MATLAB EXPO

Digital Transformation in Education: Lightning Round

Dr. Will Greenwood, MathWorks

Prof. Rick Hill, University of Detroit Mercy

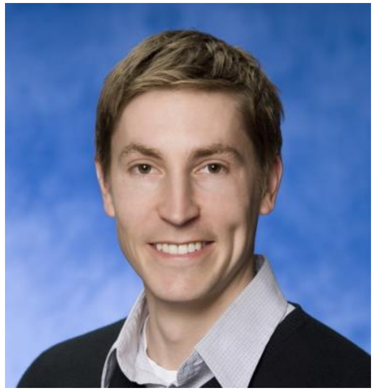
Prof. Ayse Tekes, Kennesaw State University

Prof. Kristopher Ray S. Pamintuan, Mapúa University

Prof. S. Rajakarunakaran, Ramco Institute of Technology

MathWorks

Digital Transformation in Education: Speakers



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Engaging Your Students with the MATLAB Live Editor

Rick Hill, Ph.D., Department of Mechanical Engineering

MATLAB EXPO

Characteristics of Teaching STEM

- Complex, mathematically dense
- Abstract – yet tied to the physical world
- Design and interpretation can be an “art”

↓

- Challenging to teach
- Challenging to keep students engaged

Engaging Your Students with the MATLAB Live Editor

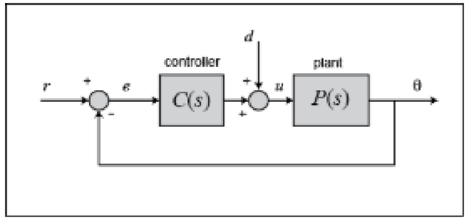
DC Motor Position: PID Controller Design

Key MATLAB commands used in this tutorial are: `tf` , `step` , `feedback`

From the main problem, the open-loop transfer function of the DC Motor is given as follows.

$$P(s) = \frac{\Theta(s)}{V(s)} = \frac{K}{s((Js+b)(Ls+R)+K^2)} \qquad \left[\frac{rad}{V}\right]$$

The structure of the control system has the form shown in the figure below.

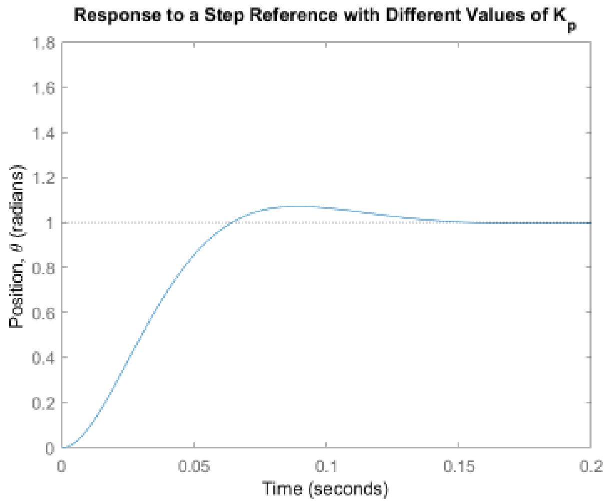


For the original problem setup and the derivation of the above equations, please refer to the DC Motor Position: System Modeling page.

Proportional control

We will begin by considering only the P term of our PID controller. In this situation, the applied control is *proportional* to the error of our controlled variable, the motor position. In the following, one can employ the slider to vary the gain K_p and observe the resulting effect on the system's closed-loop unit step response.

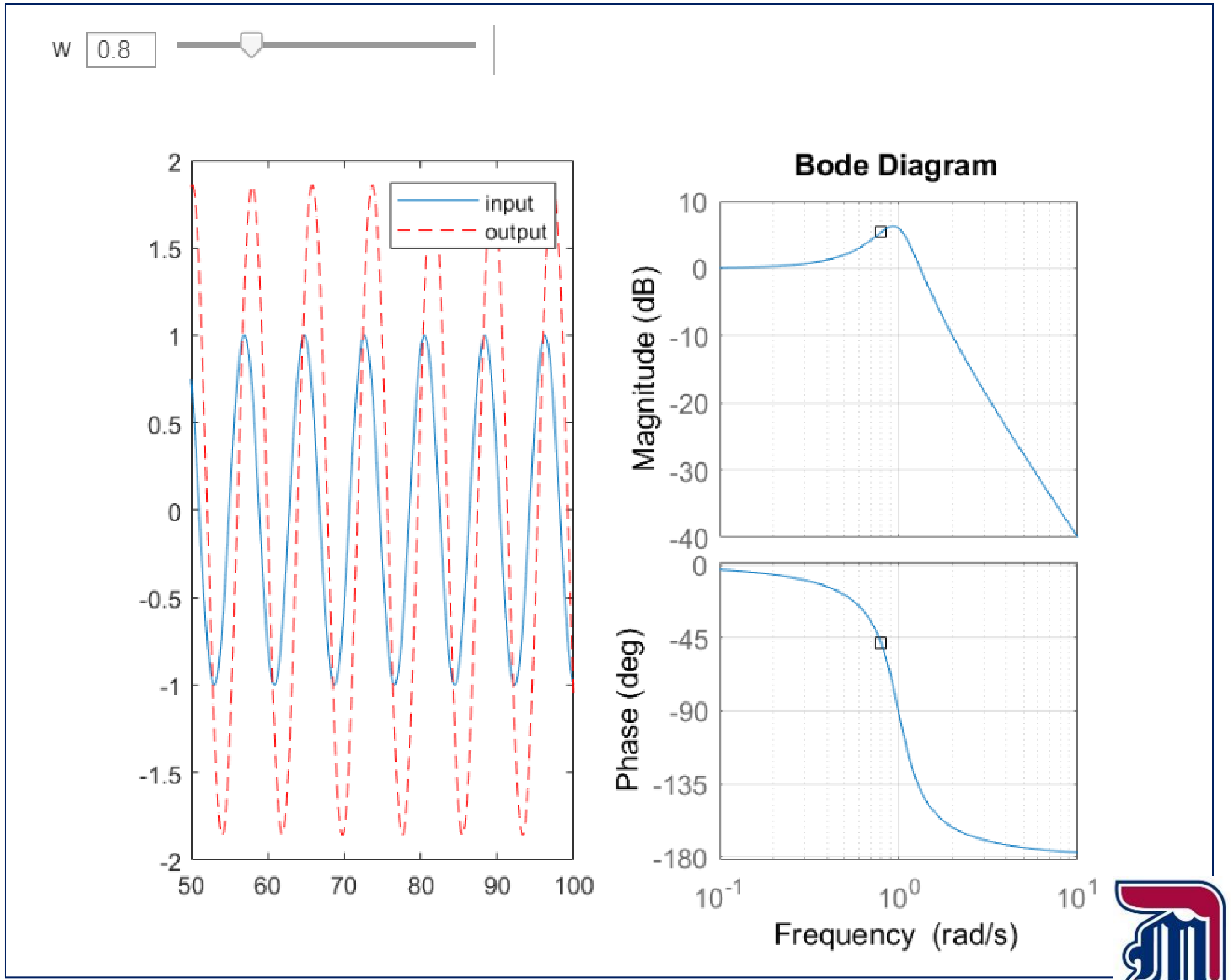
```
Kp = 1                ;
C = Kp;
sys_cl = feedback(C*P_motor,1);
t = 0:0.001:0.2; step(sys_cl,t)
ylabel('Position, \theta (radians)')
title('Response to a Step Reference with Different Values of K_p')
```



