



# RAMCO INSTITUTE OF TECHNOLOGY

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NBA Accredited UG Programs: CSE, EEE, ECE and MECH

Department of Mechanical Engineering

Academic Year 2021 – 2022 (Even Semester)

|                               |   |                                                                                                                                                                                                                                                                                                                                                                                          |
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| <b>Name of the Faculty</b>    | : | Dr.S.Rajakarunakaran, Professor & Head/Mech<br>Dr.V.Siva Kumar, Assoc.Prof./Mech<br>Dr. J.Jerold John Britto AP(Sr.Gr.)/Mech<br>Mr.R.Venkatesh, AP/Mech                                                                                                                                                                                                                                  |
| <b>Course Code and Title</b>  | : | ME8492 Kinematics of Machinery<br>ME8693 Heat and Mass Transfer<br>ME8692 Finite Element Analysis<br>ME8711 Simulation and Analysis Laboratory                                                                                                                                                                                                                                           |
| <b>Year and Branch</b>        | : | II,III,IV-Mechanical                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Unit/ Topic</b>            | : | Basic kinematic concept, velocity and acceleration analysis of simple mechanisms, Kinematic Inversions, Phase change Heat Transfer and Heat Exchangers, Element types, Two Dimensional scalar and vector variable problems, Mechanism simulation using Multibody dynamics, Use of Matlab to solve simple problems in vibration.                                                          |
| <b>Course Outcome</b>         | : | Demonstrate proficiency in mathematical modeling, computational analysis, and modern tools like MATLAB & Simulink, applying them to solve complex problems in mechanical engineering, as exemplified in the analysis of Kinova® Gen3 robotic arm's shoulder link for deformation under pressure and other related topics such as kinematics, heat transfer, and finite element analysis. |
| <b>Topic Learning Outcome</b> | : | Demonstrate proficiency in mathematical modeling, optimal design, and computational analysis using MATLAB & Simulink, as evidenced by their                                                                                                                                                                                                                                              |



|                                    |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
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|                                    |   | successful application in modal and frequency response analysis of the Kinova® Gen3 Robotic Arm, fostering enhanced problem-solving skills and engineering graduate attributes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Activity Chosen</b>             |   | Theory and Practice with MATLAB & Simulink: Advanced Robotics and Mechanical Analysis                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Time Allotted for Activity</b>  | : | 5 minutes presentation of the above activity at MATLAB EXPO 2022®                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Date of the activity</b>        | : | 18.05.2022                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>No.of Students participated</b> | : | International Participation All over the World                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Justification</b>               | : | <p>The integration of MATLAB and Simulink in the teaching and learning process within mechanical engineering, particularly in the case study focused on the Kinova® Gen3 robotic arm, offers significant advantages for both teachers and students. The challenges posed by mathematical modeling, optimal design, debugging, computational analysis, and the extraction of results are effectively addressed through the modern tools provided by MATLAB and Simulink. In the context of the experimental findings related to the shoulder link deformation under pressure, these tools enable a comprehensive approach encompassing structural modeling for modal analysis, harmonic motion simulations, and the evaluation of deformation at peak response frequencies. The use of MATLAB aids in solving multivariable problems, providing a practical and efficient solution for complex engineering scenarios. This approach not only enhances the understanding of theoretical concepts in courses such as Kinematics of Machinery, Heat and Mass Transfer, and Finite Element Analysis but also equips students with valuable skills in computational analysis and simulation, aligning with the essential attributes of engineering graduates in the</p> |



