MATLAB EXPO 2017
Academic Faculty Focus Track
# Academic Faculty Focus Track

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Speaker</th>
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</thead>
<tbody>
<tr>
<td>11:45am – 12:15pm</td>
<td>Academic Keynote</td>
<td>Jim Tung, MathWorks Fellow</td>
</tr>
<tr>
<td>12:15 – 1:30pm</td>
<td>Effective Teaching Techniques using MATLAB and Simulink – Part 1</td>
<td>Prof. Arun Tangirala, IIT Madras</td>
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<tr>
<td>2:45 – 3:30pm</td>
<td>Effective Teaching Techniques using MATLAB and Simulink – Part 2</td>
<td>Prof. Arun Tangirala, IIT Madras</td>
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<tr>
<td>3:45 – 4:30pm</td>
<td>Leveraging MathWorks Resources for Academia</td>
<td>Dr. Viju Ravichandran, MathWorks</td>
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<tr>
<td>4:45 – 5:30pm</td>
<td>Building a Course Implementation Plan</td>
<td>Anuja Apte and Dr. Viju Ravichandran, MathWorks</td>
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MATLAB EXPO 2017

Computational Thinking:
Making an Impact on Engineering Education

Jim Tung
MathWorks Fellow
jim@mathworks.com
Industry Case Studies

Spectral Imaging: Breast Density Measurement Using Matlab Coder

Introduction

- The IFB group celebrates over four decades of technical excellence, leading technology solutions that have touched people’s lives.
- IFB launched first connected washing machine that can connect with smartphone via Bluetooth.

1989 - India’s First Front Load washing machine
2002 - India’s First Digital washing machine
2013 - India’s First Connected washing machine

Smart phone? Take Control!
IFB pioneering India from now
Scania Automatic Emergency Braking System

Sensor fusion
Two sensors -> One "truth"

Sensors have different advantages
- Radar
  - Range (longitudinal)
  - Relative velocity
  - Solid object reflection
    - No shapes
    - Lateral position
- Camera
  - Object type
  - Object width
  - Lateral position
  - Range
  - Optical illusions
Scania Automatic Emergency Braking System

80 km/h catching up on 30 km/h vehicle
Johns Hopkins Thought-controlled Prosthetic Arms

Combines
- Pattern recognition algorithms classify neural signals to movement
- Controls
- Virtual simulator for training
“Computational Thinking is the thought processes involved in formulating problems and their solutions … in a form that can be effectively carried out by an information-processing agent.”

- Cuny, Snyder, Wing
“Computational thinking will be a fundamental skill used by everyone by the middle of the 21st century…as fundamental as reading, writing and arithmetic.”

-Wing
Computational Thinking

A Thought Process to Formulate Problems and Solutions

Decomposition

Abstraction

Pattern Recognition

Algorithms
Computational Thinking: Making an Impact on Engineering Education

1. How can we teach **Computational Thinking** effectively in Higher Ed?

2. Can **Computational Thinking** be introduced earlier?

3. How can we prepare students so they can use **Computational Thinking** after they graduate?
The Computational Thinking Continuum

Higher Ed

Research and Industry

https://www.whitehouse.gov/sites/default/files/stem_11_final.pdf
How Can We Teach Computational Thinking?

Computational Thinking
Do students just “pick up” computational thinking?

Math Skills
Isn’t math taught systematically and reinforced throughout the curriculum?
How Math is Introduced in a 4-Year EE Curriculum?

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Chemistry</td>
<td>Humanities</td>
<td>Humanities</td>
<td>Micro-electronics</td>
</tr>
<tr>
<td>Intro to Engineering</td>
<td>Calculus I</td>
<td>Circuits</td>
<td>Semi-Conductors</td>
</tr>
<tr>
<td>Calculus I</td>
<td>Physics I</td>
<td>Algorithms</td>
<td>Controls</td>
</tr>
<tr>
<td>Programming</td>
<td>Physics II</td>
<td>Digital Systems</td>
<td>Electronics</td>
</tr>
<tr>
<td>Linear Algebra</td>
<td>Signals &amp; Systems</td>
<td>Signals &amp; Systems</td>
<td>Energy &amp; Power</td>
</tr>
<tr>
<td>Calculus II</td>
<td>Differential Equations</td>
<td>Electromagnetics</td>
<td>Embedded Systems</td>
</tr>
<tr>
<td>Calculus III</td>
<td>Numerical Methods</td>
<td>Statistics</td>
<td>Statistics</td>
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Core Math Courses:
- Calculus I
- Calculus II
- Calculus III
- Linear Algebra
How Math is Used in the Curriculum?