You should observe that the steady-state error is zero for all values of K_p. This is expected since the integrator in the plant makes the system type 1. Type 1

Demonstrating Concepts

- Make your lectures come alive
- Illustrate complex topics
- Easy to implement and customize



Demonstrating Concepts

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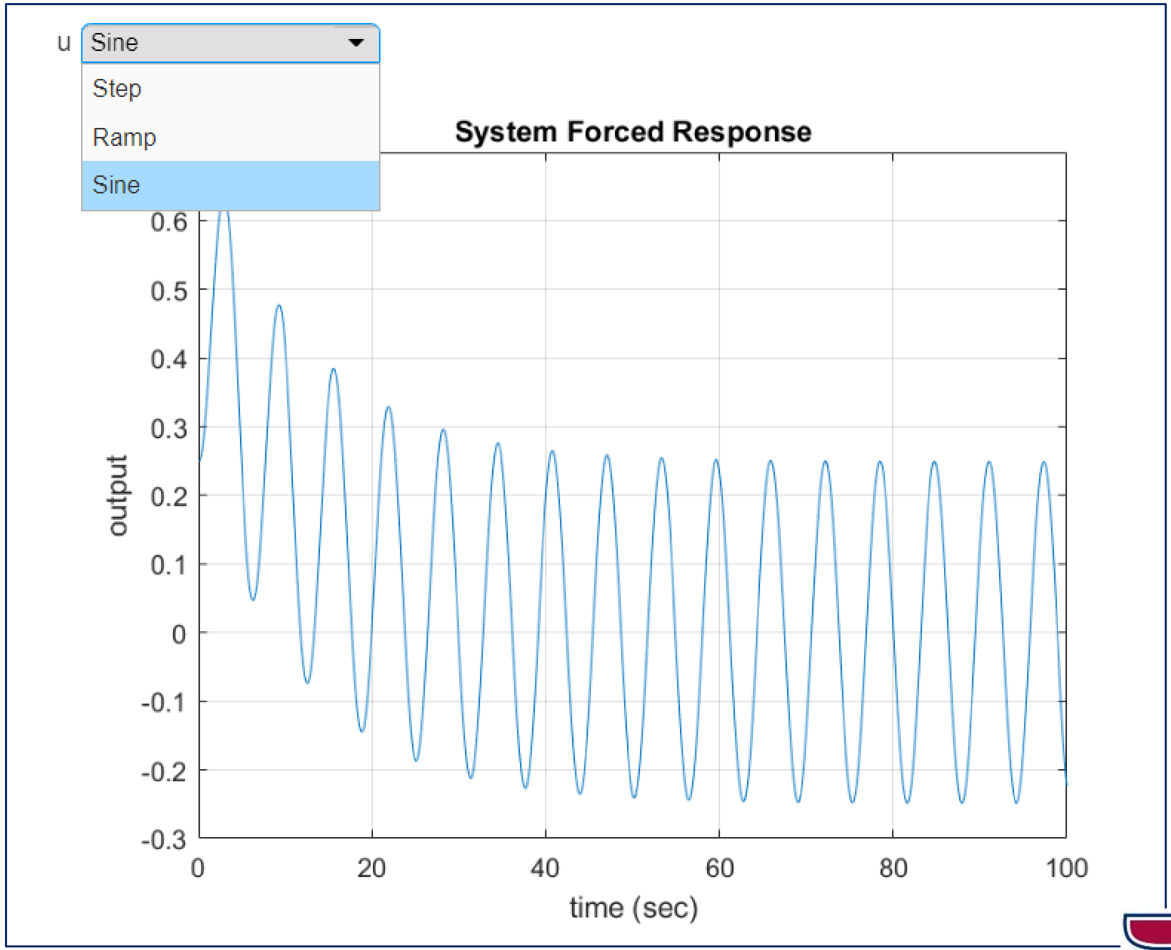
Inquiry-based Instruction

- Active learning is known to be effective
- Engage students in class
- Facilitate self-learning out of class



Inquiry-based Instruction

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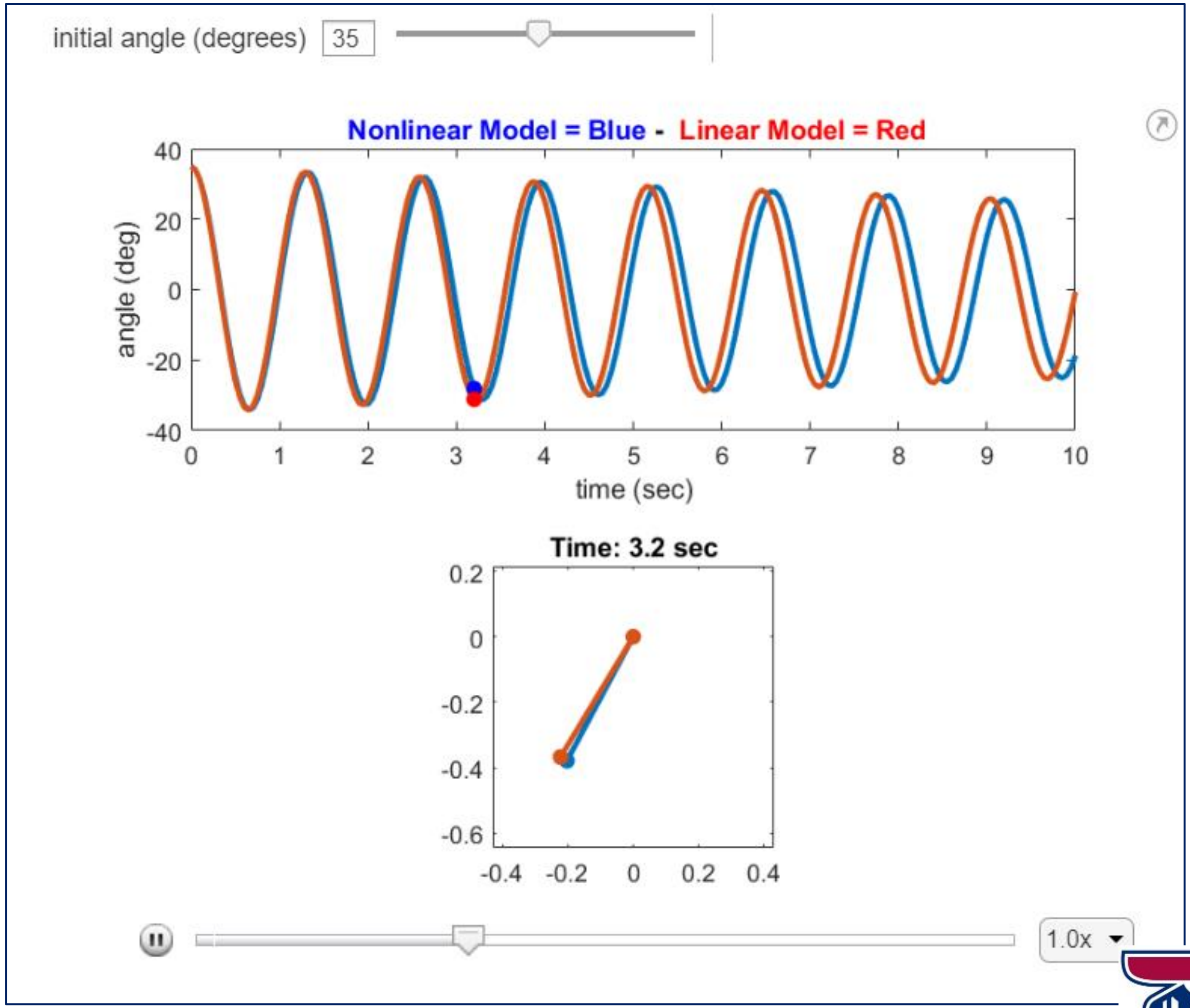
Virtual Laboratories

