# Savitribai Phule Pune University
## Faculty of Science & Technology


Curriculum/Syllabus
For
**Fourth Year**
**Bachelor of Engineering**
**(Choice-Based Credit System)**
**Automation and Robotics**
**(2019 Course)**
**Board of Studies – Mechanical and Automobile Engineering**
(With effect from Academic Year 2023-24)

# Savitribai Phule Pune University

## Board of Studies - Mechanical and Automobile Engineering

## Undergraduate Program – Automation and Robotics (2019 pattern)

| Course Code | Course Name | Teaching Scheme (Hrs./week) | | | Examination Scheme and Marks | | | | | | Credit | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | TH | PR | TUT | ISE | ESE | TW | PR | OR | Total | TH | PR | TUT | Total |
| **Semester-VII** | | | | | | | | | | | | | | |
| 402541 | Industrial Automation & Control Systems | 3 | 2 | -- | 30 | 70 | -- | -- | 25 | 125 | 3 | 1 | -- | 4 |
| 402542 | Robotic Process Automation & Development | 3 | 2 | -- | 30 | 70 | 25 | -- | -- | 125 | 3 | 1 | -- | 4 |
| 402543 | Artificial Neural Networks and Deep Learning | 2 | 2 | -- | -- | 50 | -- | 50 | -- | 100 | 2 | 1 | -- | 3 |
| 402544 | *Elective – III | 3 | -- | -- | 30 | 70 | -- | -- | -- | 100 | 3 | -- | -- | 3 |
| 402545 | **Elective – IV | 3 | -- | -- | 30 | 70 | -- | -- | -- | 100 | 3 | -- | -- | 3 |
| 402046 | Data Analytics Laboratory | -- | 2 | -- | -- | -- | 50 | -- | -- | 50 | -- | 1 | -- | 1 |
| 402547 | Project Stage – I | -- | 4 | -- | -- | -- | 50 | -- | 50 | 100 | -- | 2 | -- | 2 |
| 402548 | $Audit Course – VII | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | **Total** | **14** | **12** | **--** | **120** | **330** | **125** | **50** | **75** | **700** | **14** | **6** | **--** | **20** |
| **Semester-VIII** | | | | | | | | | | | | | | |
| 402549 | Embedded Systems in Robots | 3 | 2 | -- | 30 | 70 | 25 | -- | 25 | 150 | 3 | 1 | -- | 4 |
| 402550 | Fundamentals of Autonomous Systems | 3 | 2 | -- | 30 | 70 | 25 | -- | 25 | 150 | 3 | 1 | -- | 4 |
| 402551 | Elective - V | 3 | -- | -- | 30 | 70 | -- | -- | -- | 100 | 3 | -- | -- | 3 |
| 402552 | Elective - VI | 3 | -- | -- | 30 | 70 | -- | -- | -- | 100 | 3 | -- | -- | 3 |
| 402553 | Data Visualization and Analytics Laboratory | -- | 2 | -- | -- | -- | 25 | 25 | -- | 50 | -- | 1 | -- | 1 |
| 402554 | Project Stage - II | -- | 10 | -- | -- | -- | 100 | -- | 50 | 150 | -- | 5 | -- | 5 |
| 402555 | $Audit Course – VIII | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | **Total** | **12** | **16** | **--** | **120** | **280** | **175** | **25** | **100** | **700** | **12** | **8** | **-** | **20** |

| **Elective-III** | | **Elective-V** | |
|---|---|---|---|
| 402544A | Robotics: Cognitive & Medical | 402551A | Industrial Robotics & Material Handling systems |
| 422544B | Microprocessors and Microcontrollers | 402551B | Supply Chain Management |
| 402044C | Modern Machining Processes | 402045A | Product Design & Development |
| 402044D | Industrial Engineering | 402050C | Manufacturing Systems and Simulation |
| 402044F | Computational Fluid Dynamics | 402050D | Engineering Economics and Financial Management |
| **Elective-IV** | | **Elective-VI** | |
| 402545A | Lean Manufacturing | 402552A | Data Science |
| 402545B | Project Management | 402552B | Data Visualization |
| 402045C | Additive Manufacturing | 402552C | Network Science |
| 402045D | Operations Research | 402044E | Internet of Things |
| 402045E | Augmented Reality and Virtual Reality | 402051D | Industrial Psychology and Organizational Behavior |

**Abbreviations: TH**: Theory, **PR**: Practical, **TUT**: Tutorial, **ISE**: In-Semester Exam, **ESE**: End-Semester Exam, **TW**: Term Work, **OR**: Oral

## Audit Courses

| | | | |
|---|---|---|---|
| 402548A | Yoga Practices | 402548B | Stress Management |
| 402555A | Managing Innovation | 402555B | Operations Management |

## Instructions:

- Practical/Tutorial must be conducted in **FOUR batches per division only**.
- Minimum number of Experiments/Assignments in PR/Tutorial shall be carried out **as mentioned in the syllabi** of respective courses.
- Assessment of tutorial work has to be carried out similarly to term work. The Grade cum marks for Tutorial and Term-work shall be awarded based on **continuous evaluation.**

$ Audit course is mandatory but non-credit course. Examination has to be conducted at the end of Semesters for award of grade at institute level. Grade awarded for audit course shall not be calculated for grade point & CGPA

# Program Outcomes (POs)

POs are statements that describe what students are expected to know and be able to do upon graduating from the program. These relate to the skills, knowledge, analytical ability attitude and behavior that students acquire through the program.

The POs essentially indicate what the students can do from subject-wise knowledge acquired by them during the program. As such, POs define the professional profile of an engineering graduate.

1. **Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem Analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

3. **Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions for complex problems:

    a. that cannot be solved by straightforward application of knowledge, theories and techniques applicable to the engineering discipline as against problems given at the end of chapters in a typical text book that can be solved using simple engineering theories and techniques;

    b. that may not have a unique solution. For example, a design problem can be solved in many ways and lead to multiple possible solutions;

    c. that require consideration of appropriate constraints / requirements not explicitly given in the problem statement such as cost, power requirement, durability, product life, etc.;

    d. which need to be defined (modelled) within appropriate mathematical framework; and

    e. that often require use of modern computational concepts and tools, for example, in the design of an antenna or a DSP filter.

5. **Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

6. **The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings**.**

10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

# Savitribai Phule Pune University

**Board of Studies - Mechanical and Automobile Engineering**

**Undergraduate Program – Final Year Automation and Robotics (2019 pattern)**

## 402541: Industrial Automation & Control Systems

| Teaching Scheme | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|
| **Theory** | 03 Hr./Week | **Theory** | 3 | **In-Semester** | 30 Marks |
| **Practical** | 02 Hr./Week | **Practical** | 1 | **End-Semester** | 70 Marks |
| | | | | **Oral** | 25 Marks |

**Prerequisites:** Mathematics course in differential equations, Laplace transforms, basic electrical network analysis.

**Course Objectives:**

1. Select & Apply appropriate power system for Automation systems
2. Understand Design of Fluid Power System
3. UNDERSTAND the Transient and steady-state responses and Stability.
4. UNDERSTAND to Compute the frequency domain specifications of a system.
5. UNDERSTAND the State space analysis of systems.
6. UTILIZE the various methods used for analyzing nonlinear systems.

**Course Outcomes:** On completion of the course the learner will be able to:

CO1. SELECT control systems in robots.
CO2. DESIGN Hydraulic Control System
CO3. DESIGN Pneumatic Control System
CO4. ANALYZE linear control system
CO5. ANALYZE non-linear control system
CO6. UNDERSTAND and USE appropriate control systems

## Course Contents

**Unit 1** **Automation & Fluid Power System**

**Automation**: Definition, Types, reasons for automating; Automation strategies, Introduction of fluid power system: significance in industrial automation, fluids & their properties, governing laws, symbols, working principle, design and analysis of reservoir, pumps, filters, valves, actuators, accumulators, intensifiers, special pneumatic components viz. logical valves, time delay valve, etc.

**Unit 2** **Hydraulic Control Systems**

Standards in circuit diagram, Design considerations and component selection**.** Control of Single and Double -Acting Hydraulic Cylinder, Regenerative circuit, Pump Unloading Circuit, Counter balance Valve Detail analysis speed control, flow control, pressure control circuits, Safety circuit, Accumulators, types, construction and applications with circuits, Intensifier circuits. Proportional valves and servo valves in hydraulic circuit design.

PLC based electro-hydraulic systems, PLC programming using ladder logic for automation and robotics applications

**Unit 3** **Pneumatic Control Systems**

Pneumatic circuits design using Displacement – Time and Travel-Step diagrams, sequencing and cascade circuits, Construction of pneumatic circuit diagrams for industrial applications. Use of Logic gates - OR and AND gates in pneumatic applications.

Electro-Pneumatic Control: Principles - signal input and output, pilot assisted solenoid control of directional control valves, Use of relay and contactors.

| **Unit 4** | **Linear Systems** |
|---|---|

Definition, Open loop vs closed-loop control systems- components of a typical control system- Necessity of a control system in a robot, bird's eye view of typical actuators in robot control systems-hydraulic, pneumatic and electric actuators

Transfer function, Necessity of knowing the transfer function, Modelling -Mechanical and Electromechanical systems – block diagram representation - block diagram reduction, characteristic equation, signal flow graph, overview Mason's gain formula; the Basic idea of feedbacks in robotic systems-sensors- eg. Linear and rotary encoders.

| **Unit 5** | **Non-linear Systems** |
|---|---|

Introduction - characteristics of nonlinear systems. Types of nonlinearities. Determination of describing the function of nonlinearities (relay, dead zone, and saturation only) - application of describing function for stability analysis of autonomous Robotics & Automation system with single nonlinearity. Singular points – Classification of singular points. Definition of stability- asymptotic stability and instability.

| **Unit 6** | **Advance Automated Systems** |
|---|---|

Introduction to Advance Automated Systems, definition and scope of automated systems, benefits and challenges, Large scale control systems: Distributed control system and Supervisory control and data Acquisition (SCADA), HMI, Remote Terminal Unit (RTU), Digital Communication Unit (DCU), Industrial automation using robots

## Books and other resources

**Text Books:**


1. Antanio Espisito, Fluid Power with Applications, Pearson Education Seventh Edition
2. Process Control Instrumentation Technology Curtis D. Johnson Eighth Edition
3. I. J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International Pvt Ltd, 6/e.
4. Katsuhiko Ogata, "Modern Control Engineering", Pearson Education India, 5/e.
5. M. Gopal, "Control Systems Principles and Design", McGraw Hill Education (India) Pvt. Ltd., 4/e.
6. A. Anand Kumar, "Control Systems", PHI, 2/e.
7. D. Roy Choudhury, "Modern Control Engineering", PHI.
8. Peter Corke, Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer.


**References Books:**


1. Nise N. S., Control Systems Engineering, 6/e, Wiley Eastern, 2010.
2. Dorf R. C. and R. H. Bishop, Modern Control Systems, Pearson Education, 2011.
3. Hassan K Khalil, Nonlinear Systems, Prentice - Hall International (UK), 2002.
4. Ashitava Ghosal, Robotics- Fundamental Concepts and Analysis, Oxford University Press.
5. Control System Engineering, Gupta, Wiley Publications.
6. Control Engineering, K. P. Ramachandran, Wiley Publications.


**Web References:**

1. NPTEL Course "Control System" - https://nptel.ac.in/courses/107/106/107106081/
2. NPTEL Course "Control System Design" - https://nptel.ac.in/courses/115/108/115108104/
3. NPTEL Course "Advanced Linear Continuous Control Systems: Applications with MATLAB Programming and Simulink" - https://nptel.ac.in/courses/108107115/

**Guidelines for Laboratory Sessions**

1. Assessment must be based on an understanding of theory, attentiveness during practice, and understanding.
2. There should be continuous assessment and Timely submission of the journal.
3. Use suitable software wherever necessary to perform experiments.

**The student shall perform any 8 experiments of the following:**

1. Case study - Design of speed control hydraulic circuits.
2. Case study - Design of regenerative circuits
3. Case study - Design of electro-hydraulic sequencing circuits
4. Experiment on pneumatic circuits by demonstrating logic gates.
5. Experiment on electro-pneumatic circuits
6. Experiment on programmable logic controllers: Ladder logic programming
7. Microprocessor programming for basic operations.
8. Microcontroller programming for basic operations.
9. Computation of transfer function of Electric Circuits, Mechanical Circuits for concept understanding with their analogy Force-Voltage and Force Current.
10. Stability analysis for any given system with Characteristic Equation given (Software Simulation).
11. Observe the effect of P, PI, PD, and PID controllers on the step response of a feedback control system. Comment on the effect of Controller mode Time domain specifications/ analysis.

