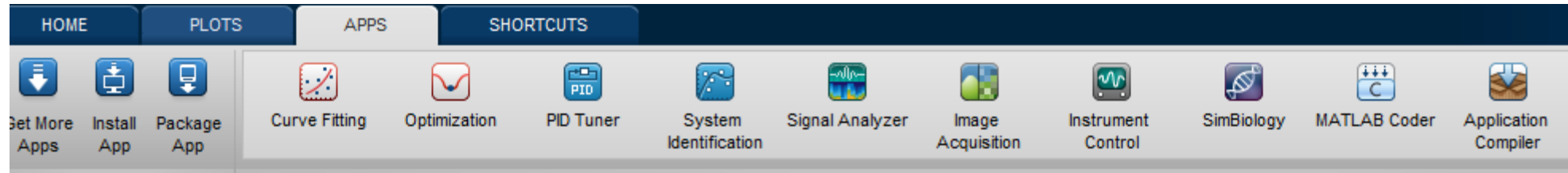
HTML



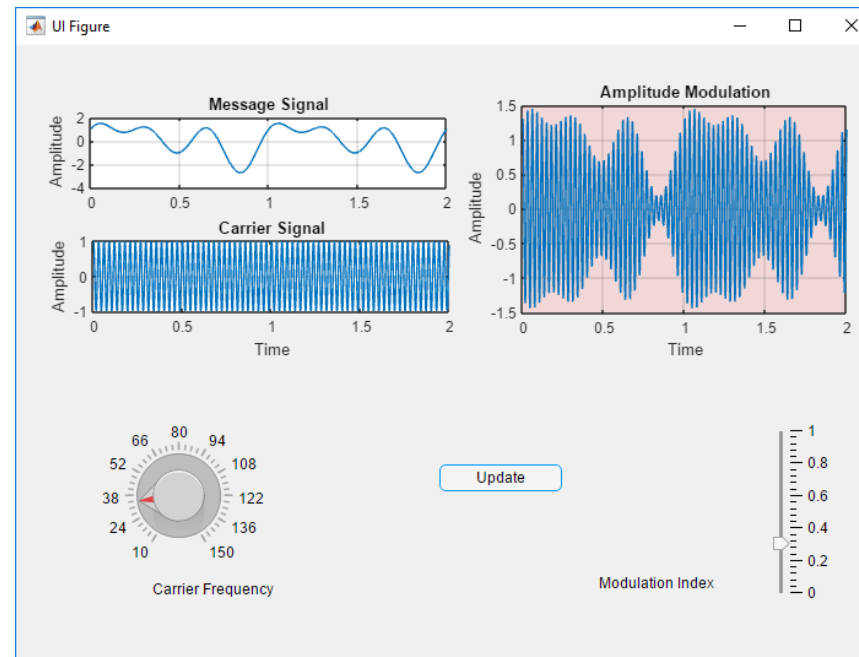
PDF

# Demo: Apps

- Apps Tab in MATLAB



- Creating an App/UI in MATLAB



# Developing a UI in MATLAB

## Programmatic Approach

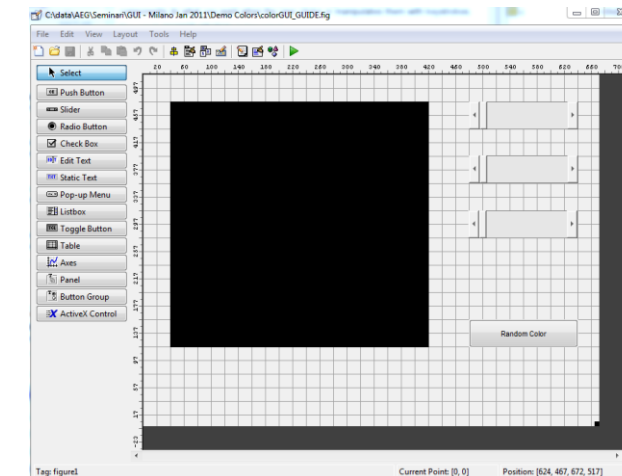
- MATLAB code to layout and program
- Full control of UI initialization and setup

```

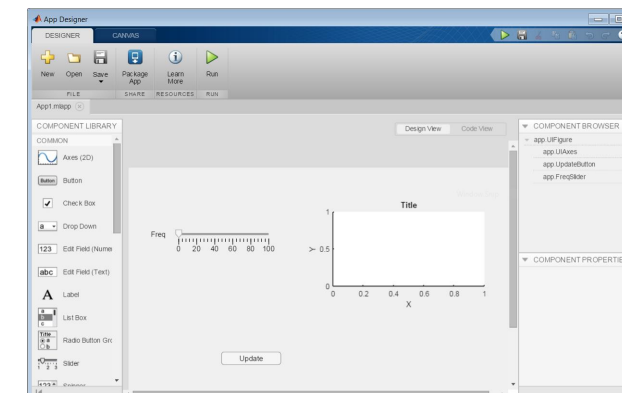
1 function myGUI
2 % Let's start by creating a new figure
3 figure('Name','Color GUI','Renderer','zbuffer');
4
5 %
6
7 axes('Units','normalized','Position',[0.1 0.1 0.5 0.8],'Color',[0 0 0],...
8 'XTick',[1],'YTick',[1]);
9
10 % Let's add some UIControl - Random Color button
11
12 hbutton = uicontrol('Style','pushbutton','Units','normalized',...
13 'Position',[0.7 0.1 0.2 0.1],'String','Random Color');
14
15 % Set a CALLBACK
16
17 set(hbutton,'callback',@randomColor)
    
```

## GUIDE (GUI Development Environment)

- Interactive UI construction kit
- Layout the UI interactively
- Program on an auto-generated template



## App Designer (from R2016a)



# App Designer

- 1) Define UI layout
- 2) Drag & Drop UI elements
- 3) Develop code for auto-generated callbacks

Introduced in R2016a

Built on JavaScript; useful in deploying MATLAB apps on the web; uses 'methods'

