

# MathWorks Special Session at ACC 2021

## Special Session:

### Teaching Modeling and Controls with the MATLAB Live Editor

**Date / Time:** Thursday, May 27 / 2 pm EST *(please refer to [the conference program](#) for the meeting link)*

In this special session, Dr. Richard Hill will share his experiences on teaching controls with the interactive MATLAB Live Scripts. You'll also hear from Dr. Craig Buhr on various resources that MathWorks provides for online teaching.

## Abstract

Teaching modeling and control of dynamic systems is challenging because the topic requires significant mathematics and can be somewhat abstract. In this session, Professor Richard Hill demonstrates how to use the MATLAB Live Editor to help your instruction come alive. The use of the Live Editor allows you to create live scripts that combine code, formatted text, and graphics to generate clear professional materials. By embedding live controls such as numeric sliders, buttons, and dropdown lists, you can create lectures that illustrate complex topics through interactive figures. These live scripts can also be deployed as in-class activities for students and as interactive homework assignments that help students build intuition for course material and construct meaning for themselves. Pedagogical research clearly demonstrates the benefits of inquiry-based, active learning. Specific examples will be demonstrated showing how to use live scripts to illustrate the mathematics of control, as well as to teach the graphical tools central to controller design such as the Bode diagram and root locus. Further cases will be presented demonstrating how interactive live controls can teach students the iterative nature of controller design and tuning. The examples shared in this session align with the popular web-based Control Tutorials for MATLAB and Simulink ([ctms.engin.umich.edu](http://ctms.engin.umich.edu)).

## About the Presenter



**Richard Hill**

Dr. Richard Hill is a Professor and Assistant Dean in the College of Engineering & Science at University of Detroit Mercy. Dr. Hill received a B.S. degree in Mechanical Engineering from the University of Southern California in 1998, and an M.S. degree in Mechanical Engineering from the University of California, Berkeley in 2000. He joined the faculty of Detroit Mercy in 2008 after receiving a Ph.D. degree in Mechanical Engineering and an M.S. degree in Applied Mathematics from the University of Michigan, Ann Arbor. His research interests lie in the areas of vehicle control, control and diagnosis of discrete event systems, and modular and hierarchical control. Dr. Hill also has a strong interest in diversifying the STEM pipeline and leads the innovating Detroit's Robotics Agile Workforce (iDRAW) program in partnership with underserved Detroit-area high schools.

## Meet MathWorks Experts:



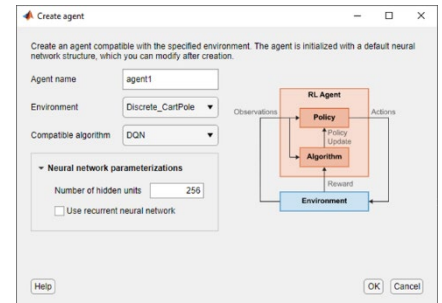
**Dr. Craig Buhr** received his Ph.D. degree from the School of Mechanical Engineering at Purdue University in 2003. His research interests include dynamic system modeling and identification, linear systems and control theory. He joined MathWorks as a Senior Developer for the Control System Toolbox in 2003, developing software tools to facilitate the design and analysis of control systems. He is currently the Senior Team Lead of the Control Design group.

## Latest Features in Controls

### Reinforcement Learning Designer

New in 2021a

Design, train, and simulate agents for using a visual interactive workflow with the **Reinforcement Learning Designer** app. You can import existing MATLAB/Simulink environments, automatically create or import agents, train and simulate them, analyze simulation results and refine agent parameters and export the final agent to the MATLAB workspace for further use and deployment.



### Large-Scale Linear Models

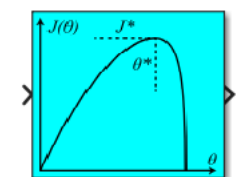
New in 2020b

Control System Toolbox now provides support for **sparse state-space matrices** for creating, combining, and analyzing large-scale linear models. You can represent first-order and second-order sparse state-space model objects and combine them with regular LTI objects to perform time and frequency domain analysis.

### Data-Driven and Learning-Based Control

New in 2021a

Implement data-driven and learning-based control techniques using reference examples and blocks from Simulink Control Design. The toolbox now provides the **Extremum Seeking Control** block for model-free real-time optimization to automatically adapt control system parameters to maximize an objective function. You can also generate C/C++ code from the block to deploy onto hardware. Additionally, the toolbox provides the capability of modifying control actions to **enforce constraints** and action bounds in control systems.