# Savitribai Phule Pune University

**Board of Studies - Mechanical and Automobile Engineering**

**Undergraduate Program – Final Year Automation and Robotics (2019 pattern)**

## 402542: Robotic Process Automation & Development

| Teaching Scheme | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|
| **Theory** | 03 Hrs/ Week | **Theory** | 3 | **In-Semester** | 30 Marks |
| **Practical** | 02 Hrs/ Week | **Practical** | 1 | **End-Semester** | 70 Marks |
| | | | | **Term Work** | 25 Marks |

**Prerequisites:**

Basic Programming Knowledge, Concepts of Modeling and Simulation.

**Course Objectives:**

1. To provide students with a comprehensive understanding of Robotic Process Automation (RPA) and its development.
2. To learn the concepts, tools, and techniques involved in automating business processes using RPA technology.
3. To design, develop, and deploy RPA bots to optimize and automate various business processes.

**Course Outcomes:**

On completion of the course the learner will be able to;

CO1: DESCRIBE RPA, where it can be applied and how it's implemented.

CO2: DESCRIBE the different types of variables, Control Flow and data manipulation techniques.

CO3: IDENTIFY and understand Image, Text and Data Tables Automation.

CO4: DESCRIBE how to handle the User Events and various types of Exceptions and strategies.

CO5: UNDERSTAND the Deployment of the Robot and maintain the connection.

CO6: UNDERSTAND need of deployment and maintenance of bots

**Course Contents**

| **Unit 1** | **Introduction to Robotic Process Automation** |
|---|---|

**RPA BASICS:** History of Automation - What is RPA - RPA vs Automation - Processes & Flowcharts - Programming Constructs in RPA - What Processes can be Automated - Types of Bots - Workloads which can be automated - RPA Advanced Concepts - Standardization of processes - RPA Development methodologies - Difference from SDLC - Robotic control flow architecture - RPA business case - RPA Team - Process Design Document/Solution Design Document - Industries best suited for RPA - Risks & Challenges with RPA - RPA and emerging ecosystem.

| **Unit 2** | **RPA Tool Introduction and Basics** |
|---|---|

**Introduction to RPA Tool** - The User Interface - Variables - Managing Variables - Naming Best Practices - The Variables Panel - Generic Value Variables - Text Variables - True or False Variables - Number Variables - Array Variables - Date and Time Variables - Data Table Variables - Managing Arguments - Naming Best Practices - The Arguments Panel - Using Arguments - About Imported Namespaces - Importing New Namespaces- Control Flow - Control Flow Introduction - If Else Statements - Loops - Advanced Control Flow - Sequences - Flowcharts - About Control Flow - Control Flow Activities - The Assign Activity - The Delay Activity - The Do While Activity - The If Activity - The Switch Activity - The While Activity - The For Each Activity - The Break Activity.

| Unit3 | Advanced Automation Concepts |
|---|---|

**Data Manipulation** - Data Manipulation Introduction - Scalar variables, collections and Tables - Text Manipulation - Data Manipulation - Gathering and Assembling Data

Scope and techniques of automation, Robotic process automation - What can RPA do? Benefits of RPA, Components of RPA, RPA platforms, The future of automation.

Recording Introduction - Basic and Desktop Recording - Web Recording - Input/ Output Methods - Screen Scraping - Data Scraping - Scraping advanced techniques - Selectors - Defining and Assessing Selectors - Customization - Debugging - Dynamic Selectors - Partial Selectors

| Unit 4 | Advanced Automation Techniques |
|---|---|

RPA Challenge - Image, Text & Advanced Citrix Automation - Introduction to Image & Text Automation – Image-based automation - Keyboard based automation - Information Retrieval - Advanced Citrix Automation challenges - Best Practices - Using tab for Images - Starting Apps - Excel Data Tables & PDF - Data Tables in RPA - Excel and Data Table basics - Data Manipulation in excel – Extracting Data from PDF - Extracting a single piece of data - Anchors - Using anchors in PDF.

| Unit 5 | Handling User Events & Assistant Bots, Exception Handling |
|---|---|

What are assistant bots? - Monitoring system event triggers - Hotkey trigger - Mouse trigger - System trigger - Monitoring image and element triggers - An example of monitoring email - Example of monitoring a copying event and blocking it - Launching an assistant bot on a keyboard event.

**EXCEPTION HANDLING:** Debugging and Exception Handling - Debugging Tools - Strategies for solving issues - Catching errors.

| Unit 6 | Deploying and Maintaining the Bot |
|---|---|

Publishing using publish utility - Creation of Server - Using Server to control the bots - Creating a provision Robot from the Server - Connecting a Robot to Server - Deploy the Robot to Server - Publishing and managing updates - Managing packages - Uploading packages - Deleting packages

## Books and Other Resources

**Text Books:**


1. Alok Mani Tripathi, "*Learning Robotic Process Automation*", Packt Publishing, 2018.


**References Books:**


1. Frank Casale, Rebecca Dilla, Heidi Jaynes, Lauren Livingston, "*Introduction to Robotic Process Automation: a Primer*", Institute of Robotic Process Automation, 1st Edition 2015.
2. Richard Murdoch, *Robotic Process Automation: Guide To Building Software Robots, Automate Repetitive Tasks & Become An RPA Consultant"*, Independently Published, 1st Edition 2018.
3. Srikanth Merianda," *Robotic Process Automation Tools, Process Automation and their benefits: Understanding RPA and Intelligent Automation"*, Consulting Opportunity Holdings LLC, 1st Edition 2018.
4. Lim Mei Ying, "*Robotic Process Automation with Blue Prism Quick Start Guide: Create software robots and automate business processes*", Packt Publishing, 1st Edition 2018.


**Web References:**

1. https://www.uipath.com/rpa/robotic-process-automation
2. https://www.academy.uipath.com

## Term Work

**The student shall complete the following activity as a Term Work (Any Eight):**

1. Installing and configuring an RPA tool
2. Analyzing business processes for automation potential
3. Designing and documenting RPA workflows
4. Building and testing RPA bots using drag-and-drop interfaces
5. Integrating RPA bots with external systems and databases

6. Optimizing and improving RPA solutions
7. Exploring web automation and data extraction techniques
8. Implementing cognitive automation in RPA bots
9. Evaluating RPA performance and identifying optimization areas

# Savitribai Phule Pune University

**Board of Studies - Mechanical and Automobile Engineering**

**Undergraduate Program – Final Year Automation and Robotics (2019 pattern)**

## 402543: Artificial Neural Network and Deep Learning

| Teaching Scheme | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|
| **Theory** | 02 Hr/week | **Theory** | 2 | **End-Semester** | 50 Marks |
| **Practical** | 02 Hr/week | **Practical** | 1 | **Practical** | 50 Marks |

**Prerequisites:** Artificial Intelligence and Statistics

**Course Objectives:**

1. To provide students with a basic understanding of the fundamentals and applications of artificial neural networks
2. To identify the learning algorithms and to know the issues of various feed-forward and feedback neural networks.
3. To Understand the basic concepts of Associative Learning and pattern classification.
4. To solve real-world problems using the concept of Artificial Neural Networks.

**Course Outcomes:**

On completion of the course the learner will be able to;

CO1: UNDERSTAND the basic features of neural systems and be able to build the neural model.
CO2: PERFORM the training of neural networks using various learning rules.
CO3: GRASPING the use of Associative Learning Neural Network
CO4: DESCRIBE the concept of Competitive Neural Networks
CO5: IMPLEMENT the concept of Convolutional Neural Networks and its models
CO6: USE a new tool /tools to solve a wide variety of real-world problems

**Course Contents**

| **Unit 1** | **Introduction to Artificial Neural Networks** |
|---|---|

Introduction to ANN, History of Neural Networks, Structure and working of Biological Neural Networks, Neural net architecture, Topology of neural network architecture, Features, Characteristics, Types, Activation functions, Models of neuron-Mc Culloch & Pitts model, Perceptron, Adaline model, Basic learning laws, Applications of neural networks, Comparison of BNN and ANN.

| **Unit 2** | **Learning Algorithms** |
|---|---|

Learning and Memory, Learning Algorithms, Numbers of hidden nodes, Error Correction and Gradient Decent Rules, Perceptron Learning Algorithms, Supervised Learning Backpropagation, Multilayered Network Architectures, Backpropagation Learning Algorithm, Feed forward and feedback neural networks, example and applications.

| **Unit3** | **Associative Learning** |
|---|---|

Introduction, Associative Learning, Hopfield network, Error Performance in Hopfield networks, simulated annealing, Boltzmann machine and Boltzmann learning, State transition diagram and false minima problem, stochastic update, simulated annealing. Basic functional units of ANN for pattern recognition tasks: Pattern association, pattern classification and pattern mapping tasks.

| **Unit 4** | **Competitive learning Neural Network** |
|---|---|

Components of CL network, Pattern clustering and feature mapping network, ART networks,

Features of ART models, character recognition using ART network. Self-Organization Maps (SOM): Two Basic Feature Mapping Models, Self-Organization Map, SOM Algorithm, Properties of Feature Map, Computer Simulations, Learning Vector Quantization, Adaptive Pattern Classification

| **Unit 5** | **Convolution Neural Network** |
|---|---|

Building blocks of CNNs, Architectures, convolution/pooling layers, Padding, Strided convolutions, Convolutions over volumes, SoftMax regression, Deep Learning frameworks, Training and testing on different distributions, Bias and Variance with mismatched data distributions, Transfer learning, multi-task learning, end-to-end deep learning, Introduction to CNN models: LeNet – 5, AlexNet, VGG – 16, Residual Networks

| **Unit 6** | **Applications of ANN** |
|---|---|

Pattern classification – Recognition of Olympic games symbols, Recognition of printed Characters. Neocognitron – Recognition of handwritten characters. NET Talk: to convert English text to speech. Recognition of consonant vowel (CV) segments, texture classification and segmentation

**Books and other resources**

**Text Books:**


2. Neural Networks a Comprehensive Foundations, Simon Haykin, PHI edition.
3. Laurene Fausett: Fundamentals of Neural Networks: Architectures, Algorithms & Apps, Pearson, 2004.
4. An introduction to neural networks, Gurney, Kevin, CRC press.


**References Books:**


1. Artificial Neural Networks - B. Vegnanarayana Prentice Hall of India P Ltd ,2005
2. Neural Networks in Computer Inteligance- Li Min Fu, MC GRAW HILL EDUCATION, 2003
3. Neural Networks -James A Freeman David M S Kapura, Pearson Education, 2004.
4. Introduction to Artificial Neural Systems- Jacek M. Zurada, JAICO Publishing House Ed.,2006.


**Web References:**

1.https://www.pdfdrive.com/neural-networks-a-comprehensive-foundationpdf-e18774300.html
2.https://www.pdfdrive.com/elements-of-artificial-neural-networks-e17103719.html
3.https://www.pdfdrive.com/neural-networks-methodology-and-applications-e38107895.html

**MOOC Courses:**

1.https://nptel.ac.in/courses/117105084
2. https://www.coursera.org/projects/predicting-weather-artificial-neural-networks

**Guidelines for Laboratory Conduction**

- The instructor is expected to frame the assignments by understanding the prerequisites, technological aspects, utility and recent trends related to the topic.
- The assignment framing policy needs to address the average students and be inclusive of an element to attract and promote the intelligent students.
- The instructor may set multiple sets of assignments and distribute among batches of students. It is appreciated if the assignments are based on real world problems/applications.
- Encourage students for appropriate use of Hungarian notation, proper indentation and comments.
- Use of open-source software is to be encouraged. In addition to these, instructor may assign one real life application in the form of a mini-project based on the concepts learned. Instructor may also set one assignment or mini-project that is suitable to respective branch

beyond the scope of syllabus.

- Set of suggested assignment list is provided in groups- A and B. Each student must perform at least 10 assignments and one mini project (at least 6 from group A and 4 from group B). Group A and B assignments should be implemented in Python without using built-in methods for major functionality of assignment. Operating System recommended:- 64-bit Open source Linux or its derivative Programming tools recommended: - Open Source Python, Programming tool like Jupyter Notebook, Pycharm, Spyder, Tensorflow.

**Term Work**

**The student shall complete the following activity as a Term Work:**

**Group A (Any 6)**

1. Write a Python program to plot a few activation functions that are being used in neural networks.
2. Generate ANDNOT function using McCulloch-Pitts neural net by a python program.
3. Write a Python Program using Perceptron Neural Network recognize even and odd numbers. Given numbers are in ASCII from 0 to 9
4. With a suitable example demonstrate the perceptron learning law with its decision regions using Python the output in graphical form.
5. Write a python Program for Bidirectional Associative Memory with two pairs of vectors.
6. Write a python program to recognize the number 0, 1, 2, 39. A 5 * 3 matrix forms the numbers. For any valid point it is taken as 1 and invalid point it is taken as 0. The net has to be trained to recognize all the numbers and when the test data is given, the network has to recognize the particular numbers
7. Implement Artificial Neural Network training process in Python by using Forward Propagation, Back Propagation.
8. Create a Neural network architecture from scratch in Python and use it to do multi-class classification on any data.
   Parameters to be considered while creating the neural network from scratch are specified as:
   (1) No of hidden layers: 1 or more
   (2) No. of neurons in hidden layer: 100
   (3) Non-linearity in the layer: Relu
   (4) Use more than 1 neuron in the output layer. Use a suitable threshold value
   Use appropriate Optimization algorithm

**Group B (Any 4)**

1. Write a python program to show Back Propagation Network for XOR function with Binary Input and Output
2. Write a python program to illustrate ART neural network.
3. Write a python program in python program for creating a Back Propagation Feed-forward neural network
4. Write a python program to design a Hopfield Network which stores 4 vectors
5. Write Python program to implement CNN object detection. Discuss numerous performance evaluation metrics for evaluating the object detecting algorithms' performance.