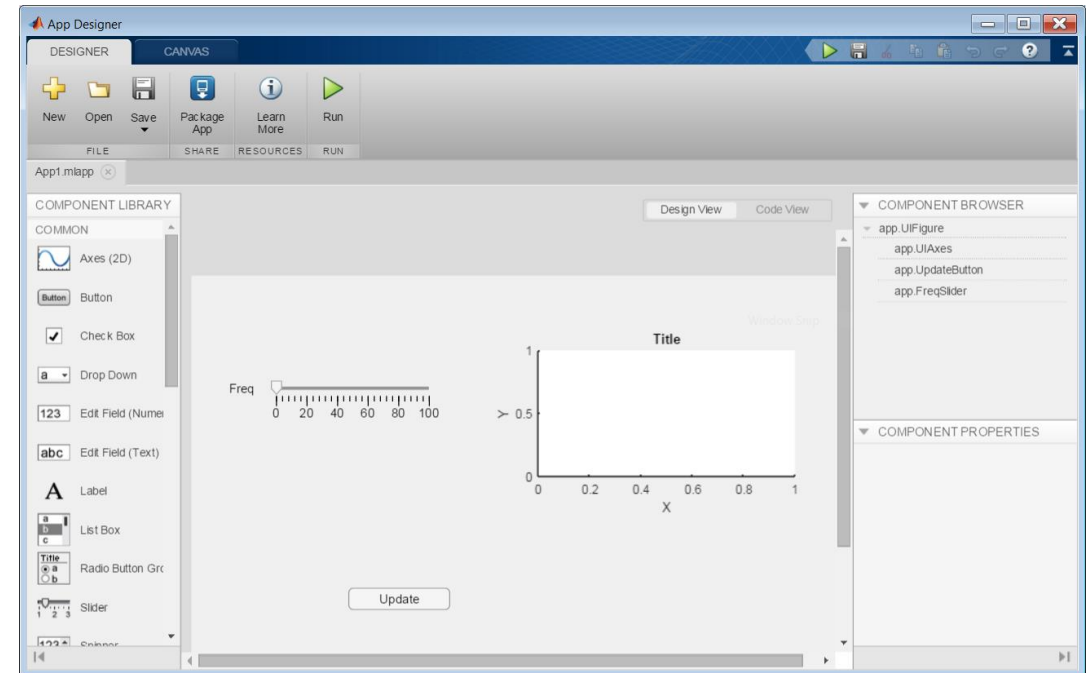
## Key Features:

Interactive Design Environment

Set of Standard User Interface Components

Gauge, Knob, Switch, and Lamp Components

New Code Format for Apps compared to GUIDE





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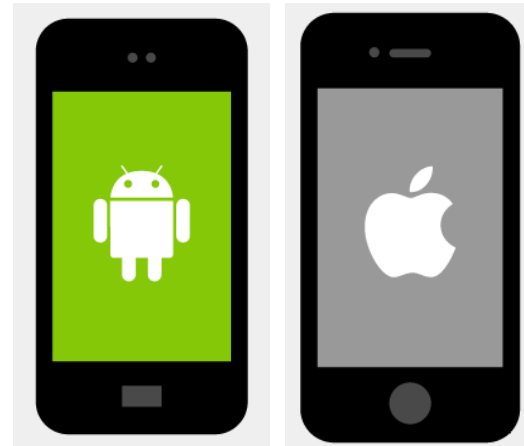
## Demo: Hardware Connectivity

- Raspberry Pi for Video Processing

# Why Hardware? Why Project-based Learning?

## Changing Hardware Trends - It's everywhere!

- Prototyping is easier and cheaper
- HW companies developing “dual”  
maker & commercial hardware
- More powerful hardware
- Everyone is connected
- More data is collected