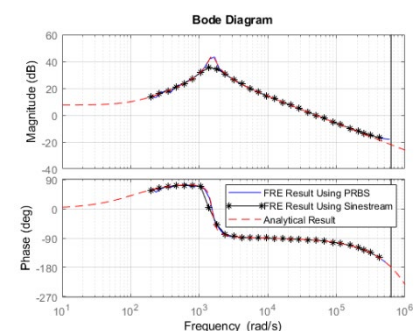


Extremum Seeking Control

### Frequency Response Estimation Workflows

New in 2020a

The toolbox now provides **pseudorandom binary sequence signals** (PRBS) to estimate frequency responses for highly nonlinear and discontinuous models, such as in power electronics and communications applications. In 2021a, you can automatically determine PRBS signal parameters and perform filtering to improve the quality of frequency response estimation results.



## Learn More about MATLAB and Simulink Capabilities

### Automated Driving

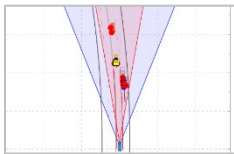
[mathworks.com/solutions/automotive/automated-driving](https://mathworks.com/solutions/automotive/automated-driving)



Design automated driving system functionality including sensing, path planning, and sensor fusion and controls.

### Model Predictive Control

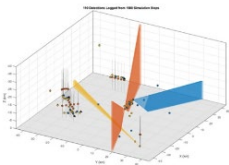
[mathworks.com/products/mpc](https://mathworks.com/products/mpc)



Design and simulate MPC controllers for adaptive cruise control, lane keeping assist and lane following control systems.

### Sensor Fusion and Tracking

[mathworks.com/products/sensor-fusion-and-tracking](https://mathworks.com/products/sensor-fusion-and-tracking)



Design and simulate multi-object trackers, sensor fusion filters, motion and sensor models, and data association algorithms that let you evaluate fusion architectures using real and synthetic data.

## Resources for Learning and Teaching Control Systems

### Low-Cost Hardware Support

[mathworks.com/hardware](https://mathworks.com/hardware)



Download hardware packages for Arduino, Raspberry Pi, and LEGO.

### MATLAB Tech Talks

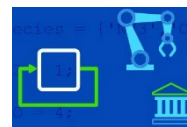
[mathworks.com/tech-talks](https://mathworks.com/tech-talks)



Learn fundamental concepts in different topics such as controls, deep learning, state machines and reinforcement learning.

### Teaching Controls with MATLAB and Simulink

[mathworks.com/academia/courseware/teaching-controls-with-matlab-and-simulink](https://mathworks.com/academia/courseware/teaching-controls-with-matlab-and-simulink)



Explore controls teaching resources including a sampling of course curricula, online labs, educational videos, code examples and auto grading tools.

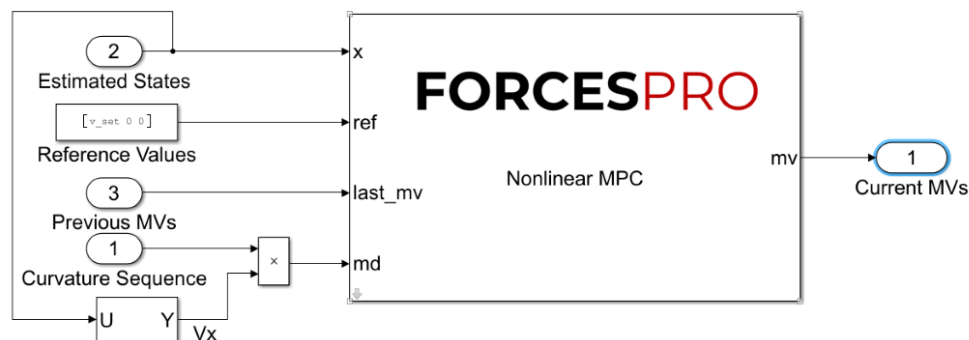
### Resources for learning about curriculum support:

- Learn through interactive examples with MATLAB and Simulink Onramps: [matlabacademy.mathworks.com](https://matlabacademy.mathworks.com)
- Classroom training in MATLAB or other MathWorks products: [mathworks.com/training-schedule](https://mathworks.com/training-schedule)
- Webinars of Teaching Examples: [mathworks.com/academia/webinars](https://mathworks.com/academia/webinars)
- Hardware for Project-Based Learning: [mathworks.com/academia/hardware](https://mathworks.com/academia/hardware)
- MATLAB Courseware: [mathworks.com/academia/courseware](https://mathworks.com/academia/courseware)
- MATLAB Licensing for Campus-Wide Use: [mathworks.com/academia/matlab-campus](https://mathworks.com/academia/matlab-campus)