**Mini Project**

Car Object Detection using (ConvNet/CNN) Neural Network
Car Object Data: Data Source – https://www.kaggle.com/datasets/sshikamaru/car-object-detection
The dataset contains images of cars in all views.
Training Images – Set of 1000 files
Use Tensor flow, Keras & Residual Network resNet50
Constructs comparative outputs for various Optimisation algorithms and finds out good accuracy.

OR

Mini Project to implement CNN object detection on any data. Discuss numerous performance evaluation metrics for evaluating the object detecting algorithms' performance, Take outputs as a comparative results of algorithms.

| **402544A: Robotics: Cognitive & Medical (Elective- III)** | | | | | |
|---|---|---|---|---|---|
| **Teaching Scheme** | | **Credits** | | **Examination Scheme** | |
| **Theory** | 3 Hrs/Week | **Theory** | 3 | **In-Semester** | 30 Marks |
| | | | | **End-Semester** | 70 Marks |

**Prerequisites:** Industrial Robotics,Robot Kinematics

**Course Objectives:**

1. To provide knowledge on the application of robotics in health care
2. Sensor requirements for localization, control and tracking
3. Understand the design aspects of medical robots

**Course Outcomes:**

On completion of the course the learner will be able to;

CO1: IDENTIFY the type of medical robots and the concepts involved in it.
CO2: DEFINE the applications of surgical robotics
CO3: PURPOSE of Rehabilitation interface
CO4: CLASSIFY the types of assistive robots.
CO5: ANALYZE the design characteristics, methodology and technological choices for medical robots.

**Course Contents**

| **Unit 1** | **Introduction to Medical Robotics** |
|---|---|

Introduction to medical robotics : applications and paradigms – Role of AI in medical robotics – Potential impact of medical robots, types of medical robots and level of human intervention – growing healthcare challenges

| **Unit 2** | **Image-Guided Interventions** |
|---|---|

Medical imaging modalities (e.g., MRI, US, X-ray, CT) - Robot compatibility with medical imagers – Image segmentation and modeling - Tracking devices - Frames and transformations - Surgical navigation - Calibration Rigid and non-rigid registration – Radiosurgery

| **Unit3** | **Surgical Robotics** |
|---|---|

Medical robots: History, Characteristics of medical robots, Automation and Navigation Challenges - robotics in surgery: Laparoscopic and Endoscopic Manipulators, Oncology robotics, Physically assistive robotics, Socially assistive robotics

| **Unit 4** | **Minimally Invasive Surgery (MIS)** |
|---|---|

Human-machine interfaces - Teleoperation - Cooperative manipulation -Port placement for MIS - Robot design concepts - Video images in MIS - Augmented reality - Minimally invasive surgery training

| **Unit 5** | **Rehabilitation Robotics** |
|---|---|

Physiological basis of neuromotor recovery, Framework for neuro-rehabilitation robotics: implication and recovery, Actuators and sensors and prosthetic robots, Assistive controllers and

| | |
|---|---|
| modalities, Exoskeletons for upper limb and lower limb rehabilitation, Software platforms for integrating robots and virtual environments, Wearable robotic applications for neuro-rehabilitation | |
| **Unit 6** | **Medical robotics-applications, controversies and outcomes** |
| Applications in Biomedical Engineering – Bio Engineering Biologically Inspired Robots, Neural Engineering, Application in Rehabilitation – Interactive Therapy, Bionic Arm, Clinical and Surgical –Gynaecology, Orthopaedics, Neurosurgery, Controversies and outcomes | |
| **Books and other resources** | |
| **Text Books:**<br>1. Robert Schilling, Fundamentals of Robotics-Analysis and control, Prentice Hall, 2003.<br>2. Paula Gomes, "Medical robotics- Minimally Invasive surgery", Woodhead, 2012.<br>3. J.J.Craig, Introduction to Robotics, Pearson Education, 2005<br>4. Roberto Colombo Vittorio Sanguineti, Rehabilitation Robotics, 1st Edition, Imprint: Academic Press Published Date: 10th March 2018, Springer | |
| **References Books:**<br>1. R. D. Howe and Y. Matsuoka, "Robotics for surgery," Annual Review of Biomedical Engineering, vol. 1, pp. 211–240, 1999<br>2. A. R. Lanfranco, A. E. Castellanos, J. P. Desai, and W. C. Meyers, "Robotic surgery: a current perspective," Annals of Surgery, vol. 239, no. 1, pp. 14–21, 2004.<br>3. Introduction to Robotics : Mechanics and Control John J. Craig | |

# Savitribai Phule Pune University

**Board of Studies - Mechanical and Automobile Engineering**

**Undergraduate Program – Final Year Automation and Robotics (2019 pattern)**

| **402544B: Microprocessors & Microcontrollers (Elective- III)** | | | | | |
|---|---|---|---|---|---|
| **Teaching Scheme** | | **Credits** | | **Examination Scheme** | |
| **Theory** | 3 Hrs/Week | **Theory** | 3 | **In-Semester** | 30 Marks |
| | | | | **End-Semester** | 70 Marks |

**Prerequisites:** Digital electronics, electronics devices and circuits

**Course Objectives:**

1. To understand architecture of 8085.
2. To understand interfacing of memory and PPI 8085.
3. To Understand interrupt features of 8085.
4. To Understand interfacing of ADC, DAC 8085.
5. To Understand architecture of 8051.
6. To Understand interrupt features of 8051.

**Course Outcomes:**

On completion of the course the learner will be able to;

CO1: DEFINE architecture of 8085.

CO2: DEFINE interfacing of memory and PPI 8085.

CO3: DEFINE interrupt features of 8085.

CO4: DEFINE interfacing of ADC, DAC 8085.

CO5: DEFINE architecture of 8051.

CO6: DEFINE interrupt features of 8051.

**Course Contents**

**Unit 1 Architecture of 8085 Microprocessor and Programming**

Functional Block Diagram, Registers, ALU, Bus systems, Timing and control signals, Machine cycles and timing diagrams. Instruction formats, addressing modes, Instruction set, Need for Assembly language, Development of Assembly language programs.

**Unit 2 Microprossor Interfacing**

Memory Interfacing: Interface requirements, Address space partitioning, Memory control signals, timing constraints, interfacing SRAM, EPROM and DRAM. I/O Interfacing: I/O mapped I/O scheme, Memory mapped I/O Scheme, Input and Output cycles, Programmable peripheral interface (8255), Interfacing keyboard and LED display.

**Unit 3 Interrupts and DMA**

Interrupt feature, need for interrupts, Characteristics of Interrupts, Types of Interrupts, Interrupt structure, Methods of servicing interrupts, Development of Interrupt service subroutines, Multiple interrupt request and their handling, need for direct memory access, Devices for Handling DMA, Programmable DMA controller 8237.

**Unit 4 Applications**

Interfacing of A/D converter (ADC 0800/ADC 0808/ADC 0809), Interfacing of D/A converter

(DAC 0800), Multiplexed seven segment LED display systems, Waveform generator, Stepper motor control, Traffic light controller.

**Unit 5 8051 Microcontroller**

History, Architecture of 8051, Features, addressing modes, Memory Organization, Instruction set, Boolean processing, programming.

**Unit 6 8051 Peripheral Functions**

8051 interrupt structures, Timer and serial functions, parallel port features: Modes of operation, Power control, features, Interfacing of 8051, Typical applications, MCS 51 family features.

**Books and other resources**

**Text Books:**


1. Goankar, R.S., "Microprocessor Architecture Programming and Applications with the 8085/8080A", 3rd Edition, Penram International Publishing House, 1997.
2. The 8051 Microcontroller and Embedded Systems Using Assembly and C, 2/e by Muhammad Ali Mazidi, Janice Gillispie Mazidi and Rolin McKinlay (Second Edition, Pearson Education).
3. The 8051 Microcontroller & Embedded Systems using Assembly and C By K. J. Ayala, D. V. Gadre (Cengage Learning, India Edition).
4. Using the MCS-51 Microcontrollers by Han Way Huang Oxford Uni Press
5. Programming and Customizing the 8051 Microcontroller by Myke Predko Tata Mcgraw Hill.


**References Books:**


1. Singh. I.P., "Microprocessor Systems", Module 9: Microcontrollers and their Applications", IMPACT Learning Material Series IIT, New Delhi, 1997.
2. Douglas, V. Hall. "Microprocessor and Interfacing Programming and Hardware", 2nd Edition, McGraw Hill Inc., 1992.
3. Kenneth, L. Short., "Microprocessors and Programmed Logic", Prentice Hall of India, 2nd Edition, 1987.
4. The 8051 Microcontroller Architecture, Programming and Applications, Kenneth Ayala, 2nd Edition, Penram International.

# Savitribai Phule Pune University

**Board of Studies - Mechanical and Automobile Engineering**

**Undergraduate Program – Final Year Automation and Robotics (2019 pattern)**

## 402044C: Modern Machining Processes (Elective III)

| Teaching Scheme | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|
| **Theory** | 3 Hrs./Week | **Theory** | 3 | **In-Semester** | 30 Marks |
| | | | | **End-Semester** | 70 Marks |

**Prerequisite**

Engineering Materials and Metallurgy, Manufacturing Processes

**Course Objectives**

1. To understand the different modern machining process.
2. To evaluate the process parameters of modern machining processes.
3. To able to select the process for application.
4. To apply the knowledge of different modern machining for manufacturing.

**Course Outcomes**

On completion of the course, learner will be able to

CO1. **UNDERSTAND** and **ANALYZE** the mechanism, process parameters of mechanical assisted modern machining processes.

CO2. **UNDERSTAND** the mechanism, construction and working of laser, plasma and electron beam assisted machining.

CO3. **CLASSIFY** and **ANALYZE** the mechanism, process parameters of the chemical and electrochemical machining.

CO4. **RELATE** and **ANALYZE** the mechanism and select process parameters Electrical Discharge Machining for an application.

CO5. **ILLUSTRATE** the application of micromachining processes.

CO6. **SUGGEST** appropriate nanomachining process for the specific application.

**Course Contents**

**Unit 1** **Mechanically Assisted Modern Machining Process**

Introduction to modern manufacturing processes, Need and classification of modern manufacturing methods.

Introduction to advanced Mechanical Energy Process machining processes and their classification - Abrasive Jet Machining (AJM), Abrasive Water Jet Machining (AWJM), Ultra Sonic Machining (USM), Water Jet Machining (WJC) -Principle, Working, process parameters, Effect of process parameters on Material removal rate, tool wear, surface finish, Advantages, Limitations, applications, economics of machining.

**Unit 2** **Energy Assisted Modern Fabrication Process**

Introduction to Energy Process machining processes, Principle, applications, classifications and selection, process parameters, concept of energy level, Heat Affected Zone and economics of the process in Laser beam machining (LBM) Laser Optics, Plasma arc machining (PAM), Electron Beam Machining (EBM), Focused Ion beam (FIB).

| Unit 3 | Electro-chemical Machining Process |
|---|---|

Electro chemical machining (ECM): Introduction, Working Principle, equipment, process parameters, material removal rates, surface integrity, type of electrolyte, Advantages, limitations & applications of ECM, economics of machining.

Electrochemical Grinding (ECG), Electro stream Drilling (ESD), Photochemical machining (PCM) Chemical machining (ChM).

| Unit 4 | Electro-thermal Machining Process |
|---|---|

Electric discharge machining (EDM): Introduction, Working Principle, EDM-Spark Circuits, selection of tool electrodes and dielectric fluids, process parameters, material removal rates, surface integrity, Heat Affected zone, Advantages, limitations & applications of EDM, Wire Electric Discharge Machining (W-EDM), Electric Discharge Grinding (EDG), Electric Discharge Diamond Grinding (EDDG), economics of machining. Electrochemical discharge machining (ECDM)

| Unit 5 | Micro And Precision Manufacturing Process |
|---|---|

Micro machining processes that include working principle, material removal mechanism, effect of process parameters, materials processed, applications - Diamond turn machining, micro turning, Micro drilling, micro engraving, micro milling, Micro electro discharge machining, Case study on each process. economics of machining.

| Unit 6 | Nano-Machining And Nano Finishing Techniques |
|---|---|

Fundamental of micro and nano technology, Effect of material aspects, concepts of micro and Nano systems and Microsystems Products, Microsystems and Microelectronics, Micro and Nano fabrication-wet and dry etching, photolithography-LIGA process, Application of Microsystems, Case study on MEMS.