- Conduct experiments
- Include animations
- Can be used like simulation

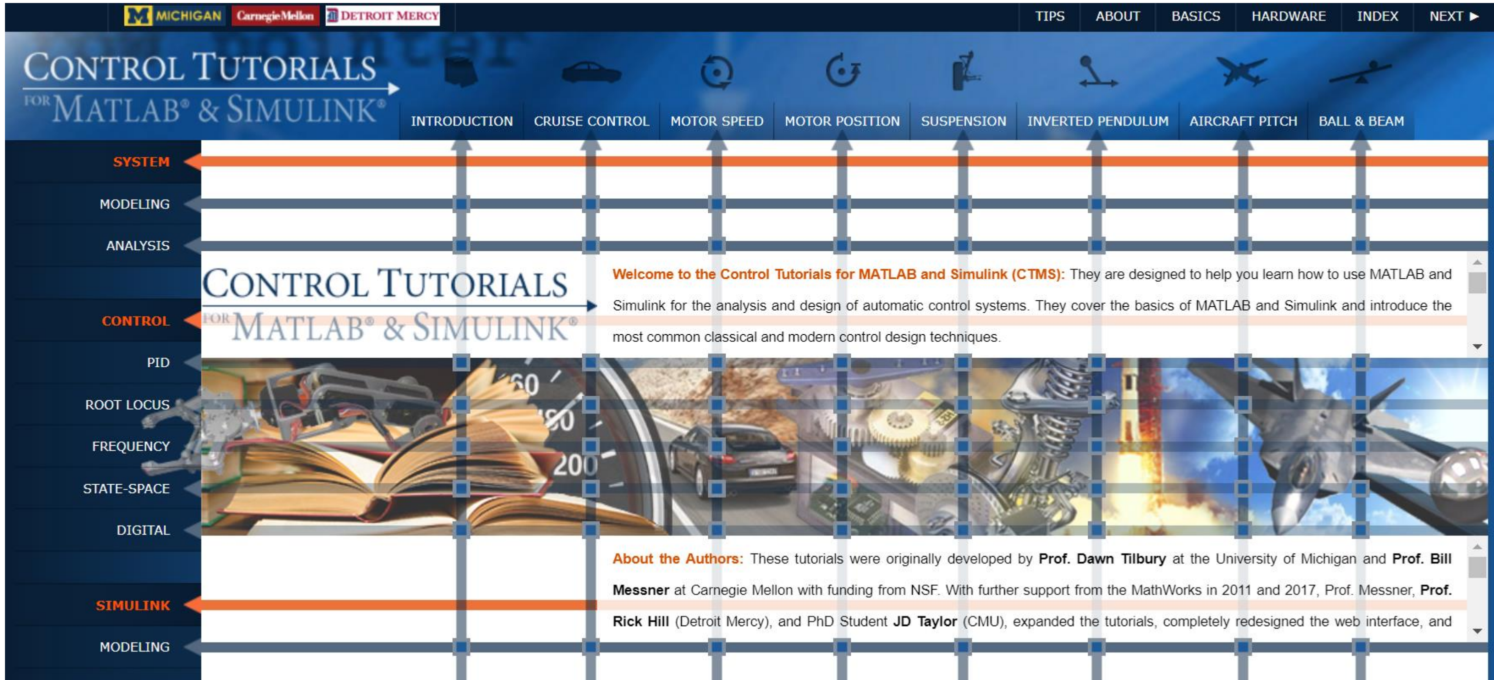


Virtual Laboratories

- Conduct experiments
- Include animations
- Can be used like simulation

Resources

- Interactive Live Script Control Tutorials for MATLAB
  - https://ctms.engin.umich.edu/
  - https://www.mathworks.com/campaigns/products/control-tutorials.html
- MathWorks website
  - Documentation
  - Examples
- MATLAB Central File Exchange



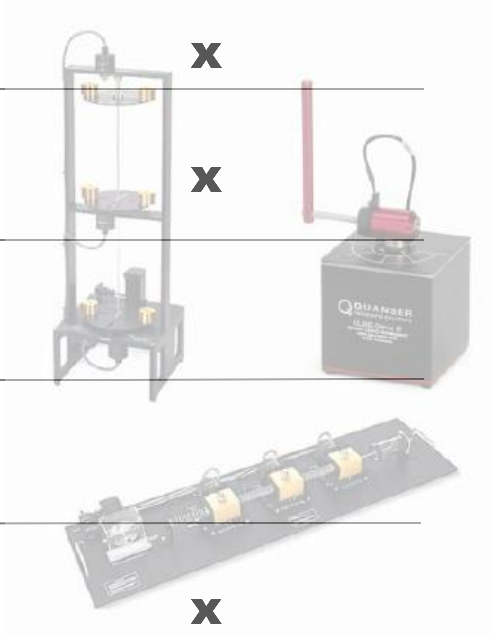
Advancing Student Learning of Engineering Courses Through Virtual Laboratories Developed in MATLAB Simscape

Dr. Ayse Tekes, Associate Professor

MATLAB EXPO

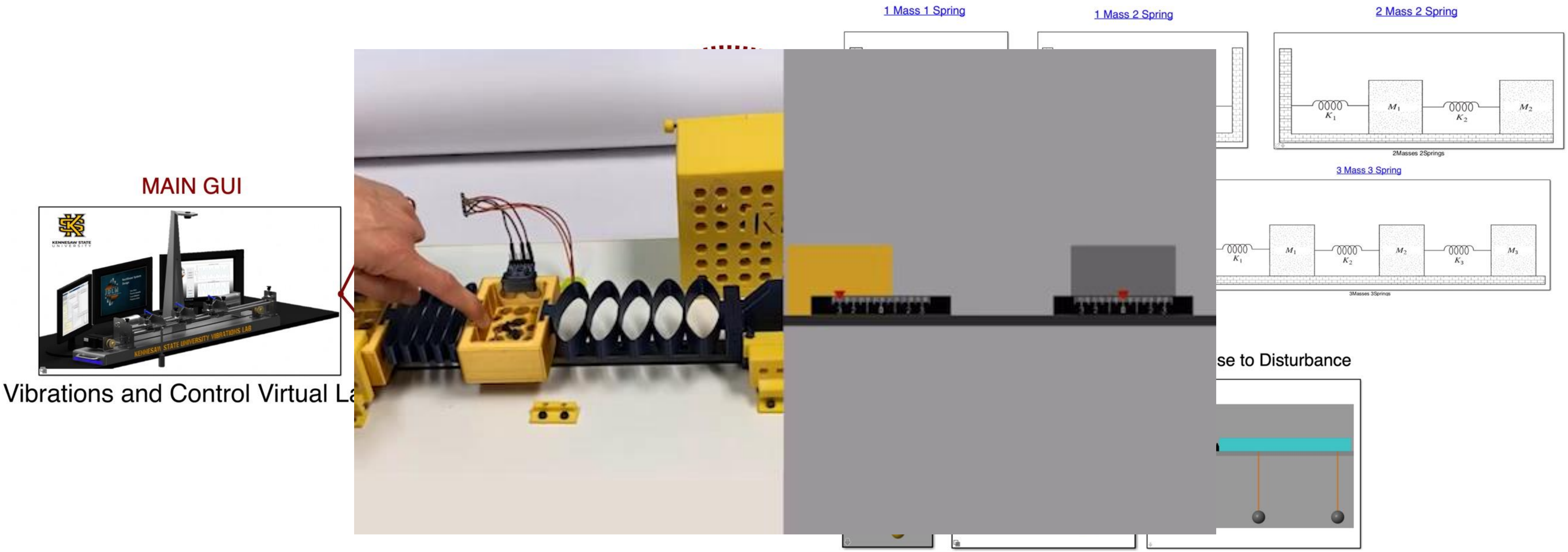
Challenges in Engineering Education

	Face to Face	Fully Online/Hybrid	Laboratories
Highly mathematical	x	x	x
Students struggle to fully comprehend the fundamentals	x	x	x
Little interaction with students	x	x	
Students are passive learners	x	x	
Improving student understanding require extra effort from faculty	x	x	x