## FORCESPRO | NMPC support for Model Predictive Control Toolbox™

FORCESPRO by Embotech AG is a solver (developed) for embedded real-time optimization for Model Predictive Controllers (MPC). With the release FORCESPRO 4.0, Embotech provides an enhanced plugin such that Nonlinear MPC can now be designed and deployed on hardware with MathWorks Model Predictive Control Toolbox™ using FORCESPRO as solver. Starting from MATLAB R2020a and R2020b, users can design Nonlinear MPC in their accustomed MATLAB workflows with the powerful capabilities of Model Predictive Control Toolbox™. The resulting optimization problem can be solved with the computational performance and numerical robustness of the FORCESPRO solver. Both, Embotech's Interior Point solver as well as the SQP solver can be chosen as a solution method and can be easily deployed on hardware such as dSPACE MicroAutoBox II and Speedgoat. The interface also comes with full Simulink® support. This novel toolchain makes real-world application of MPC for demanding control problems straightforward.

Find more information about the solver on the [FORCESPRO](#) website. For information on how to use the FORCESPRO solver together with Model Predictive Control Toolbox, visit the FORCESPRO [documentation](#) or directly download the [lane-following demo](#) for quick, hands-on testing.



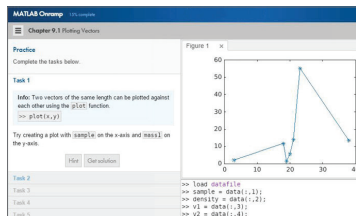
## Resources and Tools for Educators and Students

Explore these online resources to learn more about integrating MATLAB and Simulink into your teaching, research, and studies.

Get Started for Free with MATLAB Onramp  
and Deep Learning Onramp

*matlabacademy.com*

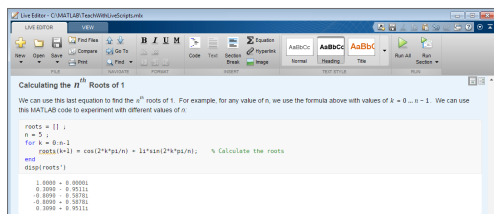
In just two hours, you can master the basics of MATLAB and start using MATLAB for deep learning through these online courses. With Deep Learning Onramp, try hands-on exercises that guide you through the deep learning workflow, which includes reading image data, classifying images, and evaluating performance.



## Interactive Notebooks – Live Editor

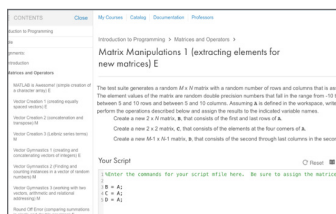
[mathworks.com/products/matlab/live-editor](https://mathworks.com/products/matlab/live-editor)

Live Editor allows you to accelerate exploratory programming, create an interactive narrative, and teach with live scripts



Automatically Grade MATLAB Code – MATLAB Grader  
grader.mathworks.com

Create interactive MATLAB course problems for students.  
Automatically grade student work and provide feedback. Run your problems in any learning environment.



## Online Learning Anytime, Anywhere – MATLAB Online and MATLAB Drive

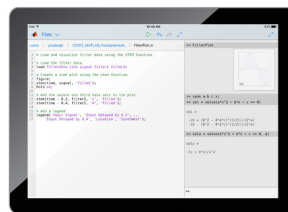
[mathworks.com/products/matlab-online](https://mathworks.com/products/matlab-online)

By running MATLAB Online directly from your web browser, you eliminate the need to download or install software. Plus, you're always using the latest version of MATLAB.



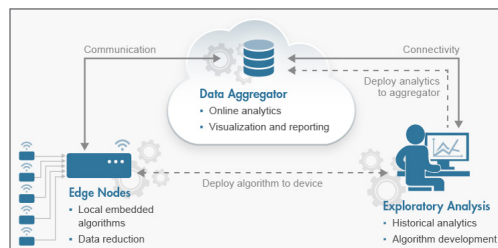
**Use MATLAB Anytime, Anywhere with MATLAB Mobile**  
[mathworks.com/products/matlab-mobile](http://mathworks.com/products/matlab-mobile)

Your figures and workspace persist across sessions, so you can resume work when you next log in.



## Internet of Things Analysis – ThingSpeak

ThingSpeak is an IoT analytics platform service that allows you to aggregate, visualize, and analyze live data streams in the cloud. It enables engineers and scientists to prototype and build IoT systems without setting up servers or developing web software.