Magnetic Abrasives Finishing (MAF), Abrasive Flow Finishing (AFF) Magnetorheological Finishing (MRF), Rotational - Magnetorheological Abrasive Flow Finishing (R-MRAFF).

**Books & Other Resources**

**Text Books**


1. V. K. Jain "Advanced Machining Processes" Allied Publishers Pvt. Ltd., New Delhi, 2007.
2. Pandey P.C. and Shan H.S. "Modern Machining Processes" Tata McGraw-Hill.
3. Production technology, HMT, McGraw Hill Education India Pvt. Ltd. 2001.
4. M. P Groover., "Fundamentals of Modern Manufacturing: Materials, Processes, and Systems", 6th edition, Wiley 2015.


**Reference Books**


1. V. K. Jain, "Micro manufacturing Processes", CRC Press.
2. R. Balasubramaniam, RamaGopal V. Sarepaka, Sathyan Subbiah, "Diamond Turn Machining: Theory and Practice", CRC Press.
3. MEMS Material and Process Handbook, Reference proceedings, Reza Ghodssi, Pinyen Lin, Springer.
4. Hassan El-Hofy, "Advanced Machining Processes", McGraw Hill Publications.
5. Julian W. Gardner, "Microsensors MEMS and smart devices", Wiley.
6. Mc Geough, "Advanced Methods of Machining", Chapman and Hall, London, 1998.
7. A. Ghosh and A. K. Mallik, Manufacturing Science, East-West Press, New Delhi, 2006.

**Web References**

1. https://nptel.ac.in/courses/112/103/112103202
2. https://nptel.ac.in/courses/112/104/112104028
3. https://nptel.ac.in/courses/112/105/112105212

# Savitribai Phule Pune University
## Board of Studies - Mechanical and Automobile Engineering
## Undergraduate Program – Final Year Automation and Robotics (2019 pattern)

| 402044D: Industrial Engineering (Elective III) | | | | | |
|---|---|---|---|---|---|
| **Teaching Scheme** | | **Credits** | | **Examination Scheme** | |
| **Theory** | 3 Hrs/Week | **Theory** | 3 | **In-Semester** | 30 Marks |
| | | | | **End-Semester** | 70 Marks |

**Prerequisites:** Basic concepts of Mathematics and Mechanical Engineering, Industrial Orientation, Quality Control, Human Psychology, Basic Finance, Passion for Continual Improvement.

**Course Objectives:**

1. To introduce the concepts, principles, and framework of Industrial Engineering and Productivity enhancement approaches.
2. To familiarize the students with different time study and work measurement techniques for productivity improvement.
3. To introduce various aspects of facility design.
4. To acquaint the students with various components and functions of Production Planning and Control.
5. To acquaint the student about inventory management and approaches to control
6. To acquire the students with concepts of ergonomics, value engineering and job evaluation.

**Course Outcomes**

Learner will be able to:

CO1. **EVALUATE** the productivity and **IMPLEMENT** various productivity improvement techniques.
CO2. **APPLY** work study techniques and **UNDERSTANDS** its importance for better productivity.
CO3. **DEMONSTRATE** the ability to **SELECT** plant location, appropriate layout and material handling equipment.
CO4. **USE** of Production planning and control tools for effective planning, scheduling and managing the shop floor control.
CO5. **PLAN** inventory requirements and **EXERCISE** effective control on manufacturing requirements.
CO6. **APPLY** Ergonomics and legislations for human comfort at work place and **UNDERSTANDS** the role of value engineering in improving productivity.

**Course Contents**

| **Unit 1** | **Introduction to Industrial Engineering and Productivity** |
|---|---|

Introduction to Industrial Engineering, Historical background and scope, Contribution of Taylor, Gilbreth, Gantt, Maynard, Ford, Deming and Ohno. Importance of Industrial engineering. Introduction to Work system design

**Productivity**: Definition of productivity, Measures of Productivity, Total Productivity Model, Need for Productivity Evaluation, Productivity measurement models, Productivity improvement

| | |
|---|---|
| approaches, Principles, Productivity Improvement techniques – Technology based, Material based, Employee based, Product based techniques. (Numerical on productivity measurement) | |
| **Unit 2** | **Work Study** |
| **Method Study**: Introduction and objectives, Areas of application of work study in industry, Selection and Basic procedure. Recording techniques, Operations Process Chart, Flow Process Chart (Man, Machine & Material) Multiple Activity Chart, Two Handed process chart, Flow Diagram, String Diagram and Travel Chart, Cycle and chronocycle graphs, SIMO chart, Therbligs, Micro motion and macro-motion study: Principles of motion economy, Normal work areas and work place design.<br><br>**Work Measurement**: Techniques, time study, steps, work sampling, Determination of time standards. Observed time, basic time, normal time, rating factors, allowances, standard time, and standard time determination. (Numerical)<br><br>Introduction to PMTS, MTM, and MOST | |
| **Unit 3** | **Production Facility Design** |
| **Plant Location**: Introduction, Factors affecting location decisions, Multi-facility location<br><br>**Plant Layout**: Principles of Plant layout and Types, factors affecting layout, methods, factors governing flow pattern, travel chart for flow analysis, analytical tools of plant layout, layout of manufacturing shop floor, repair shop, services sectors, and process plant. Layout planning, Quantitative methods of Plant layout and relationship diagrams. Dynamic plant layout<br><br>**Material Handling**: Objectives and benefits of Material handling, Relationship between layout and Material handling, Equipment selection | |
| **Unit 4** | **Production Planning and Control** |
| Types and methods of Production, and their Characteristics, functions and objectives of Production Planning and Control, Steps: Process planning, Loading, Scheduling, Dispatching and Expediting with illustrative examples, Capacity Planning, Aggregate production planning and Master production scheduling. Introduction to a line of balance, assembly line balancing, and progress control<br><br>**Forecasting Techniques**: Causal and time series models, Moving average, Exponential smoothing, Trend and Seasonality. (Numerical) | |
| **Unit 5** | **Inventory and Inventory Control** |
| **Materials**: Profit Centre: Role of materials management techniques in material productivity improvement, cost reduction and value improvement.<br><br>**Purchase Management**: Purchase management, incoming material control. Acceptance sampling and inspection. Vendor rating system. | |

**Inventory**: Functions, Costs, Classifications, Deterministic inventory models and Quantity discount

**Inventory Control**: EOQ (Numericals), concepts, type of Inventory models-deterministic and probabilistic, Selective inventory control, Fundamental of Material Requirement Planning (MRP-I), Manufacturing Resource Planning (MRP-II), Enterprise Resource Planning (ERP), Just-in-Time system (JIT) and Supply Chain Management (SCM)

| **Unit 6** | **Ergonomics, Value Engineering and Job Evaluation** |
|---|---|

**Ergonomics**: Introduction to ergonomics and human factors Engineering - physiological basis of human performance, basic anatomy of human body and its functional systems; principles of ergonomics, design of display and controls in relation to information processing by human being, Introduction to Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA)

**Value Engineering**: VE concepts, Principles, Methodologies and standards, methods of functional analysis.

**Job Evaluation and Wage Plan**: Objective, Methods of job evaluation, job evaluation procedure, merit rating (Performance appraisal), method of merit rating, wage and wage incentive plans, Performance appraisal, concept of KRA (Key Result Areas), Introduction to industrial legislation.

**Books and other resources**

## Text Books:


1. O. P. Khanna, Industrial engineering and management, Dhanpat Rai publication
2. M Mahajan, Industrial Engineering and Production Management, Dhanpat Rai and Co.
3. Martend Telsang, Industrial Engineering, S. Chand Publication.
4. Banga and Sharma, Industrial Organization& Engineering Economics, Khanna publication.


## References Books:


1. Askin, Design and Analysis of Lean Production System, Wiley, India
2. Introduction to Work Study by ILO, ISBN 978-81-204-1718-2, Oxford & IBH Publishing Company, New Delhi, Second Indian Adaptation, 2008.
3. H. B. Maynard, K Jell, Maynard's Industrial Engineering Hand Book, McGraw Hill Education.
4. Zandin K.B., Most Work Measurement Systems, ISBN 0824709535, CRCPress,2002
5. Martin Murry, SAP ERP: Functionality and Technical Configuration, SAP Press.
6. Barnes, Motion and time Study design and Measurement of Work, Wiley India
7. Sumanth, D.J, "Productivity Engineering and Management", TMH, New Delhi, 1990.
8. Edosomwan, J.A, "Organizational Transformation and Process re- Engineering", British Cataloging in publications, 1996.
9. Prem Vrat, Sardana, G.D. and Sahay, B.S, "Productivity Management - A systems approach", Narosa Publications, New Delhi, 1998.
10. Francis, R.L., and White, J.A, "Facilities layout and Location", Prentice Hall of India, 2002.
11. James A. Tompkins, John A. White, "Facilities Planning", Wiley, 2013
12. Richard L. Francis, Leon F Mc Ginnes and John A. White, "Facility Layout and Location-

An Analytical Approach", PHI, 1993
13. G. K. Agarawal, "Plant Layout and Material Handling", Jain Brothers, 2007

**Web References:**

1. https://archive.nptel.ac.in/courses/112/107/112107143/#
2. https://nptel.ac.in/courses/112107249
3. https://onlinecourses.nptel.ac.in/noc22_me04/preview
4. https://nptel.ac.in/courses/112107292
5. https://nptel.ac.in/courses/112107142

# Savitribai Phule Pune University
## Board of Studies - Mechanical and Automobile Engineering
## Undergraduate Program – Final Year Automation and Robotics (2019 pattern)

| 402044F: Computational Fluid Dynamics (Elective III) | | | | | |
|---|---|---|---|---|---|
| **Teaching Scheme** | | **Credits** | | **Examination Scheme** | |
| **Theory** | 3 Hrs./Week | **Theory** | 3 | **In-Semester** | 30 Marks |
| | | | | **End-Semester** | 70 Marks |

**Prerequisites:** Mathematics, Physics, Systems in Mechanical Engineering, Engineering Thermodynamics, Applied Thermodynamics, Fluid Mechanics, Numerical & Statistical Methods, Heat & Mass Transfer, Computer Aided Engineering

**Course Objectives:**

1. Model fluid / heat transfer problems, apply fundamental conservation principles and Identify Discretization methods
2. Formulate a model the for conduction and advection problems
3. Formulate a model the for Convection-Diffusion problems
4. Understand the External/Internal flow simulation
5. Recognize the Scales of turbulence and Understand the formulation methods
6. Understand the Fluid-Structure Interaction Problems and their applications

**Course Outcomes:**

On completion of the course the learner will be able to;

CO1. **DISTINGUISH** and **ANALYSE** the governing equations of fluid mechanics and heat transfer in various formulations

CO2. **ANALYZE** and **MODEL** the conduction and advection problems

CO3. **ANALYZE** and **MODEL** the Convection-Diffusion problems

CO4. **IDENTIFY** and **EVALUATE** the External/Internal flow and its simulation

CO5. **DISTINGUISH** and **COMPARE** concepts of stability and turbulence.

CO6. **USE** and **APPLY** a CFD tool for effectively solving practical Fluid-Structure Interaction problems