|                                  |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
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|                                  |   | <p>modern era. Through the incorporation of these tools, the learning outcomes are enriched, ensuring that students are well-prepared to tackle real-world engineering challenges with a combination of theoretical knowledge and hands-on computational skills.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Details of Implementation</b> | : | <p>The case study presented by Dr. S. Rajakarunakaran focuses on the application of MATLAB and Simulink in analyzing the shoulder link of a Kinova® Gen3 Ultra lightweight robotic arm for possible deformation under pressure. The study encompasses various aspects such as mathematical modeling, optimal design, debugging, computational analysis, extraction of results, and solving multivariable problems. The challenges and solutions are outlined as follows:</p> <p><b>Challenges:</b></p> <ol style="list-style-type: none"> <li><b>1. Mathematical Modeling:</b> <ul style="list-style-type: none"> <li>• Develop a mathematical model to represent the behavior of the robotic arm's shoulder link under pressure loads.</li> </ul> </li> <li><b>2. Optimal Design:</b> <ul style="list-style-type: none"> <li>• Optimize the design of the shoulder link to ensure minimal deformation while maintaining structural integrity.</li> </ul> </li> <li><b>3. Debugging:</b> <ul style="list-style-type: none"> <li>• Identify and address any errors or issues in the model or simulation process using MATLAB and Simulink.</li> </ul> </li> <li><b>4. Computational Analysis:</b> <ul style="list-style-type: none"> <li>• Perform complex computational analyses to simulate the effects of pressure loads on the shoulder link.</li> </ul> </li> <li><b>5. Extraction of Results:</b></li> </ol> |



- Extract meaningful results from the simulations for further analysis and interpretation.

#### **6. Solving Multivariable Problems:**

- Address the challenges posed by the multivariable nature of the problem, considering various factors influencing the shoulder link deformation.

#### **Solutions:**

##### **1. Direction of Pressure:**

- Define the direction of pressure exerted on the shoulder link based on the load applied to the robotic arm's tips.

##### **2. Structural Model for Modal Analysis:**

- Develop a structural model suitable for modal analysis, considering the material properties and geometry of the shoulder link.

##### **3. Modal Analysis:**

- Utilize modal analysis techniques in MATLAB to study the natural frequencies and mode shapes of the shoulder link.

##### **4. Harmonic Motion:**

- Simulate harmonic motion to understand the dynamic response of the shoulder link under varying frequencies.

##### **5. Deformation at Peak Response Frequency:**

- Analyze the deformation of the shoulder link at its peak response frequency to identify potential areas of concern.

##### **6. Moving Link Applied on Face 4:**



- Investigate the effects of a moving link applied to face 4 of the shoulder link, considering different loading scenarios.

#### **Case Study:**

##### **1. Experimental Findings:**

- Compare the results obtained through conventional approaches with those achieved using modern tools like MATLAB and Simulink.

##### **2. Modern Tool Approach:**

- Highlight the advantages and efficiency gained by employing MATLAB and Simulink in comparison to traditional methods.

##### **3. Learning Outcome:**

- Discuss the educational benefits for students, emphasizing the development of skills in mathematical modeling, computational analysis, and problem-solving.

##### **4. Engineering Graduate Attributes:**

- Showcase how the case study contributes to the development of essential attributes in mechanical engineering graduates.

#### **Relevant Courses:**

##### **1. ME8492 Kinematics of Machinery:**

- Integrate kinematic concepts to analyze the robotic arm's motion and understand its mechanical behavior.

##### **2. ME8693 Heat and Mass Transfer:**



|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
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|  | <ul style="list-style-type: none"> <li>Consider the effects of heat transfer in the structural analysis of the shoulder link.</li> </ul> <p><b>3. ME8692 Finite Element Analysis:</b></p> <ul style="list-style-type: none"> <li>Apply finite element analysis techniques to model and simulate the deformation of the robotic arm's shoulder link.</li> </ul> <p><b>4. ME8711 Simulation and Analysis Laboratory:</b></p> <ul style="list-style-type: none"> <li>Highlight the importance of simulation tools like MATLAB and Simulink in practical engineering analysis.</li> </ul> <p><b>Presentation at MATLAB EXPO 2022:</b></p> <ul style="list-style-type: none"> <li><b>Date:</b> 18.05.2022</li> <li><b>Presenter:</b> Dr. S. Rajakarunakaran, Professor and Head/Mech</li> </ul> <p><b>Key Components for Implementation:</b></p> <p><b>1. Mathematical Modeling:</b></p> <ul style="list-style-type: none"> <li>Utilize MATLAB for developing and validating the mathematical model.</li> </ul> <p><b>2. Simulations:</b></p> <ul style="list-style-type: none"> <li>Perform simulations using Simulink to analyze the structural response of the shoulder link.</li> </ul> <p><b>3. Data Extraction:</b></p> <ul style="list-style-type: none"> <li>Use MATLAB for extracting and processing simulation results for further analysis.</li> </ul> <p><b>4. Comparative Analysis:</b></p> <ul style="list-style-type: none"> <li>Present a comparative analysis of the conventional and modern tool approaches.</li> </ul> <p><b>5. Educational Impact:</b></p> |
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|  | <ul style="list-style-type: none"><li>• Discuss how the implementation enhances the teaching and learning process for students.</li></ul> |
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**6. Global Exposure:**