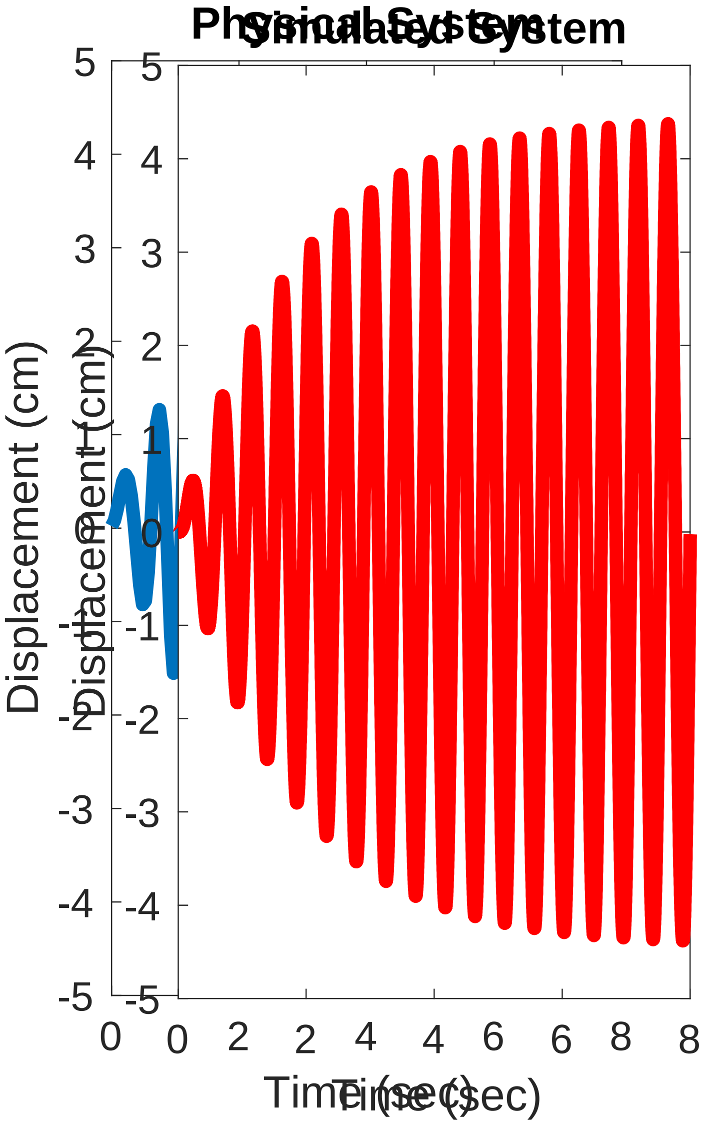
Costly, Bulky, Limited Portability

Virtual Laboratories as Educational Tools to Enhance Student Learning

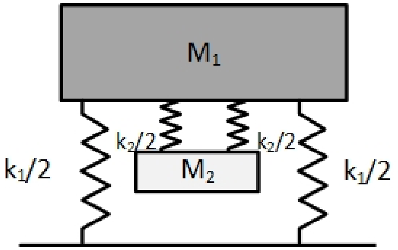


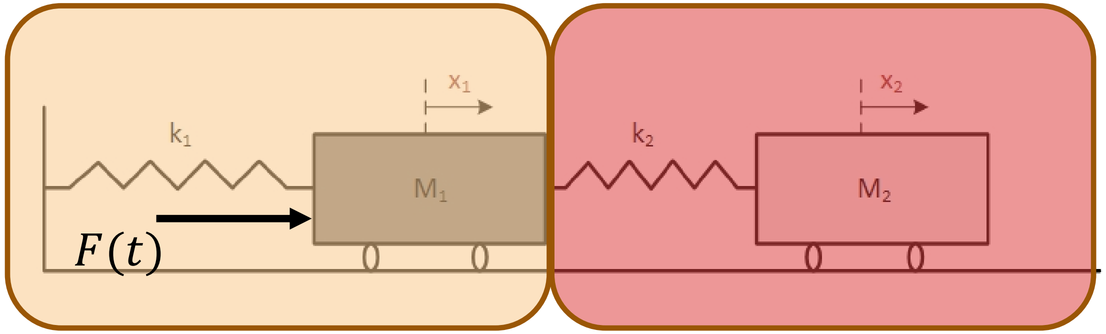
Using Hands-On and Virtual Labs Together

Example 1: Vibration Isolator Design



Theory: Vibration Isolator Design





Primary System

Secondary System

$$F(t) = A\sin(\omega t)$$

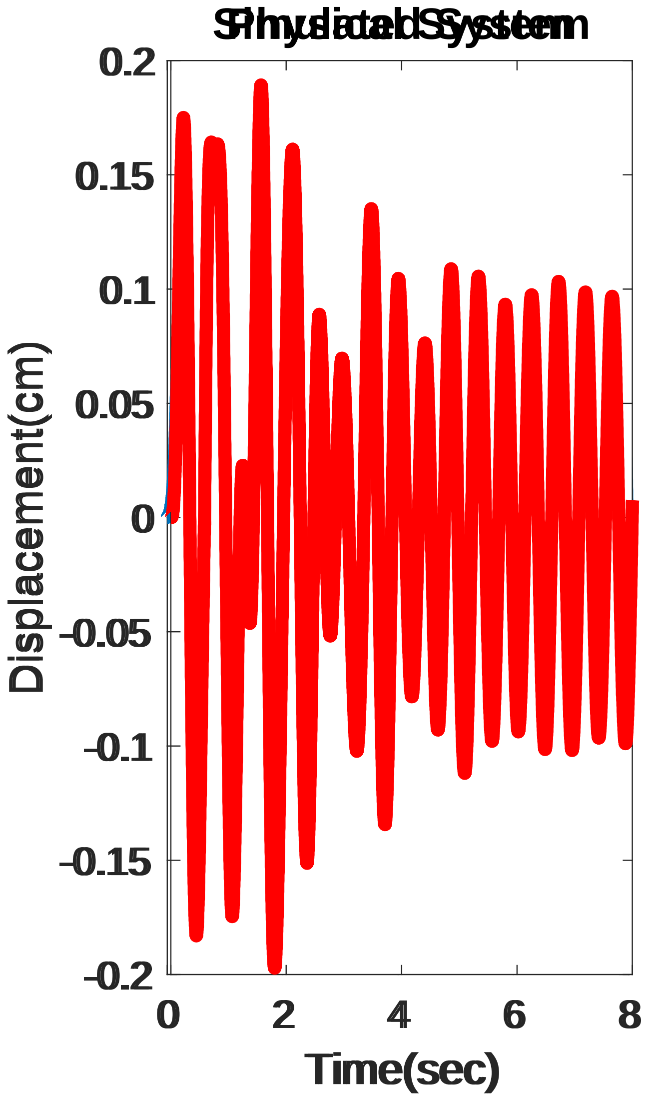
$$\omega = \omega_n$$

$$x_1(t) = \frac{F_0(k_2 - m_2 w^2)}{(k_1 + k_2 - m_1 w^2)(k_2 - m_2 w^2) - k_2^2}$$