**Course Contents**

| **Unit 1** | **Introduction to Computational Fluid Dynamics** |
|---|---|

Introduction to Computational Fluid Dynamics, CFD as a research and design tool, Applications in various branches of Engineering, Derivation and physical interpretation of governing equations (conservation of mass, momentum and energy) in differential form, Concept of substantial derivative, divergence and curl of velocity, Mathematical behavior of Governing Equations and boundary conditions, Discretization methods for the CFD (FDM, FVM, FEM, Hybrid Methods), Intro to Meshless Methods, Meshed Vs Meshless Methods

| Unit 2 | Conduction and Advection |
|---|---|
| **Conduction:** Solution of two dimensional steady and unsteady heat conduction equation using finite volume method (Implicit and Explicit) with Dirichlet, Neumann, Robbin boundary conditions, Stability Criteria<br><br>**Advection:** Solution of two dimensional steady and unsteady heat advection equation using finite volume method (Implicit and Explicit) with Dirichlet BC, Stability Criteria, Introduction to first order upwind, CD, second order upwind and QUICK convection schemes | |
| **Unit 3** | **Convection-Diffusion** |
| Solution of two dimensional steady and unsteady heat convection-diffusion equation for slug flow using finite volume method (Implicit and Explicit), Stability Criteria, 1-D transient convection-diffusion system, Peclet Number | |
| **Unit 4** | **Introduction to External/Internal flow simulation** |
| Solution of Navier-Stoke' equation for incompressible flow using SIMPLE algorithms for lid driven cavity flow problem, Introduction to external flow simulation – Flow over circular Cylinder and Aerfoils. | |
| **Unit 5** | **Turbulent Flow Modeling** |
| Introduction to turbulence, Scales of turbulence, Reynolds Averaged Navier-Stokes (RANS) equation, One equation model (Derivation) and two equation model, Introduction to Direct Numerical Simulation (DNS), Large Eddy Simulation (LES) | |
| **Unit 6** | **Introduction to Fluid-Structure Interaction** |
| Types of Fluid-Solid Couplings, Applications, Mechanical Forces and Equilibrium, Rigid Body Motions, Balance Laws in Lagrangian and Eulerian Form, Lagrangian Solid System, Eulerian Fluid System, Kinematics of Eulerian and Lagrangian Modeling, Continuum Mechanics of Moving Domains, Coupled Fluid-Structure Equations, Application of Arbitrary Lagrangian Eulerian (ALE) Formulation | |

| Books and other resources |
|---|
| **Text Books:**<br>1. Ghoshdastidar, P. S. (2017), "Computational Fluid Dynamics and Heat Transfer," Cengage learning, ISBN: 9788131533079<br>2. Atul Sharma, A., (2016), "Introduction to Computational Fluid Dynamics: Development, Application and Analysis," Wiley, ISBN: 9781119002994<br>3. Versteeg, H. K., Malalasekhara, W., (2007), "An Introduction to Computational Fluid Dynamics: The Finite Volume Method," PHI, ISBN: 9780131274983<br>4. Muralidharan, K., Sundarajan , T., (2009), "Computational Fluid Flow and Heat Transfer," Narosa Pub, ISBN: 9788173195228<br>5. Rao, J.S., (2017), "Simulation Based Engineering in Fluid Flow Design," Springer, ISBN: 9783319463810<br>6. Anderson, Jr., D. A. A (2017), "Computational Fluid Dynamics - the Basics withApplications," , McGraw Hill Education, ISBN: 9781259025969<br>7. Jaiman, R. K. and Joshi, V., (2022), "Computational Mechanics of Fluid-Structure Interaction: Computational Methods for Coupled Fluid-Structure Analysis," Springer, ISBN: 9789811653544 |
| **References Books:**<br>1. Thompson, J. F., Soni, B. K., Weatherill, N. P., (1998), "Handbook of Grid Generation," CRC Press, ISBN: 9780849326875<br>2. Ferziger, J. H., Perić, M., Street, R. L., (2019), "Computational Methods for Fluid Dynamics,"Springer, ISBN: 9783319996912<br>3. Pletcher, R.H., Tannehill, J.C., Anderson, D.A., (2012), "Computational Fluid Mechanics and Heat Transfer," CRC Press, ISBN: 9781591690375<br>4. Patankar, S. V., (2017), "Numerical Heat Transfer and Fluid Flow," CRC Press, ISBN: 9781138564695<br>5. Chung, T. J., (2014), "Computational Fluid Dynamics," Cambridge University Press, ISBN: 9781107425255<br>6. Tu, J., Yeoh, G-H. and Liu, C., (2018), "Computational Fluid Dynamics: A practical |
| **Web References:**<br>1. Singh, K. M., (2019), "Computational Fluid Dynamics," IIT Roorkee, https://nptel.ac.in/courses/112107080<br>2. Ramakrishna, M., (2019), "Introduction to CFD," IIT Madras, https://archive.nptel.ac.in/courses/101/106/101106045/<br>3. Roy, A., (2019), "Introduction to CFD," IIT Kharagpur, https://archive.nptel.ac.in/courses/101/105/101105085/<br>4. Chakraborty, S., (2020), "Computational Fluid Dynamics," IIT Kharagpur, https://archive.nptel.ac.in/courses/112/105/112105254/<br>5. Chandrasekaran, S., (2019), "Advanced Marine Structures," IIT Madras, https://nptel.ac.in/courses/114106037 |

# Savitribai Phule Pune University

**Board of Studies - Mechanical and Automobile Engineering**

**Undergraduate Program – Final Year Automation and Robotics (2019 pattern)**

| **402545A: Lean Manufacturing (Elective IV)** | | | | | |
|---|---|---|---|---|---|
| **Teaching Scheme** | | **Credits** | | **Examination Scheme** | |
| **Theory** | 3 Hrs/Week | **Theory** | 3 | **In-Semester** | 30 Marks |
| | | | | **End-Semester** | 70 Marks |

**Prerequisites:** Introduction to Manufacturing

**Course Objectives:**

1. Understand the principles and concepts of lean manufacturing
2. Explore the application areas of lean manufacturing
3. Develop knowledge of lean tools and techniques
4. Analyze and optimize manufacturing processes using lean principles
5. Cultivate a lean culture and leadership mindset
6. Apply lean principles to real-world scenarios

**Course Outcomes:**

On completion of the course the learner will be able to;

CO1: DEMONSTRATE a comprehensive understanding of the principles and concepts of lean manufacturing and their application in different industries.

CO2: ANALYZE manufacturing processes to identify and eliminate waste, inefficiencies, and non-value-added activitie

CO3: APPLY lean tools and techniques such as value stream mapping, 5S methodology, Kanban, and Kaizen to improve process flow, reduce lead time, and increase productivity.

CO4: EVALUATE the impact of lean manufacturing on key performance indicators (KPIs) such as cycle time, inventory levels, quality, and customer satisfaction.

CO5: DESIGN and IMPLEMENT lean projects and initiatives in real-world manufacturing settings, considering organizational constraints and resource limitations

CO6: UTILIZE data collection and analysis techniques to measure and monitor process performance, identifying areas for improvement and making data-driven decisions.

**Course Contents**

| **Unit 1** | **Introduction to Lean Manufacturing** |
|---|---|

**Overview of Lean Manufacturing**: Definition and principles of lean manufacturing, Evolution and history of lean manufacturing, Benefits and applications of lean manufacturing, **Lean Thinking**: Concepts of waste and value in lean thinking, Five principles of lean thinking, Customer focus and value creation, **Lean Culture and Leadership**: Building a lean culture in organizations, Role of leadership in lean transformation, Employee engagement and empowerment in lean organizations.

| **Unit 2** | **Lean Tools and Techniques** |
|---|---|

**Value Stream Mapping:** Basics of value stream mapping, Identifying value and non-value-added activities, Value stream mapping symbols and techniques, **5S Methodology**: Sort Set in Order, Shine, Standardize, Sustain (5S) principles, Implementing 5S in the workplace, Benefits and impact of 5S on productivity and efficiency**, Just-in-Time (JIT) Production:** Principles and concepts of

JIT production, Kanban systems and pull production, JIT implementation strategies and challenges.

| **Unit3** | **Lean Manufacturing Tools** |
|---|---|

**Total Productive Maintenance (TPM):** Introduction to TPM and its objectives, Components and pillars of TPM, Implementing TPM for improved equipment reliability, **Kaizen and Continuous Improvement:** Definition and principles of Kaizen, PDCA cycle and Kaizen events, Creating a culture of continuous improvement, **Poka-Yoke and Error Proofing:** Understanding poka-yoke and mistake-proofing, Types of poka-yoke devices, Designing error-proof systems and processes.

| **Unit 4** | **Lean Production Systems** |
|---|---|

**Cellular Manufacturing**: Introduction to cellular manufacturing, Benefits and characteristics of cellular manufacturing, Designing and implementing cellular layouts, **Lean Supply Chain Management**: Basics of lean supply chain management, Supplier management and partnerships, Lean principles in logistics and distribution, **Lean Six Sigma:** Integration of lean manufacturing and Six Sigma, DMAIC methodology in lean Six Sigma projects, Lean tools in Six Sigma process improvement.

| **Unit 5** | **Lean Management and Performance Measurement** |
|---|---|

**Lean Leadership and Teamwork**: Role of leaders in lean organizations, Creating cross-functional teams for lean projects, Team dynamics and collaboration in lean environments, **Lean Performance Measurement**: Key performance indicators (KPIs) in lean manufacturing Lean metrics and data collection Lean scorecards and visual management

| **Unit 6** | **Lean Implementation and Case Studies** |
|---|---|

**Lean Implementation Strategies:** Developing a lean implementation plan, Change management in lean transformation, Overcoming resistance to lean, **Case Studies in Lean Manufacturing:** Analysis of successful lean manufacturing implementations, Lessons learned from lean case studies, Applying lean principles to real-world scenarios.

**Books and other resources**

**Text Books:**


1. Design and Analysis of Lean Production Systems, Ronald G. Askin & Jeffrey B. Goldberg, John Wiley & Sons, 2003.
2. Mikell P. Groover (2002) Automation, Production Systems and CIM.
3. Rother M. and Shook J, 1999 Learning to See: Value Stream Mapping to Add Value and Eliminate Muda‘ , Lean Enterprise Institute, Brookline, MA.


**References Books:**


1. Besterfield, D H et al., “Total Quality Management”, 3rd Edition, Pearson Education, 2008.
2. K C Jain and A K Chitale , “Quality Assurance and Total Quality Management (ISO 9000, QS 9000 ISO 14000)” by, Khanna Publishers
3. Liker J. K. – ‘Becoming Lean’ – Industrial Engineering and Management Press – 1998


**Web References:**

https://archive.nptel.ac.in/courses/112/104/112104188/

# Savitribai Phule Pune University

**Board of Studies - Mechanical and Automobile Engineering**

**Undergraduate Program – Final Year Automation and Robotics (2019 pattern)**

| **402545B: Project Management (Elective IV)** | | | | | |
|---|---|---|---|---|---|
| **Teaching Scheme** | | **Credits** | | **Examination Scheme** | |
| **Theory** | 3Hrs/Week | **Theory** | 3 | **In-Semester** | 30 Marks |
| | | | | **End-Semester** | 70 Marks |

**Prerequisites:** Basic statistical Mathematics, Concept of production and control.

**Course Objectives:**

1. To Understand the project management framework
2. To develop the project planning skills.
3. To enhance the leadership and team management skills.
4. To Promoting ethical and professional conduct.
5. To provide opportunities to apply project management concepts and techniques through real-world case studies.

**Course Outcomes:**

On completion of the course the learner will be able to;

CO1: UNDERSTAND Comprehensive fundamental and technical knowledge of Project Planning.

CO2: APPLY leadership and decision-making capabilities

CO3: HANDLE the project through project planning steps.

CO4: ANALYZE the projects through network techniques and handle financial aspects of project

**Course Contents**

| **Unit 1** | **Introduction to Project Management** |
|---|---|

Forms of project organization, project planning, project control, human aspects of project management, prerequisites for successful project implementation, Project life cycle, Project stakeholders and their roles Project success factors. Function of Project Planning: Inter dependency relationship, Generation and screening of project ideas, project rating index. Characterization of the market, demand forecasting, market planning.

| **Unit 2** | **Project Initiation and Planning** |
|---|---|

Introduction to Project Initiation and Planning, Project selection and prioritization, Project charter and scope statement, Work breakdown structure (WBS), Project scheduling techniques (e.g., Gantt charts, network diagrams), Resource planning and allocation, Risk identification and analysis, Stakeholder management and communication planning, Project Procurement Planning, Project Integration and Plan Development.

| **Unit3** | **Project Execution and Control** |
|---|---|

Project team development and management, Project monitoring and control, Change management, Quality management, Procurement management, Performance measurement and reporting, Project documentation and record keeping, Network techniques for project management, development of project network, time estimation, determination of critical path, scheduling when resources are limit, PERT and CPM models.

| **Unit 4** | **Project Cost Management** |
|---|---|

Legal and ethical aspects of project management Concept, make or buy decision, assumptions, merits and demerits of breakeven analysis. Applications: Linear, multi product break-even analysis. Learning curves, product life cycle cost analysis –Tools and techniques–activity based costing – concepts, cost drivers; introduction to target costing – need and applications., Cost estimation techniques (e.g., analogies, parametric estimation, bottom-up estimation), Cost budgeting and resource allocation, Cost control and variance analysis, Earned value management (EVM), Project financial management, Cost forecasting and cash flow management

| **Unit 5** | **Project Closure and Evaluation** |
|---|---|

Significance of project closure and evaluation, Overview of the project closure and evaluation process, Project closure activities, Project Evaluation Methods and Techniques, Project Audits and Reviews, Project Success Measurement, Project Closure and Transition Management, Lessons Learned and Knowledge Management, Project Closeout and Final Reporting, Project Evaluation in Different Contexts, Agile project closure and evaluation.

| **Unit 6** | **Advancement in Project Management** |
|---|---|

Overview of emerging trends and advancements in project management and costing, Agile project management, Lean Project Management, Project Management in a Digital Environment, Sustainability and Green Project Management, Project Risk Management in Uncertain Environments, Project Management for Innovation and Product Development, Emerging Trends and Future Directions in Project Management, Project management software and tools, Project management in different industries, Sustainability and environmental considerations.

**Books and other resources**

**Text Books:**

1. “Project Management: A Systems Approach to Planning, Scheduling, and Controlling” by Harold Kerzner.
2. “Project Management: The Managerial Process” by Erik W. Larson and Clifford F. Gray.
3. “Effective Project Management: Traditional, Agile, Extreme” by Robert K. Wysocki.
4. “Project Management: Planning and Control Techniques” by R. S. Goyal.
5. “Project Management: A Managerial Approach” by Jack R. Meredith and Samuel J. Mantel Jr.
6. “Project Management: The Managerial Process” by V. K. Agarwal and M. S. Yadav.