- Highlight the international exposure gained by presenting at MATLAB EXPO 2022 with the involvement of international delegates.

By combining theoretical knowledge with practical implementation using MATLAB and Simulink, this case study contributes to the effective teaching and learning of mechanical engineering concepts, providing students with valuable skills for real-world applications.



PO/PSO mapping for the activity

| Course Outcome /Programme Outcome | PO1                                              | PO2                                                          | PO3                                       | PO4                                                           | PO5                                                              | PO6                                                            | PO7                                                                   | PO8                                                           | PO9                                                                 | PO10                                                      | PO11                                                      | PO12                                                    | PSO1                                                                       |
|-----------------------------------|--------------------------------------------------|--------------------------------------------------------------|-------------------------------------------|---------------------------------------------------------------|------------------------------------------------------------------|----------------------------------------------------------------|-----------------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------------------|---------------------------------------------------------|----------------------------------------------------------------------------|
| Level of Mapping                  | 3                                                | 2                                                            | 3                                         | 2                                                             | 3                                                                | 1                                                              | 1                                                                     | 2                                                             | 2                                                                   | 2                                                         | 2                                                         | 1                                                       | 1                                                                          |
| Justification for correlation     | ME8492 Kinematic s of Machinery, ME8693 Heat and | Case Study: Modal and Frequency Response Analysis for Kinova | Case Study: Optimal Design of Kinova Gen3 | Case Study: Experimental Findings, Comparison of Conventional | Use of MATLAB and Simulink in Computational Analysis, Debugging, | Consideration of the impact of robotic arm analysis on society | Consideration of environmental factors in the Kinova Gen3 robotic arm | Consideration of ethical aspects in the design and analysis s | Collaborative work in the analysis s of the Kinova Gen3 robotic arm | Presentation at MATLAB EXPO 2022, International Delegates | Management of the analysis is project for the Kinova Gen3 | Learning outcomes from the case study, continuous impro | Mechanical Engineering program integrates MATLAB B & Simulink tools across |



|                                                                                          |                                                                                                        |                                                  |                            |                           |            |          |         |  |  |             |                                            |                                                                                                                                                                                                  |
|------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|--------------------------------------------------|----------------------------|---------------------------|------------|----------|---------|--|--|-------------|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mass Transfer, ME8692 Finite Element Analysis, ME8711 Simulation and Analysis Laboratory | Gen3 Robotic Arm, Challenges in Mathematical Modeling, Optimization Design, and Computational Analysis | Robotic Arm, Structural Model for Modal Analysis | and Modern Tool Approaches | and Extraction of Results | and safety | analysis | process |  |  | robotic arm | vement in engineering skills and knowledge | courses, culminating in Dr. S. Rajakuru nakaran's presentation on Kinova® Gen3 robotic arm at MATLA B EXPO 2022, exemplifying a focus on modern tools and real-world problem-solving skills. PSO |
|------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|--------------------------------------------------|----------------------------|---------------------------|------------|----------|---------|--|--|-------------|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|





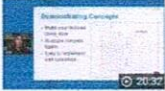


## Activity Glimpses

MATLAB EXPO 2022

19:48

### Preparing Future Engineers



**Digital Transformation in Education: Lightning Round**  
Dr. Ayse Tekes, Kennesaw State University  
Dr. Rick Hill, University of Detroit Mercy  
Dr. Rajakarunakaran S., Ramco Institute of Technology  
Dr. Kristopher Ray S. Pamintuan, Mapúa University

20:32



**Using Virtual Twins for Distance Learning in Control Systems Labs**  
Jan-Christian Kuhr, Hochschule Stralsund – University of Applied Sciences  
Martina Müller, Hochschule Stralsund – University of Applied Sciences

