

# Madhav Joshi

## Curriculum Vitae

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### Education

2019–2024 **Indian Institute of Technology Bombay, Mumbai, India**

- Major: **Mechanical Engineering**, (B.Tech. with Honors + M.Tech. in CAD & Automation)  
GPA: **9.25/10** (Department Rank: **2 out of 41**)
- Minor: **Systems and Controls Engineering**, GPA: **8.6/10**

### Awards and Achievements

- 2022 Received **Institute Academic Award** for scoring **2<sup>nd</sup>** best in the class for whole year
- 2019 Among **Top 1.5%** out of 200,000 students in JEE Advanced 2019
- 2019 Secured **99.54 percentile** among 1.15M candidates in **JEE Mains 2019**
- 2019 Secured **All India Rank 74** among 15,000 students in **UCEED** (Design Exam)
- 2019 **Ranked 107<sup>th</sup>** out of 0.39 million examinees in Maharashtra Common Entrance Test

### Internships and Research

May'22 **Modelling and Control of Compliant Mechanisms | Research Internship**

Jul'22 *Guide: Dr. Abhijeet Joshi | Siemens Technology India*

- Examined open source **SOFA framework** targeting real time for interfacing mesh, solvers, collision models and material properties to simulate a soft robot
- Implemented a research paper on **system modelling** using Koopman operator and **MPC control** of **soft robot** on compliant springs using strings coupled with brushed DC motors
- Hardware utilized **Raspberry Pi 4B** as controller and to interface camera, Arduinos and a PWM driver (PCA9685) using **I2C** communication protocol
- Installed **ROS** on Raspbian OS and developed a ROS package which could be expanded to more complex robots whose controller achieved an accuracy of **±3 mm**

Jan'21 **Topology Optimization | iSURP - In Semester UG Research Program**

Jul'21 *Guide: Prof Amuthan A Ramabathiran | Aerospace Department, IIT Bombay*

- Analyzed **density based** Topology Optimization in context of linear elasticity and applied it to a heat sink design optimization problem using open source **FEniCS** project in Python
- Implemented various numerical methods: gradient descent, forward/backward Euler, FDM and FEM in Python
- Formulated primal and adjoint equations for **Poisson membrane** problem to calculate the derivative of objective function using advanced analytical methods in variational calculus for **constrained optimization** problem

Dec'20 **Microwave Metal Heating - 3D Modelling**

Jan'21 *Guide: Prof Shruti Bhatt | Mechanical Engineering Dept | Nirma University, Gujrat, India*

- Modelled **transient electromagnetic heating** of AA6061 specimen using COMSOL 3.5a
- Calculated time required for reaching melting temperature and verify using experimental data with **95%+ accuracy** to conclude that microwave metal casting process is more efficient than conventional casting methods

### Research Publications

Shruti, C. B., Nilesh, D. G., & **Madhav, J.** (2021). Multiphysics simulation and validation of microwave melting characteristics of AA6061 by finite element analysis. *Advances in Materials and Processing Technologies*. doi:10.1080/2374068X.2021.1948708

### Projects

Jan'23 **JLR Robot Charging Challenge | Inter IIT Tech Meet 11.0**

Feb'23 *Bagged the 1<sup>st</sup> runner up out of a total of — participants from various IIT's across India*

- The task was to devise a system that can automatically detect the charging port of the vehicle and plug the socket into the charging port
- In a team of 13, we designed a 6 DoF robotic arm using Solidworks for maximum range of motion without self collision and simulated it on MATLAB and Simscape
- Generated trajectory of system to move the end effector in a straight line from the starting pose to given end pose respecting the self collisions, joint limits and velocity constraints of each part of the system
- Performed the torque and energy calculations to respect torque limits on the joint motors and compare energy consumed for traversing different trajectories i.e. straight line trajectory in cartesian as well as joint space by calculating the analytical inverse kinematics and choosing nearest solution at every point in trajectory

Feb'22 **H-Bot 3D Printer**

May'22 *Course: Design of Mechatronic Systems | Guide: Prof. Prasanna Gandhi, IIT Bombay*

- Used TIVA C microcontroller, stepper motors, timing pulleys, aluminum extrusions and LSM13 linear encoder to construct H-Bot 3D printer mechanism
- Used PWM signals to drive two stepper motors simultaneously, QEI to read linear encoder values and implement a subroutine to take the station to the desired input position

Feb'22 **Temperature Control of Fluid Column**

May'22 *Course: Advanced Feedback Theory | Guide: Prof. P.S.V. Nataraj, SysCon, IIT Bombay*

- Modelled the integrating system by performing bump test and recording data from NI DAQ card from MATLAB interface
- Tuned and tested the PI controller according to Ziegler Nichols tuning rules and added a feed forward block to improve disturbance rejection

Feb'22 **Vision Transformer on Small Data-set**

May'22 *Course: Machine Learning for Remote Sensing | Guide: Prof. Biplab Banerjee, IIT Bombay*