**Reference Books:**

1. “Project Management: A Managerial Approach” by S. Choudhury and P. Sengupta.
2. “Project Management for the Unofficial Project Manager” by Kory Kogon, Suzette Blakemore, and James Wood.
3. “Project Management: Principles, Techniques, and Tools” by N. K. Agarwal
4. “Project Management: Planning, Scheduling, and Control” by R. L. Garg
5. “Project Management: A Multi-Perspective Analysis” by Dr. Prasanna Chandra
6. “Project Management With CPM, PERT and Precedence Diagramming” Moder, J. J. and Phillips, C. Van Nostrand Reinhold, 1983, ISBN-10: 0442254156, ISBN-13: 978-0442254155.

**Web References:**

1. Project Smart – An online resource covers various project management topics, methodologies, and techniques to enhance project success. Website: https://www.projectsmart.co.uk/
2. Gartner Project Management – project management webpage provides access to research reports, webinars, and insights on project management tools, methodologies, and trends. Website: https://www.gartner.com/en/areas-of-expertise/project-portfolio-management.
3. Project Management by Prof. Raghu Nandan Sengupta, IIT Kanpur,

https://nptel.ac.in/courses/110104073.

4. Project Management for Managers by Dr. Mukesh Kumar Barua, IIT Roorkee https://nptel.ac.in/courses /110107081.

# Savitribai Phule Pune University

**Board of Studies - Mechanical and Automobile Engineering**

**Undergraduate Program – Final Year Automation and Robotics (2019 pattern)**

## 402045C: Additive Manufacturing (Elective- IV)

| Teaching Scheme | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|
| **Theory** | 3 Hrs./Week | **Theory** | 3 | **In-Semester** | 30 Marks |
| | | | | **End-Semester** | 70 Marks |

**Prerequisite:**

Manufacturing processes, Engineering metallurgy, Solid mechanics

**Course Objectives**

1. To know the principle, methods, possibilities and limitations as well as environmental hazards of Additive Manufacturing technologies.
2. To get familiar with the characteristics of the different materials used in Additive Manufacturing technologies
3. To explore the potential of additive manufacturing technologies in real life applications.

**Course Outcomes**

On completion of the course, learner will be able to

CO1. **USE** and **CLASSIFY** the fundamentals of Additive Manufacturing Technologies for engineering applications.

CO2. **IDENTIFY** and **CATEGORIZE** the methodology to manufacture the products using light-based photo-curing, LASER based technologies and **STUDY** their applications, benefits.

CO3. **IDENTIFY** and **CATEGORIZE** the methodology to manufacture the products using extrusion-based deposition, inkjet-based technologies and **STUDY** their applications, benefits.

CO4. **SYNTHESIZE, RECOMMEND** and **DESIGN** the suitable material and process for fabrication and build behavior of verities of product.

CO5. **DESIGN** and **CONSTRUCT** the AM equipment's for appropriate applications and the input CAD model.

CO6. **DEVELOP** the knowledge of additive manufacturing for various real-life applications.

**Course Contents**

**Unit 1 Introduction to Additive Manufacturing**

Introduction to AM, Historical Development, Additive v/s Conventional Manufacturing, Role of AM in Product development cycle, Rapid prototyping, Relevance of AM in Industry 4.0, Current industry and manufacturing trends driving AM, AM Process-Chain, Reverse engineering, Advantages, Types of materials, Classification of AM Processes (Process-based, material form based, application-based - direct and indirect processes and Micro- and Nano-additive processes), Process Planning for Additive Manufacturing

| Unit 2 | Light and LASER based Techniques |
|---|---|

Introduction, Process and mechanism, Materials, Process Physics, Parameters, Benefits, Drawbacks, Limitations and Applications of

**Light-Based Photo-curing**: Stereolithography (SLA), Digital Light Processing (DLP), Direct Laser Writing (DLW), Continuous Liquid Interface Production (CLIP)

**Laser-Based Melting**: Selective Laser Sintering (SLS), Direct Metal Laser Sintering (DMLS), Selective Laser Melting (SLM), Electron-Beam Melting (EBM), Laser Blown Powder, Laser Wire Deposition, Laser Engineered Net Shaping (LENS), 3D Laser Cladding

| Unit 3 | Extrusion and energy based Techniques |
|---|---|

Introduction, Process and mechanism, Materials, Process Physics, Parameters, Benefits, Drawbacks, Limitations and Applications of

**Extrusion-Based Deposition**: Fused Deposition Modeling (FDM), Fused Filament Fabrication (FFF), Direct Ink Writing (DIW), Robocasting, Bio-printing

**Inkjet(droplet)-Based Deposition and Fusion**: Multi-jet Modeling (MJM), Polyjet Printing, Nanoparticle Jetting, Binder Jetting, Multi-Jet Fusion, Color-jet Printing (CJP), Energy Deposition Techniques: Plasma/TIG/MIG/Arc Deposition, Electron Beam-based DED, Direct Metal Deposition (DMD)

| Unit 4 | Materials and Design for AM |
|---|---|

Introduction, Materials: Metals, Polymers, Ceramics & Bio-ceramics, Composites, Hierarchical Materials, Biomimetic Materials, Shape-Memory Alloys, 4D Printing & Bio-active materials, Material selection,

**AM Material Specific Process Parameters**: Processes, Heat or Chemical Treatments, Phase Transformations, Process Selection for various applications, DfAM: Process specific strategies, Rules and Recommendations,

**Quality considerations and Post-Processing techniques**: Requirements and Techniques, Support Removal, Sanding, Acetone treatment, Polishing, Heat treatments, Hot isostatic pressing, Materials science, Surface enhancement Techniques and its Material Science Analysis of AM's error sources

| Unit 5 | Hardware and Software for AM |
|---|---|

Construction of Basic AM Machines: Equipment Layout and sub-system Design, Construction, Working, Equipment Topology/Layout Frame Designs, 3D Printer Design Considerations (Filament, Frame, Build Platform, Extruder Design, Nozzles, Print Bed, Heated build/Base Plate, Heater, Dispenser, Optical system, Cooling system, Gas Recirculation System, Laser controller, Gas Filtration, Inert Gas Cooling system, Powder Handling System, Loading/unloading System, Moving Parts and end stops, Sensors, Actuators, Motors and Control Electronics, Power supply, Machine Tool Peripheral), Raw Material Manipulation Software and Controller: Types of In-fill, Types of slicing, Software Integration (with Process, Slicing, etc), Control system (PLC and safety PLC, micro control/ Microcontroller, Micro-processor control), CAD Software and Controller Interfacing, CURA Software, Relevant G/M Codes, Standard firmware (Merlin Software, etc), In-process Monitoring, Calibration

| Unit 6 | Case Studies, Application and Special Topics |
|---|---|

**Case Studies and Application of AM:** 3D printing in prominent industries (Aerospace, Electronics, Defense, Automotive, Construction, Architectural, Machine-Tools), Other industrial applications (Health-Care, Personalized Surgery, Bio-medical Applications, Assistive Devices, Food-Processing, Food & Consumer Applications, Art, Fashion, Jewelry, Toys & Other Applications, etc)

**Special Topics:** 4D/5D Printing, Bio-printing, Bio-materials, scaffolds and tissue and Organ Engineering, Mass Customization and Future trends.

**Books & Other Resources**

**Text Books**


1. Chua Chee Kai, Leong Kah Fai, "3D Printing and Additive Manufacturing: Principles & Applications", 4th Edition, World Scientific, 2015 2.
2. Amit Bandyopadhyay, Susmita Bose, "Additive manufacturing", CRC Press, Taylor & Francis Group, 2016 3.
3. Ian Gibson, David W. Rosen, Brent Stucker "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing" Springer, 2010


**Reference Books**


1. L. Lu, J. Y. H. Fuh and Y.S. Wong, "Laser-Induced Materials and Processes for Rapid Prototyping", Springer, 2001
2. Andreas Gebhardt and Jan-Steffen Hötter, "Additive Manufacturing: 3D Printing for Prototyping and Manufacturing" Hanser Publishers, Munich, 2016.
3. Ben Redwood, FilemonSchöffer& Brian Garret, "The 3D Printing Handbook: Technologies, design and applications", 3D Hubs B.V. 2017
4. Ehsan Toyserkani, Amir Khajepour, Stephen F. Corbin, "Laser Cladding", CRC Press, 2004
5. Andreas Gebhardt, "Understanding Additive", Hanser Publishers, Munich, 2011
6. Ben Redwood, Filemon Schöffer & Brian Garret, "The 3D Printing Handbook – Technologies, Design and Applications" Part One:3D Printing Technologies and Materials, 3D Hubs, 2017
7. Chee Kai, Kah Fai, Chu Sing, 'Rapid Prototyping: Principles and Applications", 2nd Ed., 2003
8. D. T. Pham and S.S. Dimov, "Rapid Manufacturing" Springer, 2001
9. Rupinder Singh J. Paulo Davim, "Additive Manufacturing - Applications and Innovations" CRC Press Taylor& Francis Group, 2019
10. . I. Gibson, D. W. Rosen, B. Stucker, "Additive Manufacturing Technologies" Springer, 2010
11. L. Jyothish Kumar, Pulak M. Pandey, David Ian Wimpenny, "3D Printing and Additive Manufacturing Technologies" Springer, 2019


**Web References**

1. NPTEL Course on Fundamentals of Additive Manufacturing Technologies by Prof. SajanKapil, IIT Guwahati, https://onlinecourses.nptel.ac.in/noc21_me115/preview
2. Introduction to Additive Manufacturing, https://www.youtube.com/watch?v=LCQoi10cG To NPTEL IIT Kanpur, "Rapid Manufacturing", Dt. Janakarajan Ramkumar Prof. Amandeep Singh, https://onlinecourses.nptel.ac.in/noc20_me50/preview

| 402045D: Operation Research (Elective- IV) | | | | | |
|---|---|---|---|---|---|
| **Teaching Scheme** | | **Credits** | | **Examination Scheme** | |
| **Theory** | 03 Hrs/Week | **Theory** | 03 | **In-Semester** | 30 Marks |
| | | | | **End-Semester** | 70 Marks |

**Prerequisites:** Engineering Mathematics, Theory of Probability, Statistics, Basic Industrial Functions and Business Environment.

**Course Objectives:**

1. Develop a conceptual framework of the course
2. Understand the concept and scope of operational research, its historical development and its role in solving complex decision-making problems.
3. Sensitizes the students of the importance of course in real life environment

**Course Outcomes**

On completion of the course, learner will be able to

CO1. **EVALUATE** various situations of Games theory and Decision techniques and **APPLY** them to solve them in real life for decision making.

CO2. **SELECT** appropriate model for queuing situations and sequencing situations and **FIND** the optimal solutions using models for different situations.

CO3. **FORMULATE** various management problems and **SOLVE** them using Linear programming using graphical method and simplex method.

CO4. **FORMULATE** variety of problems such as transportation, assignment, travelling salesman and **SOLVE** these problems using linear programming approach.

CO5. **PLAN** optimum project schedule for network models arising from a wide range of applications and for replacement situations find the optimal solutions using appropriate models for the situation.