20:04



**Electric Drives: From Basic Models to Fuzzy and Neural Network Controllers**  
Pedro Ponce, Tecnológico de Monterrey

25:00

Watch video (20:32)

View slides

Read abstract

Watch video (20:04)

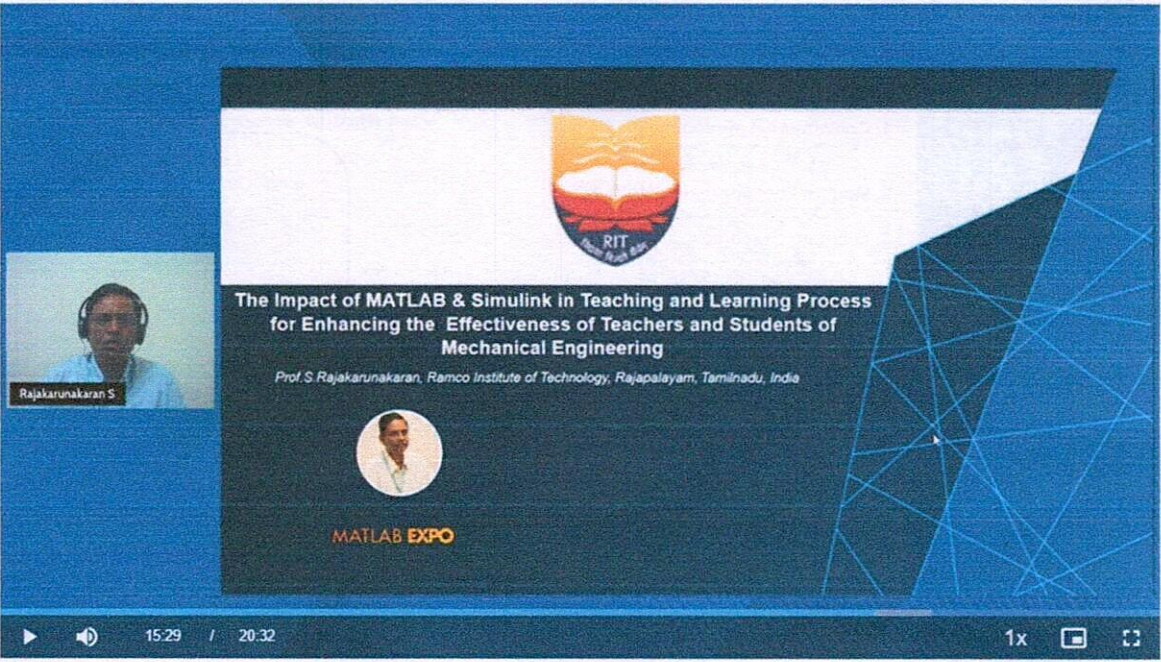
View slides

Read abstract

Watch video (25:00)

View slides

Read abstract



Rajakarunakaran S.

**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

MATLAB EXPO

15:29 / 20:32

1x



**3. Solution** MATLAB EXPO

Direction of pressure - Direction of load.

Structural model for modal analysis

Model Analysis

Harmonic motion

Deformation at the Peak Response Frequency

Moving link applied on face 4

Ref: [https://in.mathworks.com/mwaccount/?s\\_tid=qn\\_myac](https://in.mathworks.com/mwaccount/?s_tid=qn_myac)

**Case Study: Experiential Findings** MATLAB EXPO

**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 MATLAB usage in Teaching Learning Process**

- Arouses curiosity
- Upskill real-world problems
- Promotes value addition
- Exposes to new trends

**Key Takeaway**

**Impact of MATLAB Applications in Teaching Learning Process**

- Enhances active learning through
  - Problem-based learning
  - Project-based learning
  - Product-based learning
- Promotes integrative learning
- Encourages evaluative learning

## Reflective Critique:

### i. Feedback of practice from students and other stakeholders:

Students and Delegates gave positive feedback

### ii. Benefit of the practice:

The integration of MATLAB & Simulink in teaching Mechanical Engineering enhances students' analytical skills through hands-on experience in modal and frequency response analysis, optimizing design parameters, and solving multivariable problems. This approach, demonstrated in the case study on Kinova® Gen3 robotic arm, promotes a modern



and efficient learning environment, contributing to students' engineering graduate attributes.