- Implemented current SOTA ViT and SL-ViT on CIFAR-10 and CIFAR-100 datasets for image classification to increase locality inductive bias compared to ViT
- SL-ViT uses Shifted Patch Tokenization which embeds more spatial information into visual tokens and Locality Self Attention makes ViT's attention locally focused
- Achieved top-5 accuracy of 99.13% for CIFAR-10 and 82.92% for CIFAR-100 dataset

Feb'22 **Pendulum Clock**

May'22 *Course: Machine Design | Guide: Prof. V. Kartik, CSRE, IIT Bombay*

- Designed escapement mechanism, involute gears, pendulum and stand in solidworks
- Verified any collisions

Feb'22 **Two Degrees of Freedom Robotic Arm**

May'22 *Course: Robotics | Guide: Prof. Abhishek Gupta | Mechanical Engineering, IIT Bombay*

- Built a 2 Degree-of-Freedom Robotic Arm which moves in a plane to coordinates pointed by a red spot detected by phone camera around the bot
- Designed a **CAD model** for the robot in **Solidworks** consisting of Servo motors, joints and links of robot to **3-D print** all components required to assemble the robot
- Developed red spot detection algorithm, Forward and Inverse Kinematics in **MATLAB** for calculating joint parameters, current and desired position of end-effector
- Integrated **Arduino** with MATLAB for implementing **closed loop feedback control**

Mar'22 **Optimization of Swiggy Instamart Hub Locations**

Apr'22 *Course: IEOR | Guide: Prof. Avinash Bharadwaj | Mechanical Engineering, IIT Bombay*

- Modelled the revenue system of Swiggy Instamart as an **integer programming problem** by considering investment costs, operating costs and profits from all probable hub locations
- Optimized the net profit for the cases where hubs have limited or infinite capacity to store the products using CPLEX solver in **AMPL**
- Checked model robustness by performing uncertainty and risk analysis

- Jul'21 **Stride | Student Technical Team**
- May'22 *Focuses on building a quadruped which can walk autonomously on all terrain | IIT Bombay*
- Coded Newton-Euler method in **MATLAB** to find the reaction forces and torques required to produce desired angular velocities and acceleration in any configuration
  - Reviewed **MIT Cheetah 3 robot** design, **MPC** implementation using QP formulation in **ROS** and tried to simulate Gazebo and RViz
  - Researched trajectory generation using Bezier curves, localization and mapping of the quadruped in the given environment
- Aug'21 **Foot Pump Manufacturing Design**
- Nov'21 *Course: Manufacturing Processes | Guide: Prof. Deepak Marla | Mechanical Engineering, IITB*
- Studied manufacturing aspects of foot-pump including **Material and Process selection, Design and Inspection**
  - Modelled every part of the pump and assembled them in **Solidworks**
  - Carried out **cost analysis** based on the pump dimensions, materials and process used
- Jun'21 **Algorithmic Trading | FinSearch**
- Jul'21 *Finance Club of IIT Bombay*
- Grasped stock market knowledge from **financial modules** of Zerodha Varsity on basics of stock market, technical and fundamental analysis, Futures & Options and their strategies, trading systems like pairs trading
  - Scouted various trading strategies and implemented **pairs trading** strategy after back-testing results in Python and were among **top 6 teams** awarded with a cash prize of Rs 5 K for exemplary performance
- May'21 **Laser Surface Hardening (LSH)**
- Course: Manufacturing Processes | Guide: Prof Ramesh K Singh | Mechanical Department, IIT Bombay*
- Analysed and simulated LSH process via **FEM** using open-source **FEniCS** project collaborating in a **team of 5**
  - Reviewed 5+ research papers and numerically worked out **transient heat equation** to calculate temperature field and developed a model to find the **laser velocity** for required **hardened depth** and vice versa
- Jun'20 **Analemma | Krittika Summer Project**
- Krittika - Astronomy Club of IIT Bombay*
- Inspected the motion of sun using different **celestial coordinate systems** and developed a python code to generate the data points of Analemma and calculated its various properties with **98% accuracy**
  - Generated **2D and 3D interactive plots** and **colormaps** of Analemma and its properties using Matplotlib and calculated its properties like shape, size and position to study their variation with the orbital parameters both qualitatively and quantitatively
- Apr'20 **Frequency Analysis of Linear Systems**
- Controls and Dynamical Systems Group of IIT Bombay*
- Implemented MATLAB codes to design **low pass** and **high pass** filters in frequency domain to study the trade-off between smoothness and sharpness while filtering noise from an image
  - Analysed the use of **frequency domain** in **spatial** and **time** domain analysis of systems by applying the knowledge of Signals and Feedback Systems including Time-Frequency analysis, Filters and Convolution
- Sep'19 **Remote Controlled Plane**
- Aeromodelling club of IIT Bombay*
- Fabricated fuselage, stabilizers and wings of a miniature aircraft to **reduce drag** and improve flight time
  - Optimized the **performance** and **stability** of flight by careful consideration of design parameters
- Aug'19 **XLR8 | Obstacle Manoeuvring Bot**
- Electronics and Robotics Club of IIT Bombay*
- Designed and built a **Mobile App Controlled Bot** having Differential Steering using Blue-tooth module to overcome various hurdles in the least possible time among 450+ participants
  - Implemented the electrical sub-system for RC car utilizing **AT Tiny** micro-controller for controlling the bot