CO1: CO6. **APPLY** concepts of simulation and Dynamic programming

**Course Contents**

| **Unit 1** | **Introduction to OR, Theory of Games and Decision Analysis** |
|---|---|

**Introduction to OR:** Origin of Operations Research, Definition, Evolution and Classification of Quantitative methods, Operations Research Techniques and Methodology, Advantages and Limitations, Scope and Applications of OR

**Theory of Games:** Introduction, Classification of Games**,** Two-person Zero Sum Games, Solution of 2 x 2 Game with no Saddle Point, Dominance in Games, Subgame Method to Solve (2 x n or m x 2) Mixed Strategy Games, Graphical Method to Solve (2 x n or m x 2) Games

**Decision Analysis:** Introduction, Decision Under Certainty, Decision Under Risk, Decision Under Uncertainty (Maximin, Minimax, Maximax, Minimin Criterions, Hurwicz Criterion, Laplace Criterion, Savage or MiniMax Regret Criterion), Decision Tree.

| **Unit 2** | **Queuing Theory and Sequencing Model** |
|---|---|

**Queuing Theory:** Introduction, Elements of Queuing, Characteristics of Waiting Lines, Service discipline, Service Mechanism, Terminology and Kendall's Notation of Queuing system, Single Channel systems M/M/1: FCFS/ / and M/M/1: FCFS/ /

**Sequencing Models:** Solution of Sequencing Problem - Processing of n Jobs Through Two Machines, Processing of n Jobs Through Three Machines, Processing of Two Jobs Through m Machines, Processing of n Jobs Through m Machines

| **Unit 3** | **Linear Programming** |
|---|---|

Introduction, Formulation of LPP, LPP by Graphical Method, Solution of LPP by Simplex Method, Big M Method and Two-phase method (Limited to 2 variables only), Conversion of Primal to Dual problems

| **Unit 4** | **Transportation and Assignment Model** |
|---|---|

**Transportation Model:** Introduction**,** Formulation of Transportation problem, Methods to Find Basic Feasible Solution (Vogel's Approximation Method (VAM), Least Cost Method (LCM), North West Corner Rule (NWCR)), Unbalanced Transportation Problem, Degeneracy in Transportation Problem (Theoretical treatment only), Optimality Test- Modified Distributed Method

**Assignment Model:** Introduction, Mathematical Formulation of Assignment Problem Difference between Transportation and Assignment problem Assignment Problem, Hungarian Method, Balanced and Unbalanced Assignment problem, Maximization in Assignment Problems, Travelling Salesman Problem (Mathematical Formulation and Numerical)

| **Unit 5** | **Project Management** |
|---|---|

**Network Models:** Fulkerson's Rule, Concept and Types of Floats, CPM and PERT, Crashing Analysis and Resource Scheduling

**Replacement Analysis:** Replacement of Items that Deteriorate, Replacement of Items that Fail Suddenly

| **Unit 6** | **Simulation and Dynamic Programming** |
|---|---|

**Simulation:** Introduction, Simulation Definition, Types of Simulation, Steps of Simulation, Advantages and Disadvantage of simulation, Stochastic Simulation and Random numbers, Monte Carlo simulation, Random number Generation

**Dynamic Programming:** Introduction, Dynamic Programming Model, Applications of Dynamic Programming Model to Shortest Route problems, Bellman Optimality Principle, Resource Allocation problem by Dynamic Programming

**Books and other resources**

**Text Books:**


1. Prem Kumar Gupta, D. S. Hira, Problems in Operations Research: Principles and Solutions, S. Chand, 1991
2. J. K. Sharma, Operations Research: Theory and Application, Laxmi pub. India, 2010.
3. Operations Research, S. D. Sharma, Kedar Nath Ram Nath-Meerut, 2015.
4. L.C.Jhamb, Quantative Techniques Vol. I &II, Everest Publication, 2007.
5. Manohar Mahajan, Operation Research, Dhanpatrai Publication, 2006.
6. V. K. Kapoor, Operations Research: Quantitative Techniques for Management, Sultan Chand Publications, 2013.


**References Books:**


1. Hillier F.S., and Lieberman G.J., Operations Research, Eight Edition, Mc. Tata McGraw Hill, India, 2011.
2. Ravindran, ―Engineering optimization Methods and Applications‖, 2nd edition,

Wiley, India
3. Ravindran, Phillips and Solberg, Operations Research Principles and Practice, Second Edition, Mc. WSE Willey,
4. Operations Research - An introduction, Hamdy A Taha, Pearson Education, 2010

**Web References:**

https://nptel.ac.in/courses/110106062
https://nptel.ac.in/courses/111107128
https://www.digimat.in/nptel/courses/video/110106062/L01.html
https://archive.nptel.ac.in/courses/112/106/112106134/

# Savitribai Phule Pune University
## Board of Studies – Mechanical and Automobile Engineering
## Undergraduate Program – Final Year Automation and Robotics (2019 pattern)

| 402045E: Augmented Reality and Virtual Reality | | | | | |
|---|---|---|---|---|---|
| **Teaching Scheme** | | **Credits** | | **Examination Scheme** | |
| **Theory** | 3 Hrs./Week | **Theory** | 3 | **In-Semester** | 30 Marks |
| | | | | **End-Semester** | 70 Marks |

**Prerequisites:** Mathematics, Physics, Programming and Problem Solving, Engineering Graphics, Solid Modeling and Drafting, Numerical & Statistical Methods, Mechatronics, Artificial Intelligence &Machine Learning, Computer Aided Engineering

**Course Objectives:**

1. Learn the fundamental Computer Vision, Computer Graphics and Human-Computer interaction Techniques related to VR/AR
2. Review the Geometric Modeling Techniques
3. Review the Virtual Environment
4. Discuss and Examine VR/AR Technologies
5. Use of various types of Hardware and Software in Virtual Reality systems
6. Simulate and Apply Virtual/Augmented Reality to varieties of Applications

**Course Outcomes:**

On completion of the course the learner will be able to;

CO1. **UNDERSTAND** fundamental Computer Vision, Computer Graphics and Human-Computer Interaction Techniques related to VR/AR
CO2. **UNDERSTAND** Geometric Modeling Techniques
CO3. **UNDERSTAND** the Virtual Environment
CO4. **ANALYZE** and **EVALUATE** VR/AR Technologies
CO5. **APPLY** various types of Hardware and Software in Virtual Reality systems
CO6. **DESIGN** and **FORMULATE** Virtual/Augmented Reality Applications

**Course Contents**

| **Unit 1** | **Introduction to Virtual Reality (VR)** |
|---|---|

Virtual Reality and Virtual Environment, Computer graphics, Real time computer graphics, Flight Simulation, Virtual environment requirement, benefits of virtual reality, Historical development of VR, Scientific Landmark

| **Unit 2** | **Computer Graphics and Geometric Modelling** |
|---|---|

The Virtual world space, positioning the virtual observer, the perspective projection, human vision, stereo perspective projection, Color theory, Conversion From 2D to 3D, 3D space curves, 3D boundary representation, Simple 3D modelling, 3D clipping, Illumination models, Reflection models, Shading algorithms, Geometrical Transformations: Introduction, Frames of reference,

Modelling transformations, Instances, Picking, Flying, Scaling the VE, Collision detection

| Unit 3 | Virtual Environment |
|---|---|

**Input/Output Devices:** Input (Tracker, Sensor, Digital Gloves, Movement Capture, Video-based Input, 3D Menus & 3D Scanner, etc.), Output (Visual/Auditory/Haptic Devices)

**Generic VR system:** Introduction, Virtual environment, Computer environment, VR technology, Model of interaction, VR Systems, Animating the Virtual Environment: Introduction, The dynamics of numbers, Linear and Nonlinear interpolation, the animation of objects, linear and non-linear translation, shape & object in between, free from deformation, particle system

**Physical Simulation:** Introduction, Objects falling in a gravitational field, Rotating wheels, Elastic collisions, projectiles, simple pendulum, springs, Flight dynamics of an aircraft

| Unit 4 | Augmented Reality (AR) |
|---|---|

Taxonomy, Technology and Features of Augmented Reality, AR Vs VR, Challenges with AR, AR systems and functionality, Augmented Reality Methods, Visualization Techniques for Augmented Reality, Enhancing interactivity in AR Environments, Evaluating Arsystems

| Unit 5 | Development Tools and Frameworks |
|---|---|

**Human factors:** Introduction, the eye, the ear, the somatic senses

**Hardware:** Introduction, sensor hardware, Head-coupled displays, Acoustic hardware, Integrated VR systems

**Software:** Introduction, Modelling virtual world, Physical simulation, VR toolkits, Introduction to VRML

| Unit 6 | AR / VR Applications |
|---|---|

Introduction, Engineering, Entertainment, Science, Training, Game Development

**Books and other resources**

**Text Books:**


1. Coiffet, P., Burdea, G. C., (2003), "Virtual Reality Technology," Wiley-IEEE Press, ISBN: 9780471360896
2. Schmalstieg, D., Höllerer, T., (2016), "Augmented Reality: Principles & Practice," Pearson, ISBN: 9789332578494
3. Norman, K., Kirakowski, J., (2018), "Wiley Handbook of Human Computer Interaction," Wiley-Blackwell, ISBN: 9781118976135
4. LaViola Jr., J. J., Kruijff, E., McMahan, R. P., Bowman, D. A., Poupyrev, I., (2017), "3D User Interfaces: Theory and Practice," Pearson, ISBN: 9780134034324
5. Fowler, A., (2019), "Beginning iOS AR Game Development: Developing Augmented Reality Apps with Unity and C#," Apress, ISBN: 9781484246672
6. Hassanien, A. E., Gupta, D., Khanna, A., Slowik, A., (2022), "Virtual and Augmented Reality for Automobile Industry: Innovation Vision and Applications," Springer, ISBN: 9783030941017

**References Books:**


1. Craig, A. B., (2013), "Understanding Augmented Reality, Concepts and Applications," Morgan Kaufmann, ISBN: 9780240824086
2. Craig, A. B., Sherman, W. R., Will, J. D., (2009), "Developing Virtual Reality Applications, Foundations of Effective Design," Morgan Kaufmann, ISBN: 9780123749437
3. John Vince, J., (2002), "Virtual Reality Systems, "Pearson, ISBN: 9788131708446
4. Anand, R., "Augmented and Virtual Reality," Khanna Publishing House
5. Kim, G. J., (2005), "Designing Virtual Systems: The Structured Approach", ISBN: 9781852339586
6. Bimber, O., Raskar, R., (2005), "Spatial Augmented Reality: Merging Real and Virtual Worlds," CRC Press, ISBN: 9781568812304
7. O'Connell, K., (2019), "Designing for Mixed Reality: Blending Data, AR, and the Physical World," O'Reilly, ISBN: 9789352138371
8. Sanni Siltanen, S., (2012), "Theory and applications of marker-based augmented reality," Julkaisija –Utgivare Publisher, ISBN: 9789513874490


**Web References:**


1. Manivannan, M., (2018), "Virtual Reality Engineering," IIT Madras, https://nptel.ac.in/courses/121106013
2. Misra, S., (2019), "Industry 4.0: Augmented Reality and Virtual Reality," IIT Kharagpur, https://www.youtube.com/watch?v=zLMgdYI82IE
3. Dube, A., (2020), "Augmented Reality – Fundamentals and Development," NPTEL Special Lecture Series, https://www.youtube.com/watch?v=MGuSTAqlZ9Q
4. http://cambum.net/course-2.htm

# Savitribai Phule Pune University
## Board of Studies – Mechanical and Automobile Engineering
## Undergraduate Program – Final Year Automation and Robotics (2019 pattern)

| 402046: Data Analytics Laboratory | | | | | |
|---|---|---|---|---|---|
| **Teaching Scheme** | | **Credits** | | **Examination Scheme** | |
| **Practical** | 2 Hrs. | **Practical** | 1 | **Term Work** | 50 Marks |

**Prerequisites:** Engineering Mathematics**,** Artificial Intelligence & Machine Learning, Numerical and Statistical Methods, Fundamental of Engineering

**Course Objectives:**

1. To explore the fundamental concepts of data analytics.
2. To understand the various search methods and visualization techniques.
3. To apply various machine learning techniques for data analysis.

**Course Outcomes:**

On completion of the course, the learner will be able to

CO1: **UNDERSTAND** the basics of data analytics using concepts of statistics and probability.

CO2: **APPLY** various inferential statistical analysis techniques to describe data sets and withdraw useful conclusions from acquired data set.

CO3: **EXPLORE** the data analytics techniques using various tools

CO4: **APPLY** data science concept and methods to solve problems in real world context

CO5: **SELECT** advanced techniques to conduct thorough and insightful analysis and interpret the results

**Course Contents**

**Preamble:**

The motivation behind the data analytics lab for mechanical engineers is to make them competent to learn data-driven decision-making involving predictive, prescriptive, descriptive, and diagnostic analytics. Data analytics offers a new paradigm of bottom-up versus top-down modelling and solving supported by the traditional physics-based approach. An engineer involved in traditional modelling (e.g., developing a finite analysis or a reliability model) looks at the problem of interest and in essence, fits in the model he/she was trained to use. An engineer equipped with data science knowledge gathers historical data and uses data-mining tools to build the model of interest. If needed, he/she can further optimize this data-driven model with tools such as evolutionary computation algorithms.

**Possible approaches:**

*Predictive Analytics:*

Predictive analytics involves the use of mathematical methods and tools such as machine learning, data mining, statistical analysis, and predictive models. It is used to:

- Identify anomalies in the process, which help in preventive maintenance.
- Estimate the demand for product, raw material etc.: based on historical data and current

scenario.

- Forecast possible outcomes based on data obtained from the process.

*Prescriptive Analytics:*

Prescriptive analytics is used to identify ways in which an industrial process can be improved. While predictive analytics tells when could a component/asset fails, prescriptive analytics tells what action you need to take to avoid the failure. So, you can use the results obtained from prescriptive analysis to plan the maintenance schedule, review your supplier, etc. Prescriptive analytics also helps you manage complex problems in the production process using relevant information.

*Descriptive Analytics:*

The core purpose of descriptive analytics is to describe the problem by diagnosing the symptoms. This analytics method also helps discover the trends and patterns based on historical data. The results of a descriptive analytics are usually shown in the form of charts and graphs. These data visualization tools make it easy for all the stakeholders, even those who are non-technical to understand the problems in the manufacturing process.

*Diagnostic Analytics:*

Diagnostic analytics is also referred to as root cause analysis. While descriptive analytics can tell what happened based on historical data, diagnostic analytics tells you why it happened. Data mining, data discover, correlation, and down and drill through methods are used in diagnostic analytics. Diagnostic analytics can be used to identify cause for equipment malfunction or reason for the drop in the product quality.