## For Teaching and Research

Learn about the benefits of campus-wide access to MATLAB and Simulink [mathworks.com/campus-license](https://mathworks.com/campus-license)

Download MATLAB courseware to develop and enhance curriculum [mathworks.com/academia/courseware](https://mathworks.com/academia/courseware)

Discover examples to reference for demos and student assignments [mathworks.com/examples](https://mathworks.com/examples)

Learn how MATLAB and Simulink are used in industry and education [mathworks.com/academia-user-stories](https://mathworks.com/academia-user-stories)

Find and install add-ons using Add-On Explorer [mathworks.com/add-on-explorer](https://mathworks.com/add-on-explorer)

Discover, create, and share MATLAB apps [mathworks.com/matlab-apps](https://mathworks.com/matlab-apps)

Find MATLAB and Simulink resources for research [mathworks.com/academia/research](https://mathworks.com/academia/research)

Teach with MATLAB and Simulink in primary and secondary schools [mathworks.com/primary-secondary](https://mathworks.com/primary-secondary)

## For Learning MATLAB and Simulink

Learn at your own pace with in-depth online course options [matlabacademy.com](https://matlabacademy.com)

Get started by taking a MATLAB and Simulink video tutorial [mathworks.com/tutorials](https://mathworks.com/tutorials)

Browse MATLAB and Simulink based books [mathworks.com/books](https://mathworks.com/books)

View on-demand webinars and videos [mathworks.com/academia/webinars](https://mathworks.com/academia/webinars)

Explore MathWorks supported student competitions [mathworks.com/student-competitions](https://mathworks.com/student-competitions)

## Join Our Online User Community

[matlabcentral.com](https://matlabcentral.com)

## Do You Need MATLAB and Simulink?

See all license options—including campus-wide, student, and home use [mathworks.com/academic-licenses](https://mathworks.com/academic-licenses)

## Do You Need Help Using MATLAB and Simulink?

For installation or technical help

[mathworks.com/support](https://mathworks.com/support)

### Connect to Hardware with MATLAB and Simulink

#### Hardware Connectivity – Support Packages

[mathworks.com/hardware](https://mathworks.com/hardware)

Download hardware packages for Arduino, Raspberry Pi, and LEGO.

#### Arduino Engineering Kit

[mathworks.com/arduino-kit](https://mathworks.com/arduino-kit)

Learn important engineering concepts while programming fun Arduino projects.

#### Live Data Streaming to and from Hardware

Directly receive and send real-world inputs and outputs from MATLAB and Simulink. Use for lab instruments, data acquisition systems, image and video acquisition and camera applications, audio streaming, and more.

#### Generating Code and Targeting Hardware

Automatically generate C, HDL, or PLC from your MATLAB and Simulink algorithms, and run them on microprocessors, FPGAs, and more.

#### Hardware Solutions include:

- iPhone and Android devices
- Drones
- Robots
- SDR



# Accelerate Learning and Research with MATLAB and Simulink

## MathWorks Licensing for Campus-Wide Use

At 6500 universities around the world, MATLAB and Simulink are used extensively in teaching, research, and student projects in engineering, science, business, medicine, and social sciences. More than 5 million students and faculty at over 1500 universities globally—including the 10 top-ranked universities—have unlimited access to MATLAB and Simulink through a Campus-Wide License.

### A Campus-Wide License provides:

- Unlimited use of MATLAB and Simulink products to all students, faculty, staff, and researchers, on and off campus, on any device
- A wide range of resources to support teaching, learning, and collaborative research
- Open access to scaling for MATLAB programs and Simulink simulations to clusters, clouds, and HPC centers

### These schools are among the thousands with a Campus-Wide License:

Aalborg University	Ohio State University	University of California
Carnegie Mellon University	Princeton University	Berkeley
Cornell University	RWTH Aachen University	University of Cambridge
École Centrale de Lyon	Sapienza Università di Roma	University of Melbourne
Georgia Institute of Technology	Seoul National University	University of Michigan
Johns Hopkins University	Stanford University	University of Oxford
KTH Royal Institute of Technology	Tokyo University of Science	University of Science and Technology of China
Lund University	Tsinghua University	University of Sydney
Massachusetts Institute of Technology	TU Eindhoven	University of Toronto
Mondragón Unibertsitatea	TU München	Vanderbilt University
	University of Applied Sciences Augsburg	

For students, knowing how to use MATLAB and Simulink opens the door to a wide range of disciplines and modeling methods. Each year, tens of thousands of new graduates enter the workforce with MATLAB and Simulink skills and experience. MATLAB is listed as a common skill among LinkedIn members with a technical background and is listed as a required skill in thousands of job postings.