$$x_2(t) = \frac{F k_2}{(k_1 + k_2 - m_1 w^2)(k_2 - m_2 w^2) - k_2^2}$$

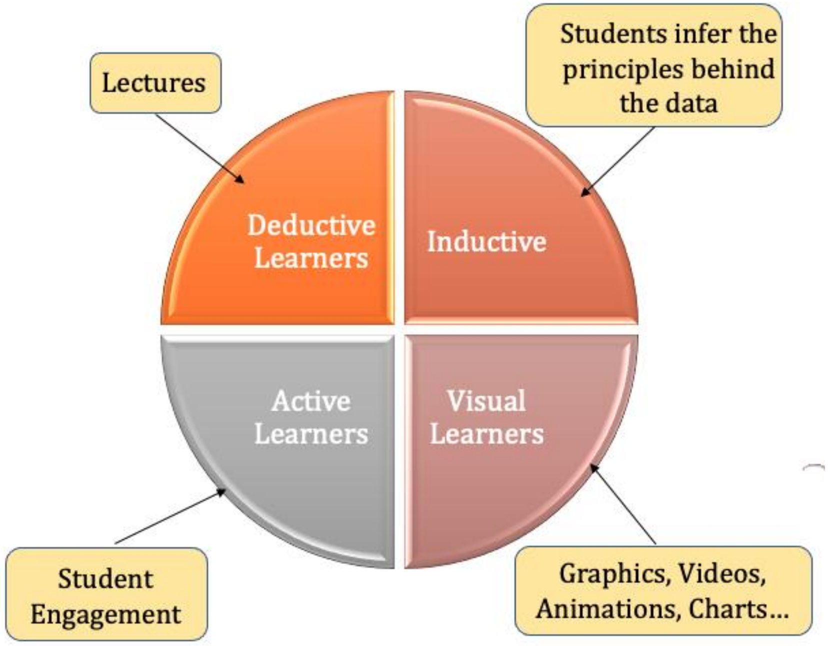
$$\frac{k_1}{m_1} = \frac{k_2}{m_2}$$

Example: Vibration Isolator Design



Key Takeaways

- Bridge the gap between theory and real-world applications
- Supports Kolb's 4 stages of learning
- Self-paced learning
- Face to face and remote learning



"It was really cool to see how frequencies and resonances can change within that little bit of tweak. In the app, there are a lot of things you visually see instead of being taught them theoretically."

"It greatly helps with visualizing different situations and understanding the concept behind vibratory motion and how each change effects the end result".

MATLAB App Designer as a supplementary tool for distance learning in ChE Laboratory courses

Kristopher Ray S. Pamintuan, PhD

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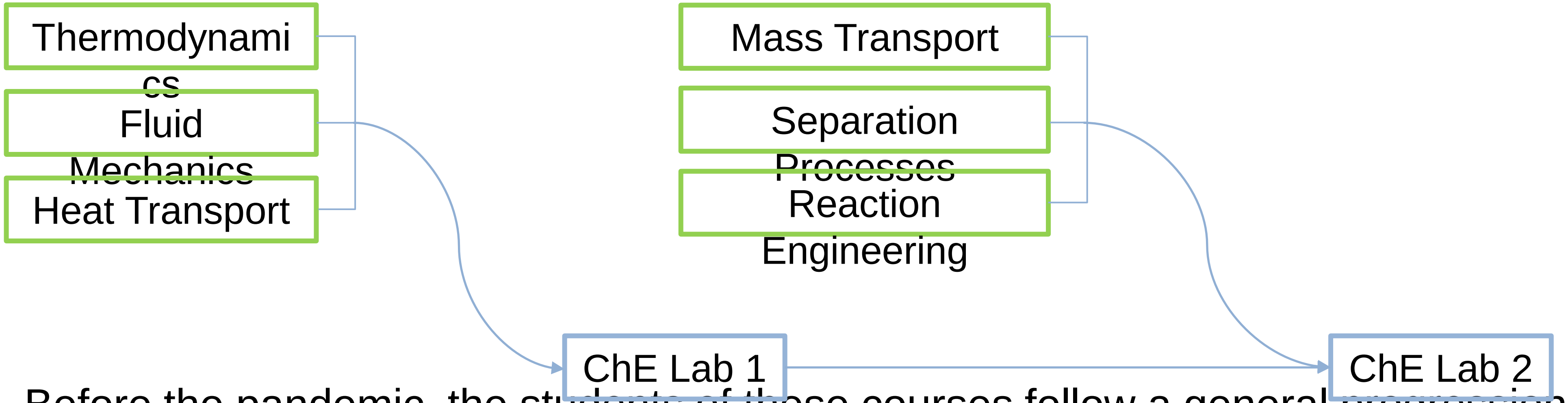
Mapua University, Philippines

Chemical Engineering Laboratory Courses

- These lab courses are taken after (or in parallel) with core ChE courses to supplement their theoretical understanding with tangible applications.