**iii. Whether the practice is adopted in any of the courses early:**

No.

**Challenges faced in implementation:**

Implementing MATLAB and Simulink for the analysis of the Kinova Gen3 robotic arm posed challenges in mathematical modeling, optimal design, debugging, computational analysis, and result extraction. The complexity of solving multivariable problems, determining the direction of pressure, and developing a structural model for modal analysis required advanced engineering skills. Additionally, the need for experimental validation and comparison between conventional and modern tool approaches added further intricacy to the process. Despite these challenges, the implementation enhanced learning outcomes for mechanical engineering students, addressing fundamental concepts in courses such as Kinematics of Machinery, Heat and Mass Transfer, Finite Element Analysis, and Simulation and Analysis Laboratory. The presentation at MATLAB EXPO 2022 by Dr. S. Rajakarunakaran showcased the successful use of MATLAB and Simulink in overcoming these challenges, demonstrating their effectiveness in engineering education and research.

**References:**

1. <https://www.matlabexpo.com>
2. <https://www.mathworks.com/products/matlab.html>

*CO: Students will be able to Demonstrate proficiency in mathematical modeling, computational analysis, and modern tools like MATLAB & Simulink, applying them to solve complex problems in mechanical engineering, as exemplified in the analysis of Kinova® Gen3 robotic arm's shoulder link for deformation under pressure and other related topics such as kinematics, heat transfer, and finite element analysis.*





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

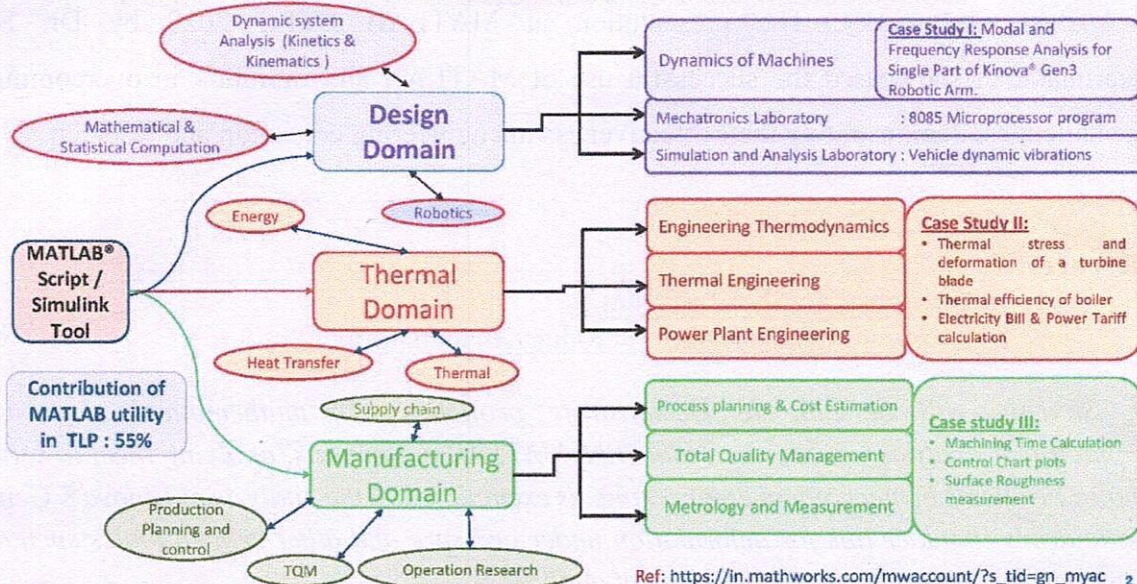
Prof.S.Rajakarunakaran, Ramco Institute of Technology, Rajapalayam, Tamilnadu, India