Core Math Courses

Courses applying Math
How Math is Introduced in the Curriculum?

- **Year 1**
  - Core Math Courses: General Chemistry, Intro to Engineering, Calculus I
  - Courses applying Math: Linear Algebra, Circuits, Programming

- **Year 2**
  - Core Math Courses: Physics I, Calculus II
  - Courses applying Math: Algorithms, Digital Systems, Signals & Systems

- **Year 3**
  - Core Math Courses: Humanities
  - Courses applying Math: Semi-Conductors, Electronics, Electromagnetics, Differential Equations

- **Year 4**
  - Core Math Courses: Micro-electronics, Controls, Energy & Power

- Students' cumulative Math proficiency increases throughout the curriculum.
How is Computational Thinking Introduced?

Year 1
- Humanities
- General Chemistry
- Intro to Engineering
- Calculus I

Humanities
- Circuits
- Physics I
- Programming
- Calculus II

Year 2
- Humanities
- Algorithms
- Physics II
- Linear Algebra
- Calculus III

Year 3
- Humanities
- Semi-Conductors
- Digital Systems
- Signals & Systems
- Differential Equations

Year 4
- Micro-electronics
- Controls
- Electronics
- Electromagnetics
- Numerical Methods

Year 1
- Technical Elective
- Technical Elective
- Technical Elective
- Technical Elective

Year 2
- RF & Optics
- Comm
- Capstone Design I

Year 3
- Energy & Power
- Embedded Systems
- Statistics

Year 4
- Capstone Design II
How is Computational Thinking Introduced?

Year 1
- General Chemistry
- Intro to Engineering
- Calculus I

Year 2
- Humanities
- Circuits
- Physics I
- Linear Algebra
- Calculus II

Year 3
- Humanities
- Algorithms
- Physics II
- Signals & Systems
- Calculus III

Year 4
- Micro-electronics
- Semi-Conductors
- Digital Systems
- Energy & Power
- Controls

- Technical Elective
- RF & Optics
- Comm

- Technical Elective
- Capstone Design I
- Technical Elective
- Capstone Design II

Computational Courses
### Year 1
- **General Chemistry**
- **Intro to Engineering**
- **Calculus I**

### Year 2
- **Humanities**
- **Physics I**
- **Programming**
- **Calculus II**
- **Linear Algebra**
- **Signals & Systems**
- **Calculus III**
- **Differential Equations**

### Year 3
- **Humanities**
- **Algorithms**
- **Semi-Conductors**
- **Electro-magnetics**
- **Engineering Methods**
- **Embedded Systems**
- **Statistics**

### Year 4
- **Humanities**
- **Controls**
- **Energy & Power**
- **RF & Optics**
- **Comm**
- **Capstone Design I**

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How is **Computational Thinking** Introduced?

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**Forgetting Curve**

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<table>
<thead>
<tr>
<th>Computational Courses</th>
<th>Students’ cumulative Computational proficiency</th>
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Should Computational Thinking be built up like we introduce Math?

Year 1
- General Chemistry
- Intro to Engineering
- Calculus I

Year 2
- Humanities
- Circuits
- Physics I
- Linear Algebra
- Calculus II

Year 3
- Humanities
- Algorithms
- Digital Systems
- Signals & Systems
- Differential Equations

Year 4
- Micro-electronics
- Semi- Conductors
- Electronics
- Electromagnetics
- Numerical Methods

Computational Courses

Courses using Computation

Students’ cumulative Computational proficiency
Integrated Curriculum for Computational Thinking

Year 1
- General Chemistry
- Intro to Engineering
- Calculus I
- Humanities
- Physics I
- Programming

Year 2
- Circuits
- Physics II
- Linear Algebra
- Calculus II
- Humanities
- Algorithms
- Digital Systems
- Signals & Systems
- Differential Equations

Year 3
- Humanities
- Semi- Conductors
- Electronics
- Electro- magnetics
- Numerical Methods
- Energy & Power
- Embedded Systems
- Statistics