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## Key Courses and Technical Skills

Automation	Mechatronics, Robotics, Vibro-Acoustics, Machine Learning, Advanced PID Control, Linear and Non Linear systems, Signals and Feedback systems
Labs	Microprocessors and Automatic Controls, Mechanical Measurements, Manufacturing Processes, Mechanical Workshop, Computer Programming
Coding	C, C++, Python (Numpy, Pandas, Tensorflow, FEniCS), MATLAB, L <sup>A</sup> T <sub>E</sub> X, Linux
Hardware	Arduino, ESP32, TIVA-C, Raspberry Pi 4B, Stepper and DC motor, I2C communication
Softwares	SolidWorks, AutoCad, Adams, ROS, LABView, MS-Office, G-Suite, COMSOL, SOFA
Languages	English, Hindi, Marathi and learning French

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## Position of Responsibility

- Sept'21 **Water Polo Team Captain | Aquatics | IIT Bombay Sports**
- Sept'22 *Led 13 member institute water polo team in Inter IIT Aquatics meet 2022*
- Revamped the training process and the team structure after the 2 year COVID-19 pandemic break, as a result of which IIT Bombay reached **Semi Finals** after 6 years
  - Scouted for players, identified each player's strong points, scheduled regular team practices, matches and discussions for improving our game
- Feb'20 **Events Convener | Institute Sports Council | IIT Bombay**
- Mar'21 *36-member team responsible for execution of sports events for 10K+ students and faculties*
- Ideated and organized first-ever **Virtual Run** with **1.2K+ runners** across the country to promote physical activity during the pandemic and raised INR 15K for **COVID relief** campaign by NGO-Goonj
  - Conducted **Virtual Cup** for hostels through fantasy leagues and virtual General Championship; **India's largest** 1-Day Online Chess tournament attracting **550+** players (15 GMs) with prizes worth Rs70K
  - Organized IIT Bombay's annual sports fest **Aavhan** which attracted a lot of sports enthusiasts from **150+ colleges** across the country and **Blackcats Championship** a virtual fitness event for **200+** inter IIT players across 14 sports
- May'20 **Events Coordinator | TechFest**
- Jan'21 *Asia's Largest Science and Technology Festival | Events: 280+ | Footfall: 175K+*
- Assisted in HOPE - **150+** virtual workshops on **Mental Health Awareness** in association with 10+ NGOs
  - Collaborated with **100+ neurologists** and Mar de Somnis, a global non-profit organisation to train teachers in **150+ schools** to respond to epileptic seizures, under the aegis of HEAL, a social initiative by Techfest

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## Extra Curricular

### Sports

- 2022 Secured **Silver medal** in 4 × 100 medley relay and 4th position in 400m Freestyle in 55th Inter-IIT Aquatics meet organised jointly by IIT Delhi and IIT Roorkee
- 2022 Secured Gold medal in 50m Butterfly and a Bronze medal in 4 × 50m Medley relay in Inter Hostel General Championship held at IIT Bombay
- 2019 Secured 4th position in 400m Freestyle in 54th Inter-IIT Aquatics meet organised jointly by IIT Kharagpur and IIT Bhubaneswar
- 2015–16 Selected for **State Level** Swimming competition for two consecutive years
- 2016 Participated in Inter-School **Football** League organized by YMCA
- Oct'15 Represented school in **Zonal** Swimming competition organised by CBSE
- 2013 Completed **State Level Sea Swimming** Competition (3km) held at Chivla beach, Malvan organized by Sindhudurg District Aquatic Association

### Others

- 2022 Selected **among 16 buddies** out of 115 applicants for Student Buddy Program which helps foreign exchange students breeze through their stay at our institute
- 2017 Secured 95% with Pravinya Shreni in Sanskrit Bhasha Parichay Pariksha organised by Sanskrit Bhasha Pracharini Sabha, Nagpur
- 2014-2017 Proficient in playing Tabla and have cleared exams with distinction organized by ‘Gandharva Akhil Bharatiya Mahavidyalay’
- 2015-2017 Member of Road Safety Patrol in Nagpur city for three consecutive years
- 2014 Helped in spreading Cancer awareness as part of GCCCI’s nationwide programme and helping with relief efforts for cancer sufferers
- 2012 Secured 1st position in National level JetToy making competition in Maximum Distance category organised by SAEIndia