MATLAB EXPO

### Teaching Learning Process – Potential applications in Mechanical Engineering courses

MATLAB EXPO





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

MATLAB EXPO

### 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/products/gen3-lite-robot>

#### 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.

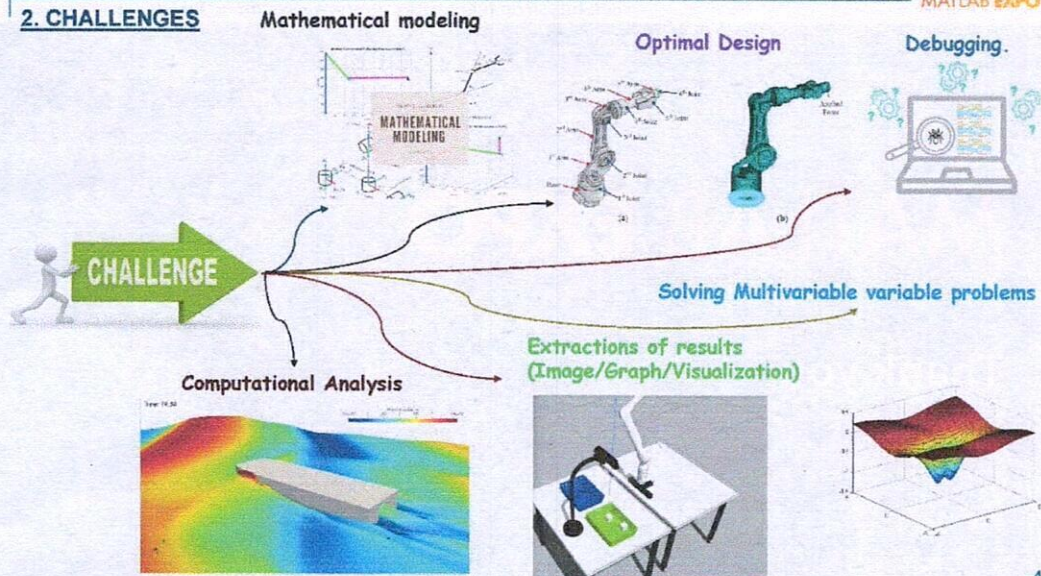
##### Psychomotor Domain:

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

3

### 2. CHALLENGES

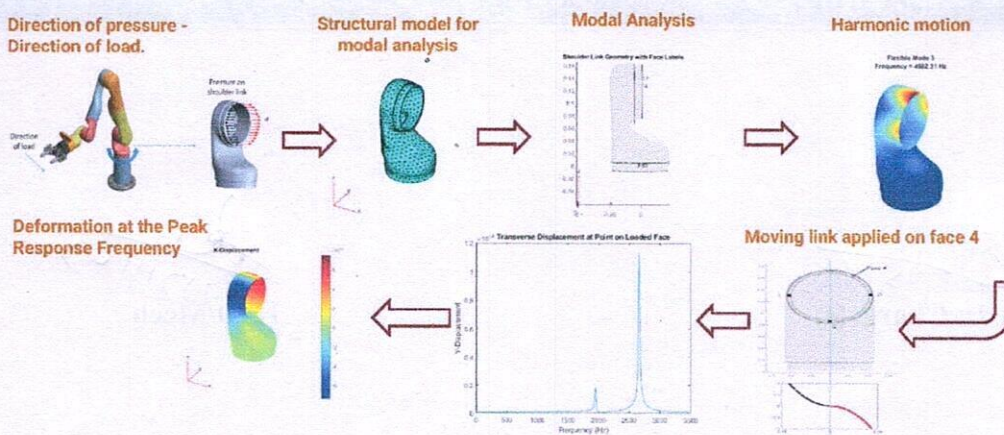
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### 3. Solution

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Ref: [https://in.mathworks.com/mwaccount/?s\\_tid=gn\\_myac](https://in.mathworks.com/mwaccount/?s_tid=gn_myac)

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## Case Study: Experiential Findings

### 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 MATLAB usage in Teaching Learning Process



## Key Takeaway

### 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.

Ref: [https://in.mathworks.com/mwaccount/?s\\_tid=gn\\_myac](https://in.mathworks.com/mwaccount/?s_tid=gn_myac)

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# MATLAB EXPO

## Thank you



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Faculty In Charge(s)

HoD/Mech