Year 4
- Micro- electronics
- Technical Elective
- Technical Elective
- Technical Elective
- Technical Elective
- Technical Elective
- Technical Elective
- RF & Optics
- Comm
- Capstone Design I
- Capstone Design II

Students’ cumulative Computational proficiency

Courses using Computation
- Computational Courses
- Intro to Engineering
- Calculus I
- Physics I
- Programming
- Calculus II
- Humanities
- Physics II
- Linear Algebra
- Calculus III
- Humanities
- Algorithms
- Digital Systems
- Signals & Systems
- Differential Equations
- Humanities
- Semi- Conductors
- Electronics
- Electro- magnetics
- Numerical Methods
- Energy & Power
- Embedded Systems
- Statistics

MathWorks
Can we introduce Computational Thinking earlier?
i2- iINVENT and iNSPIRE

- i2- iINVENT and iNSPIRE
  - Worldwide camp at 50 locations
  - Expanding to middle schools

- Partners with leading STEM organizations, e.g.
  MIT Media Lab, Stanford, Woods Hole Oceanography, Bose, MathWorks
function song (pitch, speed)
    load('musicNotes');
    % Notes being used: G4 A4 G5 E5 F5 394.2 440 493.9 392 C4 D5
    % intro
    notes = [G4 A4 G4 A4 G5 E5 F5 394.2 440 493.9 392 C4 D5];
    % first verse
    notes2 = [G5 E5 F5 E5 D5 F5 G5 E5 E5 D5 G4 G5];
    % second verse same speed & pause as the intro
    notes3 = [394.2 440 493.9 392];
    % short scale, goes down at end
    notes4 = [G5 E5 G5 E5 D5 C4 G5 E5 D5 G5 E5 G5 E5 B5 D5];
    % slow
    notes5 = [E5 G5];
    % loops back to intro
    % final note, double past long notes in section 5
    notes6 = G5;
    % intro
    for k = 1:30
        % sineSound(notes(k)/pitch, 0.2/speed);
        board.playTone('D9', notes(k)/pitch, 0.2/speed);
        pause(0.2/speed)
        plot(notes)
    end
Computational Thinking in Primary and Secondary

“Programming in MATLAB teaches you how to think in a logical way”

Trinity High School, Indiana

French Engineering Olympiad
The Computational Thinking Continuum

Primary and Secondary

Higher Ed

Research and Industry
The Computational Thinking Continuum

Primary and Secondary

Higher Ed

Research and Industry

https://www.whitehouse.gov/sites/default/files/stem_11_final.pdf
BuildingIQ
Adaptive building energy management
BuildingIQ

25% cost reduction

Temperature

Comfort bounds

Temperature setpoint

actual temperature

24 °C

21 °C

0:00 8:00 18:00 0:00

TIME

Temperature

Comfort bounds

Temperature setpoint

actual temperature

24 °C

21 °C

0:00 8:00 18:00 0:00

TIME
Respiri
Cloud + Embedded Analytics
for wheeze detection and asthma management

Machine learning, pre-trained with 40,000 audio signals and voice prints

Find key characteristics and classify the wheeze

Windpipe sound capture and processing to clean up and reduce ambient noise
Internet of Things

BuildingIQ

Respiri
Internet of Things
ThingSpeak
IoT platform for students, makers, and industry

Edge Node development using Simulink and Raspberry Pi

Built-in MATLAB analysis
Tools for Computational Thinking

- Symbolic Computing
- Deep Learning
- Optimization
- Financial Modeling
- Image Processing
- Machine Learning
- Statistics
- Signal Processing
- Control Systems
- Language
- Apps
- Symbolic Computing
Computational Thinking: Making an Impact on Engineering Education

1. How do we help students develop Computational Thinking?
   ► Integrated Curriculum

2. How can we introduce Computational Thinking earlier?
   ► Primary and Secondary

3. How can we prepare students so they can use Computational Thinking after they graduate?
   ► Industry Tools and Technology
3 Questions to Consider

1. How should your courses and curriculum introduce and reinforce skills in computational thinking?

2. Are you and your colleagues engaging students in secondary schools in STEM?

3. Do you have the tools to support computational thinking in your research and teaching?
Partnering with MathWorks

Contact us
Visit us at www.mathworks.com
Questions