# Examples of MathWorks Supported Hardware



**Arduino**



**Lego EV3**



**Raspberry Pi**



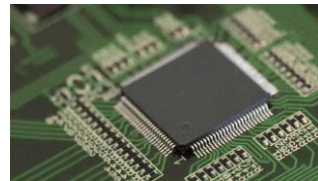
**Android/iOS  
Devices**



**Kinect for  
Windows**



**BeagleBone  
Black**



**Texas  
Instruments**



**STM  
Electronics**



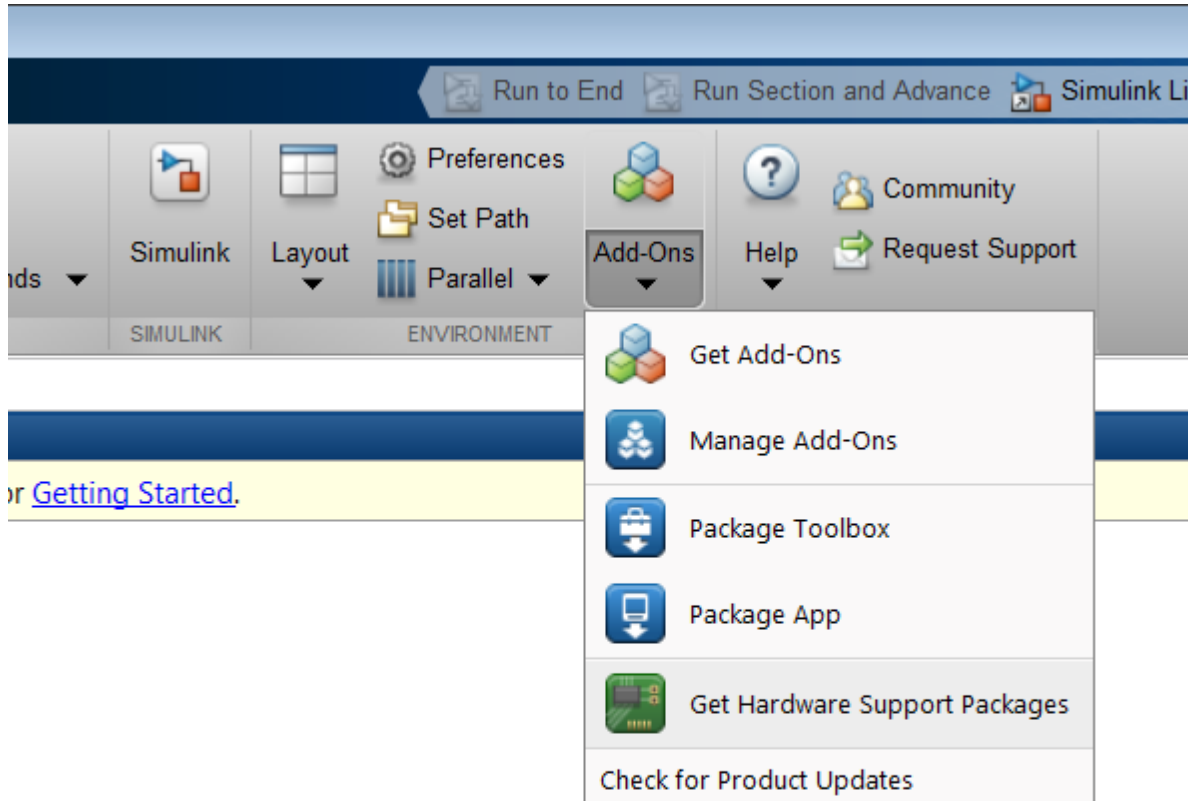
**Freescale**



**Zynq SDR**



# Getting Hardware Support Packages



- Requirement
  - MATLAB and Simulink
- Free to download
- Connects to Raspberry Pi, Arduino, Mobile sensors and many other hardware

# Simulink Support Package for Raspberry Pi

**Simulink Support Package for Raspberry Pi Hardware**

- Communications System Toolbox Support Package for RT
- Computer Vision System Toolbox
- Control System Toolbox
- DSP System Toolbox
- DSP System Toolbox HDL Support
- Embedded Coder
- Embedded Coder Support Package for Texas Instruments
- Fuzzy Logic Toolbox
- HDL Coder
- HDL Verifier
- Image Acquisition Toolbox
- Instrument Control Toolbox
- Model Predictive Control Toolbox
- Neural Network Toolbox
- OPC Toolbox
- Phased Array System Toolbox
- Report Generator
- Robotics System Toolbox
- Robust Control Toolbox
- SimEvents
- SimRF
- Simscape
- Simulink 3D Animation
- Simulink Coder
- Simulink Control Design
- Simulink Design Optimization
- Simulink Design Verifier
- Simulink Desktop Real-Time
- Simulink Extras
- Simulink Real-Time
- Simulink Support Package for Arduino Hardware
- Simulink Support Package for Raspberry Pi Hardware**
- Simulink Support Package for Samsung GALAXY Android I
- Simulink Test
- Simulink Verification and Validation

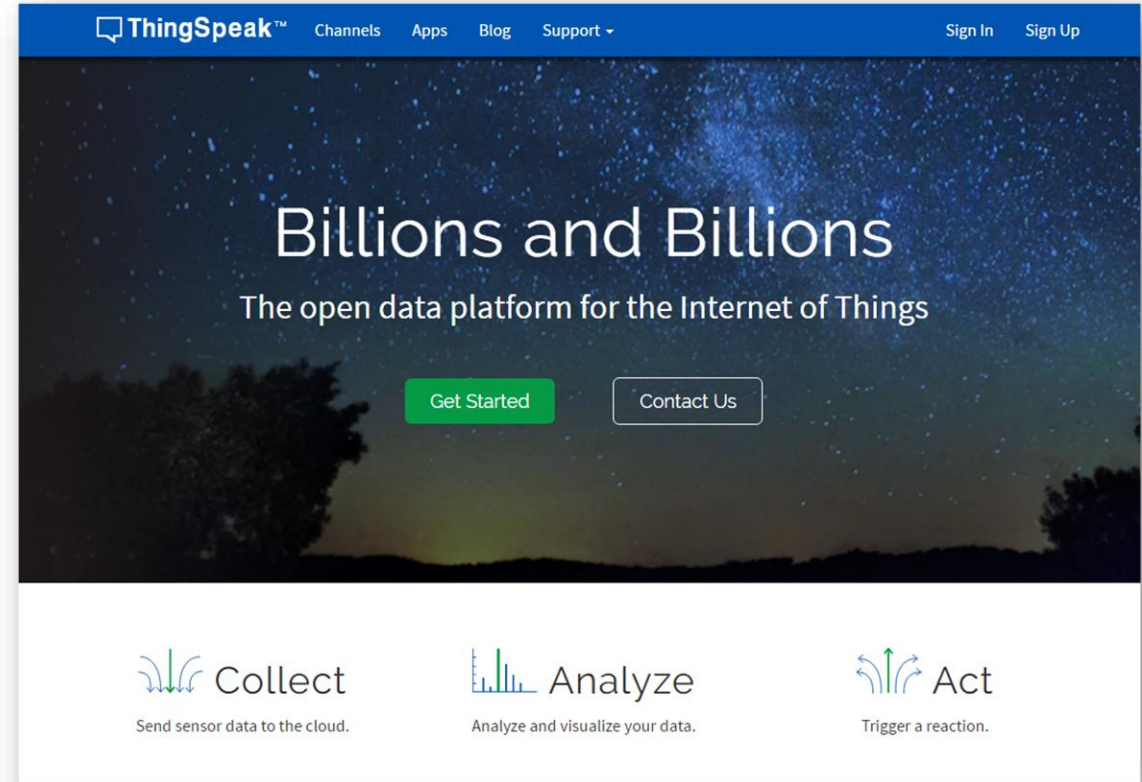
The screenshot displays the Simulink library browser for the Raspberry Pi hardware support package. The left pane shows a tree view of toolboxes, with 'Simulink Support Package for Raspberry Pi Hardware' selected. The right pane shows a grid of hardware blocks:

- ALSA Audio Capture
- ALSA Audio Playback
- eSpeak Text to Speech
- GPIO 4
- GPIO Read
- GPIO 17
- GPIO Write
- led0 (Green)
- LED
- SDL Video Display
- ThingSpeak Write** (highlighted with a red box)
- UDP Receive
- UDP Send
- V4L2 Video Capture