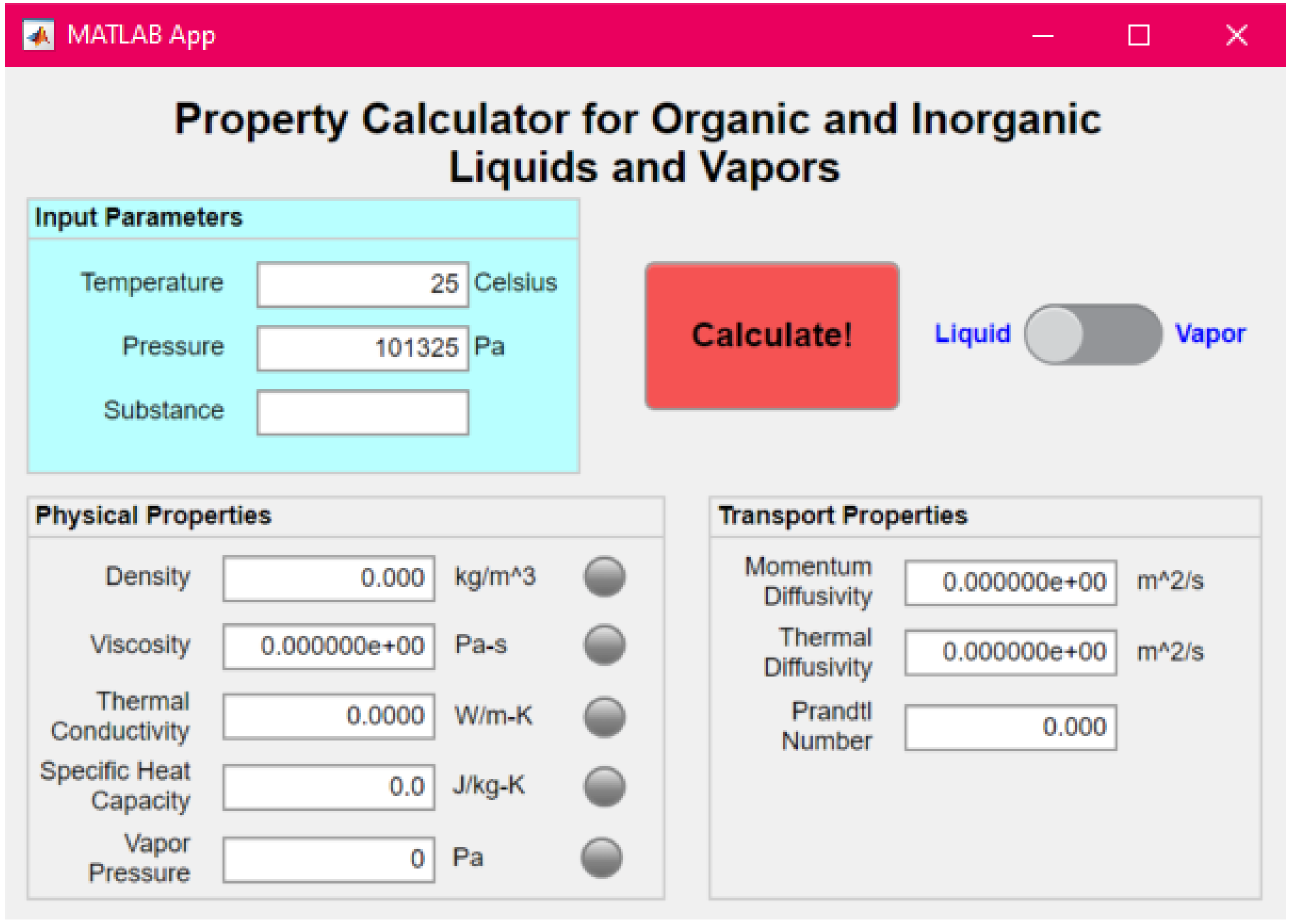
- Before the pandemic, the students of these courses follow a general progression of activities for every experiment:
  1. The students perform an experiment by group (guided by a lab manual)
  2. The students accomplish and submit a data sheet with values gathered from the experiment
  3. The instructor checks and validates the data collected
  4. The students prepare a lab report based on their data with interpretations

Distance Learning Challenges

- There's no doubt that distance learning is extra challenging for lab courses that rely on physical equipment to deliver course outcomes.
- One of the early solutions we adopted as a stopgap measure is the use of online virtual laboratories.
- There are some problems with using virtual labs for our courses:
  - Available topics and simulators are limited
  - Data gathering is limited to what is built into the simulator
  - Learning is limited to just clicking buttons

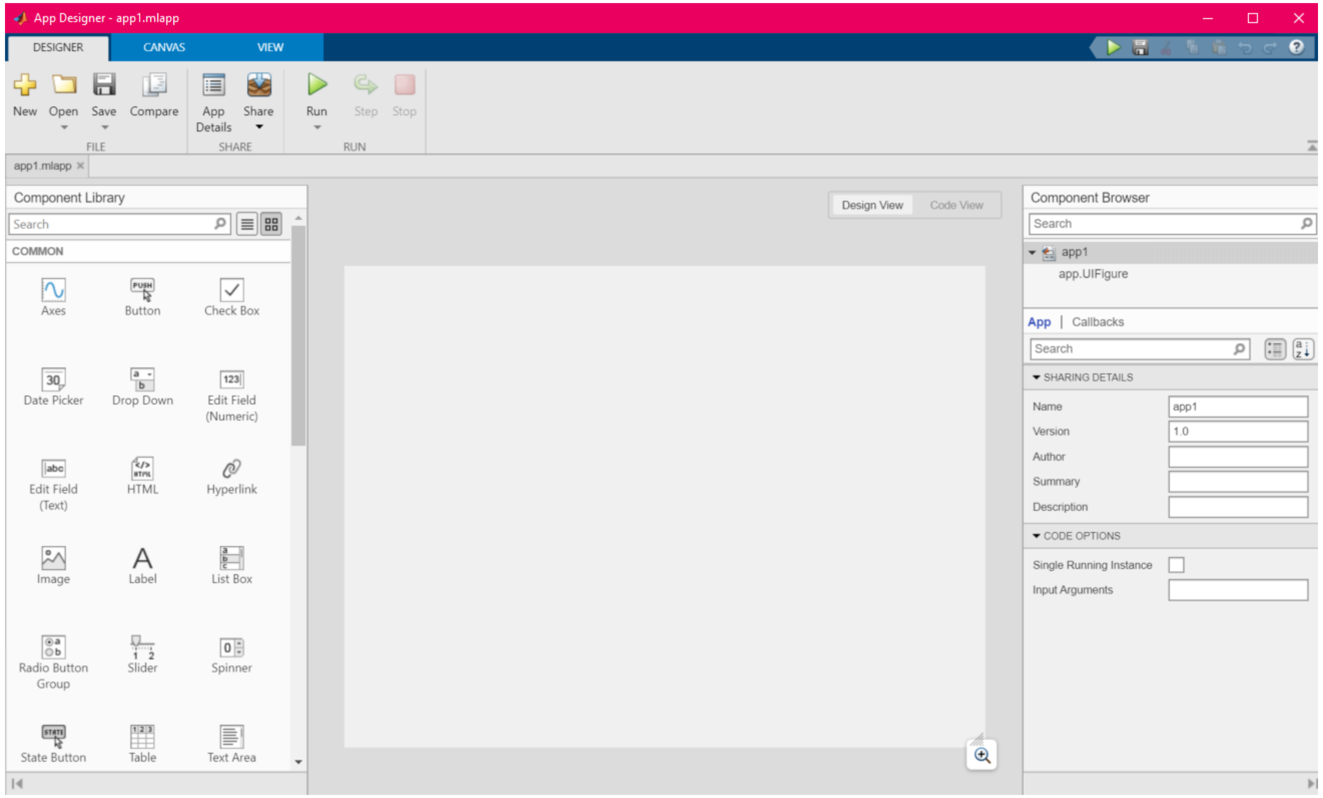
Experimental Design with App Designer

- I saw the opportunity to incorporate MATLAB App Designer in the syllabus when I got to try it out of curiosity.
- I only have limited programming skills and have no experience building apps, yet I managed to create a functional app in less than a day.
- App Design solves two problems at once:
  - Attainment of outcomes
  - Lack of variety in virtual labs



Experimental Design with App Designer

- One of the most useful feature of App Designer is the ability to drag and drop components from a library straight to the build area
- The user can immediately visualize what the app would look like
- Afterwards, basic MATLAB code is applied to the components to make them work together.
- This is a good tool for experimental design since the students can express their creativity in delivering information to the user.



Challenges

- Students need to have at least an intermediate skill in MATLAB programming
- Some need constant supervision while others are fully independent
- Some do not exercise their creative freedom
- Advanced programming knowledge is needed to create apps for certain topics (i.e. multidimensional transient heat and mass transport)

These challenges are being continuously addressed.

Conclusions

- It is possible to enhance delivery while still attaining course outcomes by integrating App Design in the course.
- The challenges are continuously addressed as this is still a relatively new implementation.