*"With MATLAB, we are combining computer science theory and concepts with problem-solving in engineering. MATLAB is the one language that we want our students to use—the one that we all use in our classrooms."*

– Dr. James Craig, Georgia Institute of Technology

*"One advantage of teaching with MATLAB is that our students are exposed to a tool that is used in the commercial world. The quality of the learning materials delivered online and onsite was excellent, enabling me to focus on teaching analytics and working with students."*

– Dr. Daniel Hulme, University College London

### Campus-Wide Access to Online Training Courses

To support users of the Campus-Wide License, MathWorks offers campus-wide access to self-paced online courses. Interactive online courses and tutorials help students quickly learn MATLAB skills for the classroom and beyond. Self-paced online training courses provide faculty, researchers, and students with hands-on practice sessions and help universities introduce industry-standard tools into the curriculum.

*"When teaching with a flipped classroom, you cannot expect students to study on their own without proper tutorial materials and come to class prepared. The interactive MATLAB tutorials were perfect for engaging students and getting them up to speed quickly." – Dr. Yu-li Wang, Carnegie Mellon University*

Campus-wide training also gives visibility to MATLAB and Simulink features that can be used in many fields to increase productivity, support multidisciplinary projects, and enhance student skills.

Learn more: [mathworks.com/products/campus-wide-training](https://mathworks.com/products/campus-wide-training)

### Save Time with MATLAB Grader

MATLAB Grader makes it easier to include graded MATLAB assignments in your course.

With it, you can:

- Create assignments that require students to submit MATLAB code
- Set custom scoring rubrics and view detailed reports and learner analytics
- Automatically grade student work and provide instant feedback to improve learning
- Run web-based assignments in any learning environment

Learn more:

[mathworks.com/products/matlab-grader](https://mathworks.com/products/matlab-grader)

## Campus-Wide License Features

- Coverage for all faculty, staff, students, and researchers, on both university and personally owned devices
- Access on campus, in the lab and field, and at home, including off network
- Widest and most up-to-date array of products, supporting everything from introductory-level courses to advanced academic research
- Annual license that provides a more predictable cost model for budget planning
- One license, which eases license management and ensures software license compliance through central administration; it also integrates easily into bring-your-own-device (BYOD) programs
- Pricing proportional to the size of the student body, providing cost efficiencies per user

*“One of the great advantages of using MATLAB and Simulink in our research is that new team members can come up to speed quickly on the project. Further, the modular approach we took with our models enables group members to work independently on their respective modules and then assemble the modules into a complete system.”*

– Dr. Christian Hatzfeld, TU Darmstadt

## Onboarding Support

MathWorks has a dedicated Customer Success team to support you from license launch to campus-wide rollout and beyond.

MathWorks will work with you to prepare for license deployment, including license installation, federated identity management, and rollout across campus. All faculty, staff, and students will have self-serve access to software and resources through a MathWorks-hosted MATLAB portal.

Contact your MathWorks Account Representative to receive a price quote.

Learn more: [mathworks.com/campus-license](https://mathworks.com/campus-license)

## Scale MATLAB and Simulink Computations to Clusters, Clouds, and HPC Centers

With MATLAB Parallel Server, you can scale MATLAB programs and Simulink simulations to clusters, clouds, and HPC centers. The Campus-Wide License includes access to MATLAB Parallel Server and allows every user on campus to run an unlimited number of simultaneous workers (MATLAB computational engines) on clusters that run on university-owned hardware or cloud resources.

### Advantages for users

- Access cluster resources through a familiar MATLAB environment
- Run on multiple machines without algorithm changes
- Leverage preconfigured cloud clusters or local HPC resources

### Advantages for IT

- Provide open access to scaling for MATLAB and Simulink throughout campus
- Provide access to cluster resources through MATLAB and your existing scheduler
- Simplify license management with a central license that accommodates all clusters

Learn more: [mathworks.com/products/matlab-parallel-server/campus](https://mathworks.com/products/matlab-parallel-server/campus)

## Get Instant Access to MATLAB through Your Web Browser

With MATLAB Online, you can run the latest version of MATLAB, including features like App Designer and Live Editor, on the MathWorks Cloud through your web browser. MATLAB Online allows you to:

- Run MATLAB on any laptop, desktop, or Chromebook with no downloads, installations, or maintenance
- Store, manage, and access your MATLAB files anywhere
- Share your content and collaborate with others through direct sharing and publishing

Learn more:  
[mathworks.com/products/matlab-online](https://mathworks.com/products/matlab-online)