# Internet of Things - ThingSpeak

- Collect data from internet-connected sensors and run MATLAB analytics on the cloud using functions from:
  - Statistics and Machine Learning Toolbox
  - Signal Processing Toolbox
  - Curve Fitting Toolbox
  - Mapping Toolbox

MATLAB Analysis and Visualization	
<code>thingSpeakRead</code>	Read data stored in ThingSpeak channel
<code>thingSpeakWrite</code>	Write data to ThingSpeak channel
<code>urlFilter</code>	Scrape numbers from web page
<code>thingSpeakArea</code>	Filled area 2-D plot
<code>thingSpeakPlot</code>	Create 2-D line plot
<code>thingSpeakScatter</code>	Create scatter plot
<code>thingSpeakStem</code>	Create discrete sequence or stem plot
<code>thingSpeakPlotYY</code>	2-D line plot with Y axes on both sides



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# MATLAB Online

Access MATLAB from a web browser.

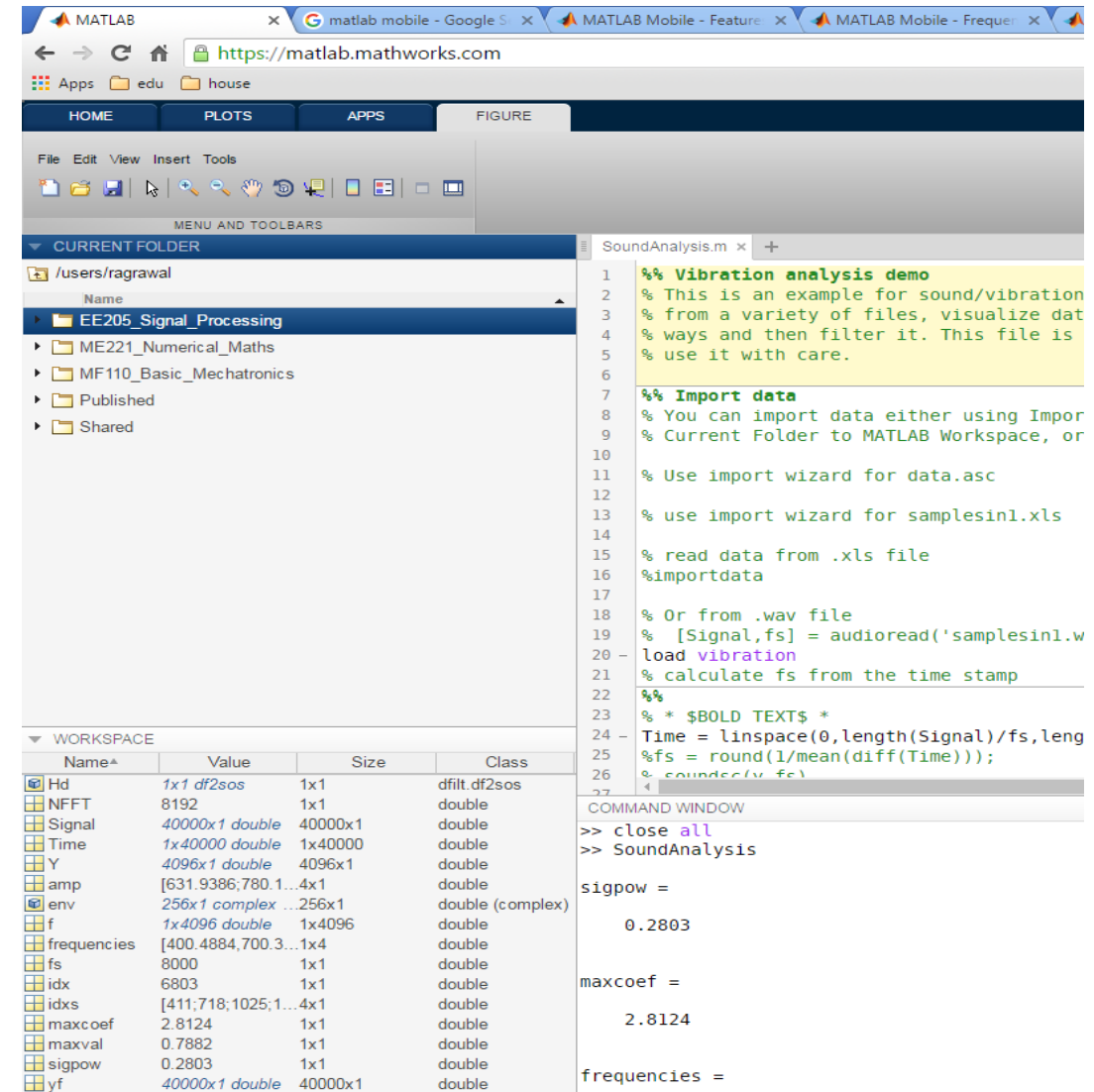
- Demo

No Download/Installation

Version Consistency

File Sharing

Everywhere Access

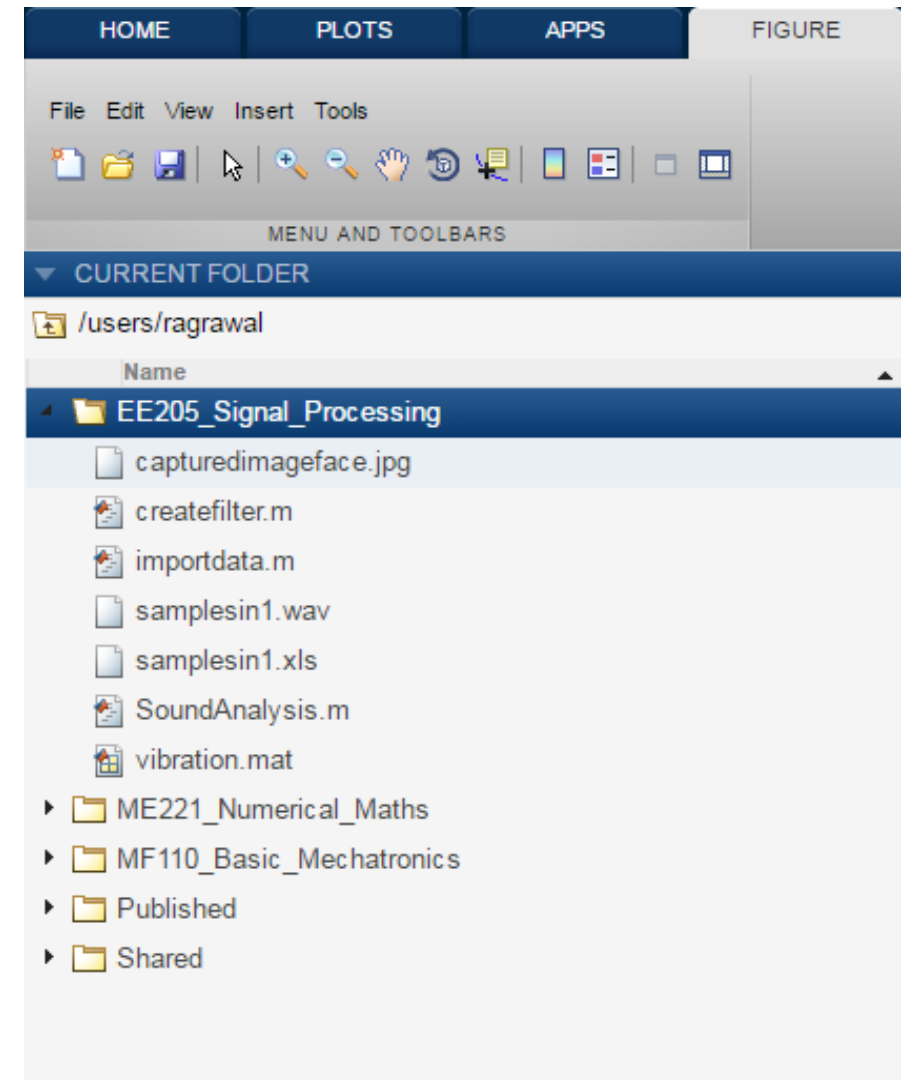




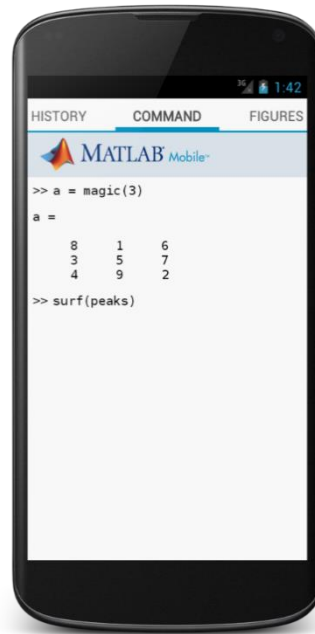
# MATLAB Online

## Your files and data on the cloud

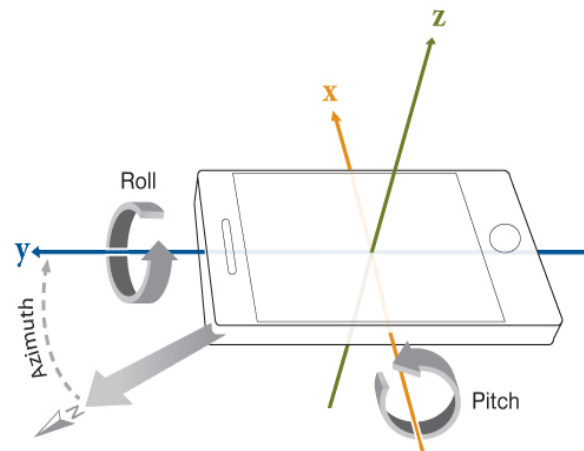
- 5 GB of cloud storage on MATLAB Drive
- Sync files between computers and MATLAB Online with MATLAB Drive Connector
- Session persists across computers
- Files and workspace are synced with MATLAB Mobile



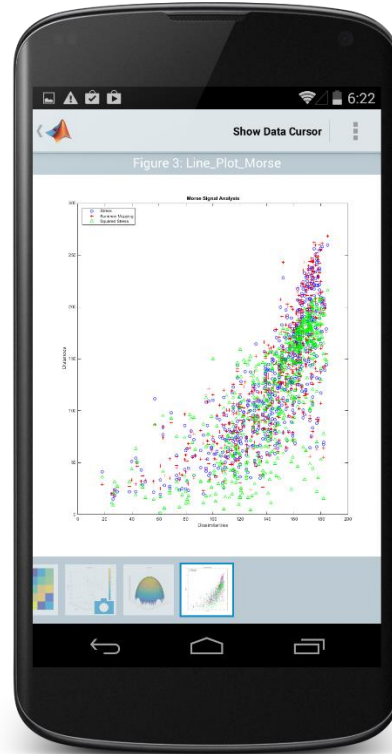
# MATLAB Mobile



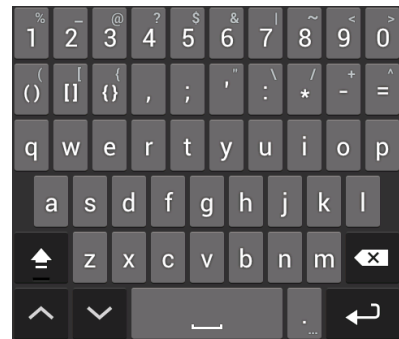
- Available for iPhone, iPad, iPod and Android devices.
- Lets you connect to a MATLAB session running on your computer, or on MathWorks Cloud.
- Smart phone as a sensor platform