The Impact of MATLAB & Simulink in Teaching and Learning Process for Enhancing the Effectiveness of Teachers and Students of Mechanical Engineering

Prof.S.Rajakarunakaran, Ramco Institute of Technology, Rajapalayam, Tamilnadu, India

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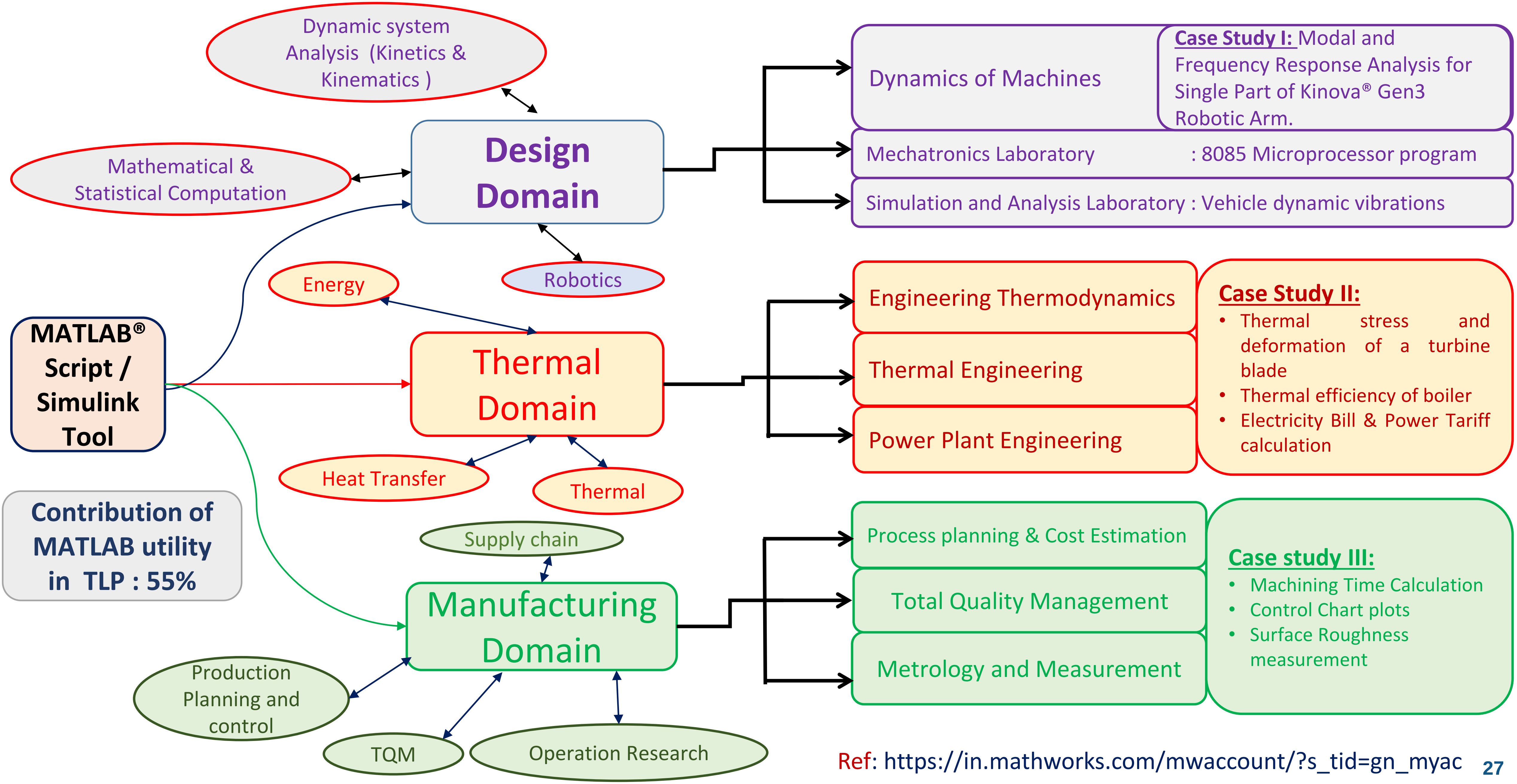
Teaching Learning Process – Potential applications in Mechanical Engineering courses



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CASE STUDY – I : Modal and Frequency Response Analysis for Single Part of Kinova® Gen3 Robotic Arm

1. PROBLEM STATEMENT

Analyze the shoulder link of a Kinova® Gen3 Ultra lightweight robotic arm for possible deformation under pressure. Loads at the tips of robotic arm cause pressure on the joints of each link. The direction of pressure depends on the direction of the load.

Source: https://www.kinovarobotics.com/product/gen3-lite-robots

OBJECTIVES

1. To know the working principle of Kinova® Gen3 Ultra light weight robotic arm.
2. To learn the steps, how to analyse & simulate the mechanism using MATLAB ® FEM Tools

OUTCOMES

After solving the problem, the students will be able to,

Cognitive Domain:

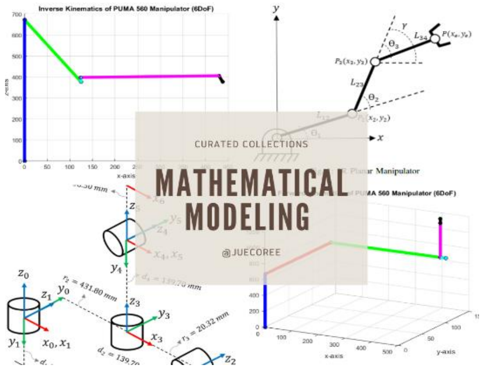
1. Analyse the Kinova® Gen3 ultra light weight robotic arm shoulder link using MATLAB ® FEM Tools.
2. Calculate the deformation of the shoulder link under the applied pressure by performing modal analysis and frequency response analysis simulation.

Psychomotor Domain:

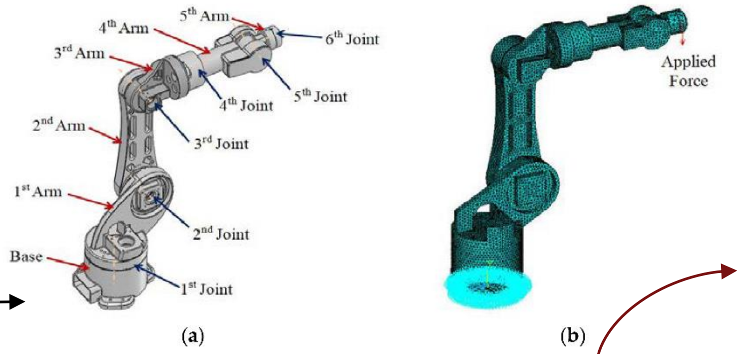
1. Reproduce the input process parameters to generate an optimal output of the shoulder link mechanism.

2. CHALLENGES

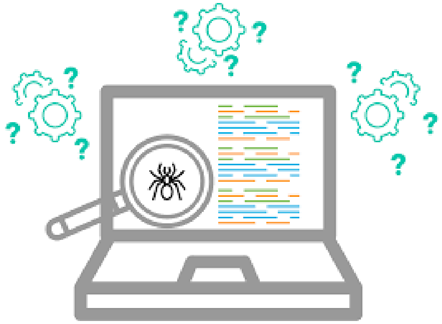
Mathematical modeling



Optimal Design



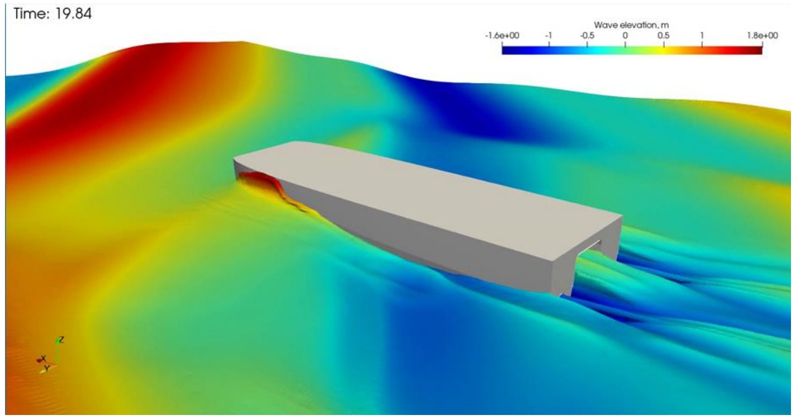
Debugging.