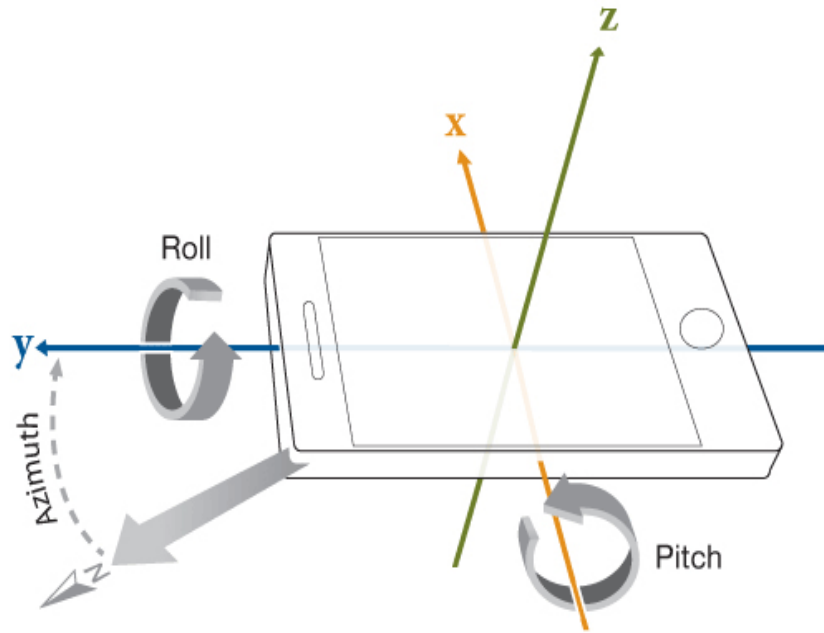
# MATLAB Mobile



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# Hardware Sensor Platform: MATLAB Mobile



Sensors	
Acceleration	
X m/s <sup>2</sup>	-0.073
Y m/s <sup>2</sup>	0.071
Z m/s <sup>2</sup>	10.147
Orientation	
Azimuth degrees	61.306
Pitch degrees	0.596
Roll degrees	-1.930
Start Sending	

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## Before we start – a few questions

- How do you test learning of concepts?
- How do you typically evaluate code submitted by students?
- Is evaluation of code time-consuming?



# Cody Coursework

- Visual environment to create MATLAB problem sets
- Instructors can set up MATLAB assignments and automatically evaluate them
- Students can test their solutions obtaining immediate feedback

The screenshot displays the Cody Coursework web interface. At the top, a blue banner reads "Welcome to Cody Coursework™". Below this, there is a "Log In" button and a link for users without a MathWorks account. A central menu lists course details, including "Getting Started", "Times 2 - START HERE" (highlighted), and subsequent weeks with various MATLAB problems. To the right, the "Times 2 - START HERE" problem set is shown, featuring a text-based problem description, examples of input and output, and a "Solve" button. Below the problem set, a "Solutions" section shows a table with 0 solvers submitted 0 solutions.

**Homework assignments**

**Exams**

**Practical sessions**

**Many others (e.g., learn MATLAB,  
share problems)**

# Workflow

<https://coursework.mathworks.com>

## Faculty creates a course in Cody Coursework

- Assignments with Problem Sets
- Invites Students to the course



## Student receives an email with an invite to the course

- Assignments with problems sets due on a particular date
- Students solves the problems, gets instant feedback and submits the assignment



## Learning analytics

- Faculty is able to see how many students attempted the problems in the assignment, how many got it correct, number of attempts
- Faculty also able to download the MATLAB code submitted and the submission data in CSV format

Week 1 To: James Pike  
Subject: [Cody Coursework] Introduction to Numerical Methods

Create

To ensure our e-mails reach your inbox, add the domain @mathworks.com to your safe sender list.

**Cody Coursework™**

**Description**

Prof. Sandra Hume is inviting you to attend **Introduction to Numerical Methods** in Cody Coursework!

To get started, click: [View Invitation](#)

Please do not forward or share this link.

**Course Access**

You need a MathWorks Account to access this course. If you don't have an account yet, Cody Coursework will help you create one.

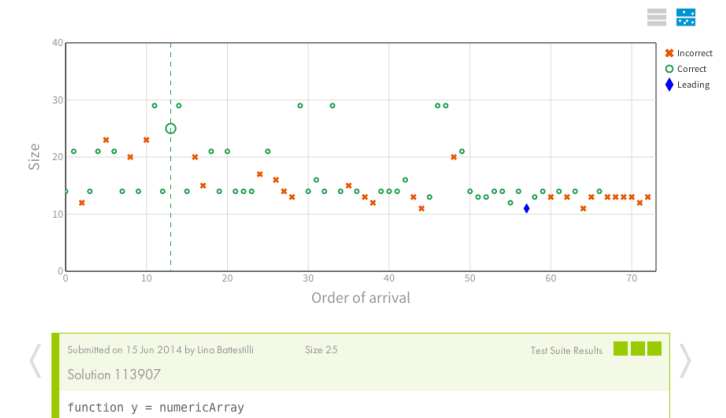
Week 1 - Data Types

```
y = [1:10]';
end
```

[View Map](#) [Improve Your Solution](#)