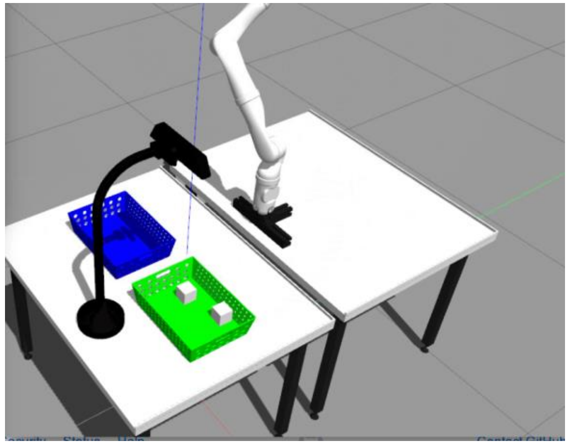


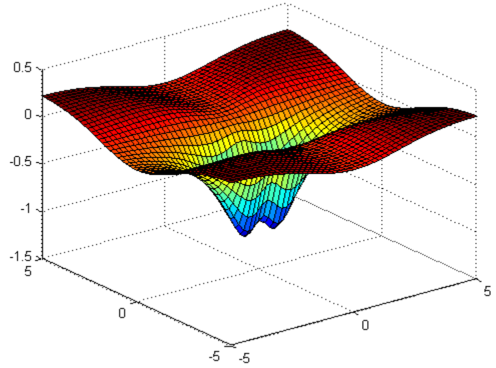
Solving Multivariable variable problems

Extractions of results (Image/Graph/Visualization)

Computational Analysis

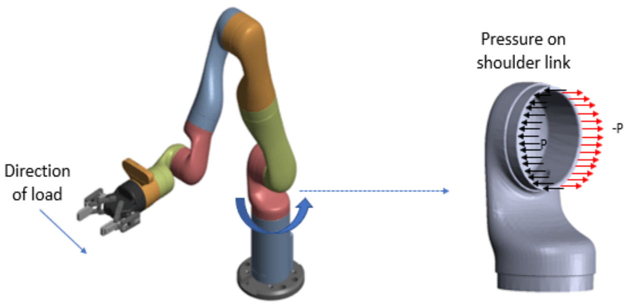




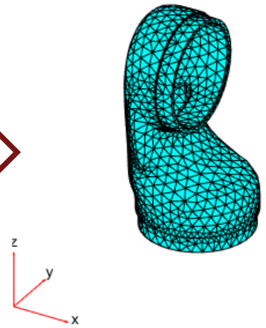


3. Solution

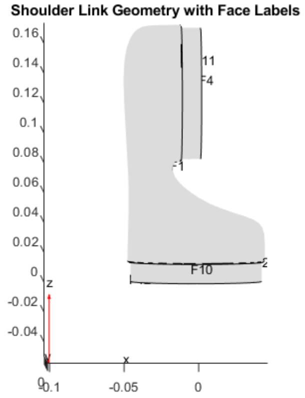
Direction of pressure - Direction of load.



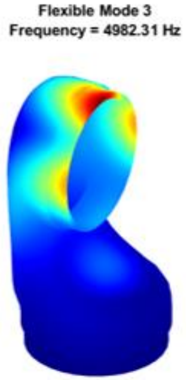
Structural model for modal analysis



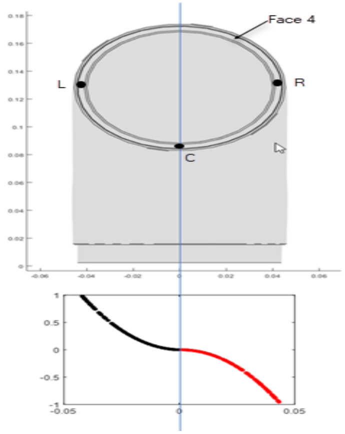
Modal Analysis

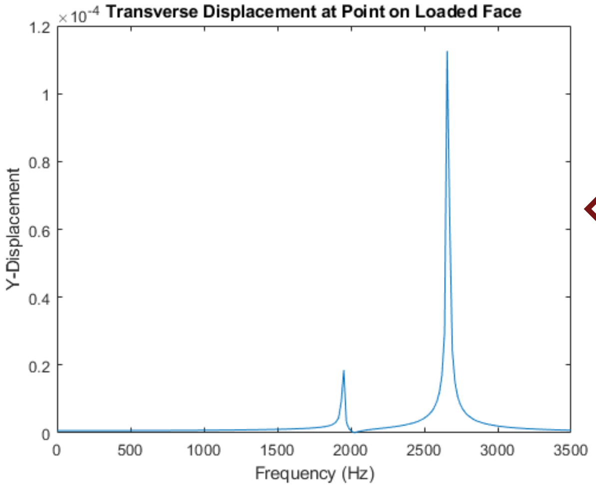


Harmonic motion

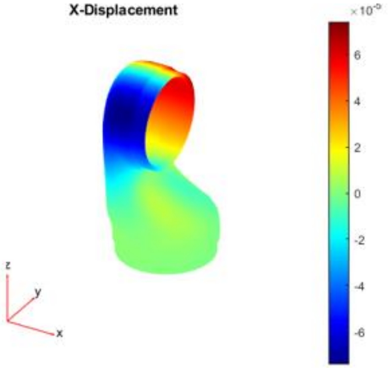


Moving link applied on face 4





Deformation at the Peak Response Frequency



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Case Study: Experiential Findings

Key Takeaway

1. Conventional approach

- Difficult to solve complex 3D geometry.
- Manual Calculations

2. Modern Tool approach (MATLAB®)

- Solving with FEM tools with PDEs library.

3. Learning Outcome

- Higher: Order Level of learning
- Skills: Cognitive & Psychomotor domain

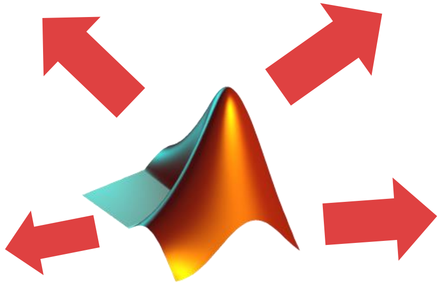
Assess: Engineering Graduate Attributes

- Conduct investigations of complex problems
- Modern tool usage

Advantages of MATALB usage in Teaching Learning Process

Arouses curiosity

Promotes value addition



Upskill real-world problems

Exposes to new trends

Impact of MATLAB Applications in Teaching Learning Process

- Enhances active learning through
  i. Problem-based learning
  ii. Project-based learning
  iii. Product-based learning
- Promotes integrative learning
- Encourages evaluative learning
- Nurtures creative learning
- Assist to create tangible products.
- Develops lifelong learning.

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Thank you

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