Test Suite

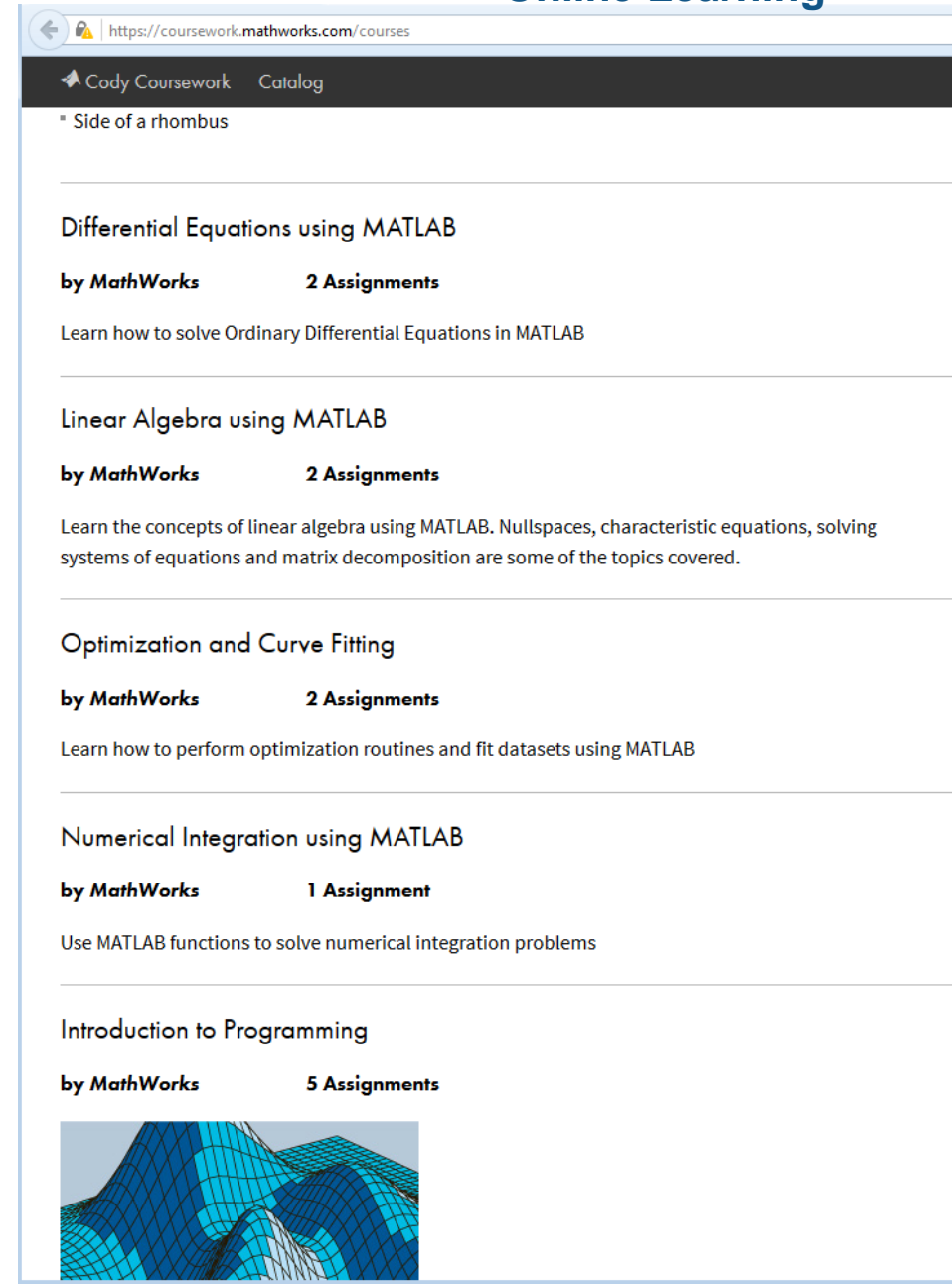
TEST	RESULT	CODE INPUT
1	Pass	%% Check one of the elements y = numericArray; assert(isequal(y(7),7),... 'Make sure it is an array containing numbers 1,2...10.');
2	Pass	%% Check all elements assert(isequal(prod(numericArray),prod(1:10)),... 'Make sure it is an array containing numbers from 1 to 10.');
3	Pass	%% Check if the array is of the right dimension assert(isequal(size(numericArray),[10, 1]),... 'Make sure it is a COLUMN vector of size [10, 1].');



# Cody Coursework

- MathWorks hosted and runs a cloud version of MATLAB
  - No local installation of MATLAB necessary
- Catalog of courses and problems
  - Basic MATLAB
  - Numerical Methods
  - Calculus
  - Control Systems
  - Signal Processing
- Requirements:
  - Instructor: License association
  - Student: MathWorks account

MATLAB EXPO 2017



The screenshot shows the Cody Coursework website interface. At the top, there is a navigation bar with "Cody Coursework" and "Catalog" links. Below this, a list of courses is displayed, each with a title, author, and number of assignments. The courses listed are:

- "Side of a rhombus"
- Differential Equations using MATLAB
  - by MathWorks
  - 2 Assignments
  - Learn how to solve Ordinary Differential Equations in MATLAB
- Linear Algebra using MATLAB
  - by MathWorks
  - 2 Assignments
  - Learn the concepts of linear algebra using MATLAB. Nullspaces, characteristic equations, solving systems of equations and matrix decomposition are some of the topics covered.
- Optimization and Curve Fitting
  - by MathWorks
  - 2 Assignments
  - Learn how to perform optimization routines and fit datasets using MATLAB
- Numerical Integration using MATLAB
  - by MathWorks
  - 1 Assignment
  - Use MATLAB functions to solve numerical integration problems
- Introduction to Programming
  - by MathWorks
  - 5 Assignments

At the bottom of the screenshot, there is a small image showing a 3D surface plot with a blue grid overlaying a landscape-like shape.

# Agenda

## Experiential Learning

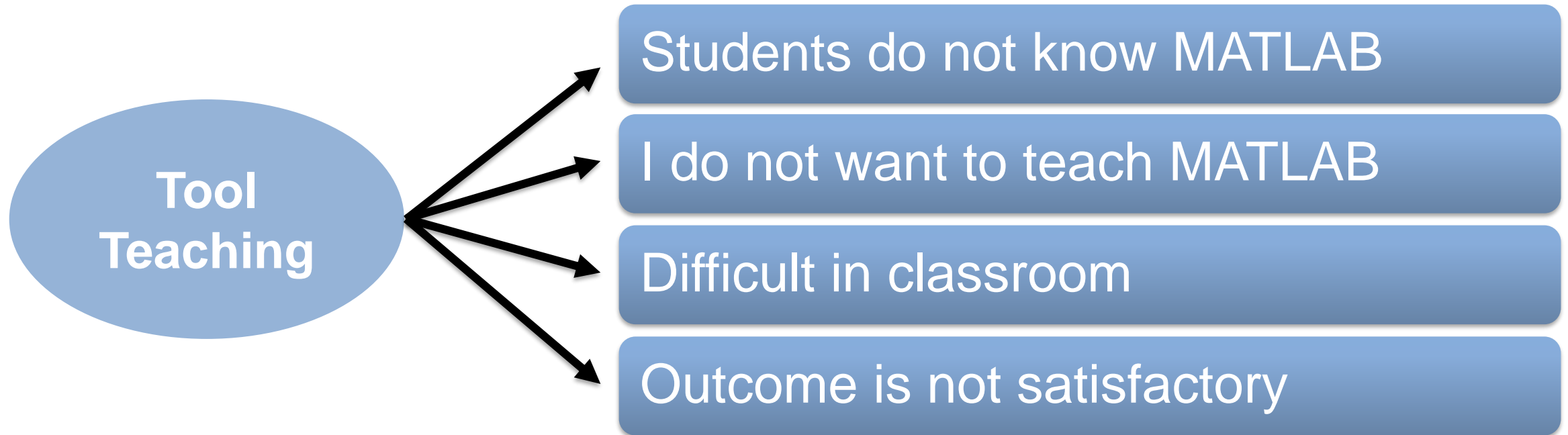
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# Challenge




**MathWorks®** | *Training Services*

<b>Mathematical Modeling and Data Analytics</b>	<b>Signal/Image Processing &amp; Communications</b>	<b>Control Systems, Robotics and Automation</b>
Statistical Methods in MATLAB	Signal Processing with MATLAB (Simulink)	Simulink for System and Algorithm Modeling
Machine Learning with MATLAB	Image Processing with MATLAB	Stateflow for Logic Driven System Modeling
Optimization Techniques in MATLAB	Computer Vision with MATLAB	Control System Design with MATLAB and Simulink
MATLAB for Data Processing and Visualization	Communication Systems Modeling with MATLAB (Simulink)	Designing Robotics Algorithms in MATLAB
	Designing LTE and LTE Advanced Physical Layer Systems with MATLAB	

# MATLAB Academy



MATLAB Academy

# MATLAB Academy



## MATLAB Onramp

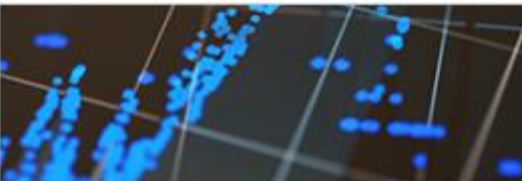
*Complimentary training - 2 hrs duration*



## MATLAB Fundamentals



## MATLAB Programming Techniques



## MATLAB for Data Processing and Visualization



## MATLAB for Financial Applications



## Machine Learning with MATLAB

## MATLAB Academic Online Training Suite (MAOTS)

- Includes all MATLAB Academy Courses
- Bundled with the University Campus License
- Available to all registered University staff/students
- Access to course completion certificate

# New Customized Course Offering: System Modeling for Control Systems and Image Processing

- **Customized course** for Indian academic audience based on trends in industry
- **Learning Outcome:**
  - Model-Based Design workflow including physical modeling, code generation, rapid prototyping, in-loop verification
- **Use cases:**
  - Design of Control System for DC motor
  - Object Surveillance System
- **Tools covered:**
  - MATLAB, Simulink, Simscape, Stateflow, Control Systems Toolbox, Image Processing Toolbox, Computer Vision Systems Toolbox, Embedded Coder



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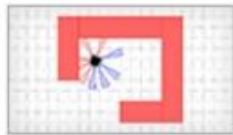
# MATLAB Courseware

## MATLAB Courseware

Search MathWorks.com

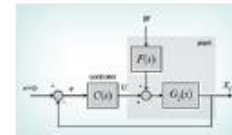
[Educator Home](#) | 
 [Classroom Resources](#) ▾ | 
 [Hardware Support](#) | 
 [License Options](#) ▾ | 
 [Research](#)

## Electrical and Computer Engineering



### Control of Mobile Robots

*Professor Magnus Egerstedt*  
*J.P. de la Croix*  
 Georgia Institute of Technology



### Control Tutorials for MATLAB and Simulink

*Professor Bill Messner*  
*Professor Dawn Tilbury*  
*Professor Rick Hill*



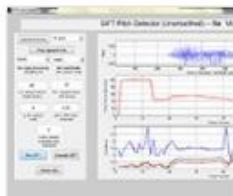
### Introduction to Model-Based System Design

*Professor Marc Herniter*  
*Professor Zachariah Chambers*  
 Rose-Hulman Institute of Technology



### Advanced Model-Based System Design

*Professor Zachariah Chambers*  
*Professor Marc Herniter*  
 Rose-Hulman Institute of Technology



### Digital Speech Processing

*Professor Lawrence Rabiner*  
 Rutgers, The State University of New Jersey



### Embedded Control and Mechatronics

*Professor Farzad Pourboghrat*  
 Southern Illinois University, Carbondale

## Call to Action

### Experiential Learning

- Interactive Live Editor and App Designer
- Hardware Connectivity and Internet of Things

### Online Learning

- MATLAB Online and MATLAB Mobile
- Cody Coursework
- MATLAB Academy
- MATLAB Courseware

Learn how to use these resources in the next session on 'Building a Course Implementation Plan'

# WHAT IF EVERYONE ON CAMPUS HAD MATLAB?



More than **1 million students and 700 universities** around the world—including the top 10 ranked universities—have unlimited access to MATLAB and Simulink with a Total Academic Headcount (TAH) license.



## HANDS-ON LEARNING

**42,000**

Faculty and students using MATLAB to program hardware

“On multidisciplinary projects, students with quite different educational backgrounds can work together more easily because they are using the same tools.”

*Professor Jakob Stoustrup, Aalborg University*



## JOB OPPORTUNITIES

**82%**

Fortune 100 companies with a MATLAB license

“If you want to work at Google, make sure you can use MATLAB.”

*Jonathan Rosenberg, Senior Vice President of Products, Google*



## RESEARCH PRODUCTIVITY

**1,970,000**

Google Scholar results referencing MATLAB

“Our teams are here to do world-class research, and easy access to MATLAB enables them to be their most productive.”

*Shailesh Shenoy, Director of Research Computing, Albert Einstein College of Medicine of Yeshiva University*