**TERM WORK:**

**A] Experiments (Any 6)**

| Sr. No. | Data Domain | Objective | Methodology | Data type |
|---|---|---|---|---|
| 1 | Thermal / Heat Transfer / HVAC / Fluid Mechanics / Fluid Power | Predictive / Prescriptive / Descriptive / Diagnostic (but not limited to) | Statistical / mathematical /numerical/computational/intelligent (but not limited to) | Numeric or image based or data in any suitable form |
| 2 | Solid Mechanics / Design | | | |
| 3 | Machining / Manufacturing | | | |
| 4 | Automation & Robotics | | | |
| 5 | Maintenance / Reliability / Condition Monitoring | | | |
| 6 | Quality Control | | | |
| 7 | Materials and Metallurgy | | | |
| 8 | Energy Conservation and Management | | | |
| 9 | Industrial Engineering, Estimation, and Costing | | | |
| 10 | Automotive technology | | | |

**B] List of Assignments (Any Three)**

The survey of methods used for data analysis in the data domain mentioned above **(Any Three)** and discussion on any case studies.

**Guidelines for selection of data domain, source, size, etc.:**

- The data domain must be selected from various fields of mechanical engineering such as (but

not limited to) thermal, heat power, design, manufacturing, automotive, HVAC, condition monitoring, process industry, solid and fluid mechanics, quality, materials and metallurgy, automation & robotics, energy conservation and management, ERP, Industrial engineering, estimation, and costing, etc.

- The volume of data should be considerably larger size in view of extracting meaningful insights, such as hidden patterns, unknown correlations, trends, and customer preferences through tools such as machine learning, deep learning, reinforcement learning, etc. Though the data size cannot be bluntly defined or there is no threshold, however, the data gathered from small trials/experimentation to analyse the input-output relationship should not be considered such as a trial on an external gear pump for studying its characteristics considering limited range of parameters for few trials. The appropriate data size must be selected as per the relevant data domain to yield a reliable model. For example, in the case of vibration-based condition monitoring based on numeric data, the size of data gathered depends on the sampling frequency of data acquisition and ranges from 5 kHz to 20 kHz or even more than that as per the data domain. Same for image data, the minimum number of images with appropriate resolution should be selected w.r.t data domain to yield a robust model.
- The data collected through real-time experiments is preferred however in case of no resources/facility available, data collected through simulation, survey, etc. can also be considered. The benchmark datasets made available by standard technical/academic/research/commercial/professional societies and organizations are also allowed.
- The standard instrumentation is preferred for performing experiments and data collection; however, the use of open-source hardware for building in-house low-cost data acquisition systems is also recommended.
- The choice of programming language and software depends on the data domain and the provision of the methodology used for its processing. Any standard programming language and data analytics software can be used.
- The approach mentioned above (but not limited to) should be considered while defining the problem and objectives, selecting the data domain, and deciding the methodology. The methodology can be statistical, mathematical, numerical, computational, or intelligent.

**Books and Other Resources**

**Text Books:**


1. Brunton, S. L., & Kutz, J. N. (2022). Data-driven science and engineering: Machine learning, dynamical systems, and control. Cambridge University Press.
2. Dunn, P. F., & Davis, M. P. (2017). Measurement and data analysis for engineering and science. CRC press.
3. Roy, S. S., Samui, P., Deo, R., & Ntalampiras, S. (Eds.). (2018). Big data in engineering applications (Vol. 44). Berlin/Heidelberg, Germany: Springer.
4. Middleton, J. A. (2021). Experimental Statistics and Data Analysis for Mechanical and

Aerospace Engineers. Chapman and Hall/CRC.
5. Brandt, S. (1970). Statistical and computational methods in data analysis.
6. Robinson, E. L. (2017). Data analysis for scientists and engineers. In Data Analysis for Scientists and Engineers. Princeton University Press.
7. Araghinejad, S. (2013). Data-driven modeling: using MATLAB® in water resources and environmental engineering (Vol. 67). Springer Science & Business Media.
8. Niu, G. (2017). Data-driven technology for engineering systems health management. Beijing, China: Springer.

References Books:

1. Zsolt Nagy, “Artificial Intelligence and Machine Learning Fundamentals”, Packt Publishing, 2018, ISBN: 978-1-78980-165-1
2. Hastie, Trevor, Robert Tibshirani, Jerome H. Friedman, and Jerome H. Friedman. The elements of statistical learning: data mining, inference, and prediction. Vol. 2. New York: springer, 2009.
3. Zaki, Mohammed J., Wagner Meira Jr, and Wagner Meira. Data mining and analysis: fundamental concepts and algorithms. Cambridge University Press, 2014.
4. Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.

Assessment of Term Work

The student shall complete the above mentioned activities and prepare a Term Work in the form of Journal.

Important Note:
Term Work of the Student shall be evaluated based on the completion of experiments, group assignments and case studies. Continuous evaluation by the faculty shall be done for the award of the credit associated with the course.

# Savitribai Phule Pune University

## Board of Studies - Mechanical and Automobile Engineering

## Undergraduate Program – Final Year Automation and Robotics (2019 pattern)

| 402547: Project (Stage I) | | | | | |
|---|---|---|---|---|---|
| **Teaching Scheme** | | **Credits** | | **Examination Scheme** | |
| **Practical** | 4 Hrs/Week | **Practical** | 2 | **Term Work** | 50 Marks |
| | | | | **Oral** | 50 Marks |

**Prerequisites:** Project Based Learning, Internship/Mini Project, Laboratory works, Skill Development, Audit Courses, Industrial Visits, Project (Stage I)

**Course Objectives:**

1. To provide an opportunity of designing and building complete system or subsystems based on areas where the student likes to acquire specialized skills.
2. To obtain hands-on experience in converting a small novel idea / technique into a working model / prototype involving multi-disciplinary skills.
3. To embed the skill in a group of students to work independently on a topic/ problem/ experimentation selected by them and encourage them to think independently on their own to bring out the conclusion under the given circumstances of the curriculum period in the budget provided with the guidance of the faculty.
4. To encourage creative thinking processes to help them to get confidence by planning and carrying out the work plan of the project and to successfully complete the same, through observations, discussions and decision making process.

**Course Outcomes:**

On completion of the course the learner will be able to;

**CO1**. IMPLEMENT systems approach.
**CO2**. CONCEPTUALIZE a novel idea / technique into a product.
**CO3**. THINK in terms of a multi-disciplinary environment.
**CO4**. TAKE ON the challenges of teamwork, and DOCUMENT all aspects of design work.
**CO5**. UNDERSTAND the management techniques of implementing a project.
**CO6**. DEMONSTRATE the final product for Functionality, Designability, and Manufacturability.

**Course Contents**

Project work in the seventh semester is an integral part of the Term Work. The project work shall be based on the knowledge acquired by the student during the graduation and preferably it should meet and contribute towards the needs of the society.

1. Fabrication of product/testing setup of an experimentation unit/small equipment, in a group.
2. Experimental verification of principles used in Automation and Robotics Applications.
3. Projects having valid database, algorithm, and output reports, preferably software based.
4. Study projects are strictly not allowed.

**Project Lab**

1. There has to be a Project Lab in the department.

a. It consists of necessary tools required to do a project.
b. Previous projects and their components.
c. Common measuring instruments.
d. Previous years' project reports.
e. Project related books and Publications.

f. Proper linkage with central workshop and various laboratories.
g. Safety measures.
2. All the project activities must be handled with a digital platform which is developed in the department according to the policies laid down by the institution. Respective authority levels to be created to maintain the transparency and confidentiality of the process. (ERP)

**Guidelines for Project Execution**

**At the end of the VI$^{th}$ Semester**

1. A group of 3-4 students shall be formed according to their suitability.
2. Department faculty will float prospective Project Titles through Project Coordinator.
3. Department will take care of a list of titles at least two times of the groups.
4. Students will interact with guides for scope and outline of the project.
5. Maximum of two groups will be given to a guide.
6. Guide and Project groups will be finalized at the end of sixth semester so that project work can be started at the start of Seventh semester.

**During the VII$^{th}$ Semester**

1. Project work is expected to be done in the Project Lab.
2. Projects must be executed in association with industrial experts/facilities.
3. Progress of project work is monitored regularly on weekly project slots/project day.
4. Regular interval presentations are to be arranged to review and assess the work.
5. Project work is monitored and continuous assessment is done by guide and authorities

**Term Work**

The student shall prepare the duly certified final report of project work in standard format for satisfactory completion of the work by the concerned guide and head of the Department/Institute.

● Recommended performance measure parameters may Include-Problem definition and scope of the project, Literature Survey, Appropriate Engineering approach used, Exhaustive and Rational Requirement Analysis.

● Comprehensive Implementation - Design, modeling, documentation, Usability, Optimization considerations (Time, Resources, Costing), Thorough Testing, Project Presentation and Demonstration (ease of use and usability), Social and environment aspects.

● The term work under project submitted by students shall include work Diary; Work Diary to be maintained by a group and countersigned by the guide (weekly). The contents of work diary shall reflect the efforts taken by project group for;

a. Searching suitable project work
b. Brief report preferably on journals/research or conference papers/books or literature surveyed to select and bring up the project.
c. Brief report of feasibility studies carried to implement the conclusion.
d. Rough Sketches/ Design Calculations
e. Synopsis

● The group should submit the synopsis in the following form.

i. Title of Project
ii. Names of Students
iii. Name of Guide
iv. Relevance
v. Present Theory and Practices
vi. Proposed work

vii. Expenditure
viii. References
●The synopsis shall be signed by each student in the group, approved by the guide (along with external guide in case of sponsored projects) and endorsed by the Head of the Department.
● Presentation: The group has to make a presentation in front of the faculty of department at the end of semester.

**Examination Scheme**

During university examination Internal examiner (preferably the guide) and External examiners jointly, evaluate the project work.
● During the process of monitoring and continuous assessment & evaluation the individual and team performance is to be measured.
● The project term work shall be evaluated on the basis of reviews. In first semester two reviews are to be taken and evaluated for total 50 marks (25 marks each)
● Review 1 and 2 will be based on synopsis submission (team members, Title of the Project Work, Abstract, Problem Definition, work done earlier, Objectives of the Project, Methodology of the Project, Application / Significance of the Project, Duration of the Project, Individual Role of the Student, References, sponsored etc.)

# Savitribai Phule Pune University

**Board of Studies - Mechanical and Automobile Engineering**

**Undergraduate Program – Final Year Automation and Robotics (2019 pattern)**

| 402548: Audit Course-VII | | | | |
|---|---|---|---|---|
| **Teaching Scheme** | | **Credits** | **Examination Scheme** | |
| | | **Non-credit** | | |

## GUIDELINES FOR CONDUCTION OF AUDIT COURSE

**Faculty mentor shall be allotted for individual courses and he/she shall monitor the progress for successful accomplishment of the course. Such monitoring is necessary for ensuring that the concept of self-learning is being pursued by the students 'in true letter and spirit'**

- If any of the following listed course is selected through Swayam/ NPTEL/ virtual platform, the minimum duration shall be of 8 weeks.
- However if any of the course duration is less than the desired (8 weeks) the mentor shall ensure that other activities in form of assignments, quizzes, group discussion etc. (allied with the course) for the balance duration should be undertaken.
- Students can join any online platform or can participate any online/offline workshop to complete the Audit course with prior-permission of mentor.

In addition to credits courses, it is mandatory that there should be an audit course (non-credit course) from Final year of Engineering. The student will be awarded grade as AP on successful completion of the audit course. The student may opt for any one of the audit courses in each semester. Such audit courses can help the student to get awareness of different issues which make an impact on human lives and enhance their skill sets to improve their employability. List of audit courses offered in the semester is provided in the curriculum. Students can choose one of the audit courses from the list of courses mentioned. Evaluation of the audit course will be done at institute level. The student registered for audit course shall be awarded the grade AP and shall be included such grade in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the Savitribai Phule Pune University and satisfactory in-semester performance and secured a passing grade in that audit course. No grade points are associated with this 'AP' grade and performance in these courses is not considered in the calculation of the performance indices SGPA and CGPA. Evaluation of the audit course will be done at institute level itself.

## List of Courses to be opted (Any one) under Audit Course

**A. Yoga Practices**

**B. Stress Management**

Note:-The title indicated above are subject to change in time to come and such an alteration (if any) should be brought to the notice of the BoS.

## Using NPTEL Platform: (preferable)

NPTEL is an initiative by MHRD to enhance learning effectiveness in the field of technical education by developing curriculum based video courses and web based e-courses. The details of NPTEL courses are available on its official website www.nptel.ac.in

- Students can select any one of the courses mentioned above and has to register for the corresponding online course available on the NPTEL platform as an Audit course.
- Once the course is completed the student can appear for the examination as per the guidelines on the NPTEL portal.
- After clearing the examination successfully; student will be awarded with a certificate.

## Assessment of an Audit Course

- The assessment of the course will be done at the institute level. The institute has to maintain the record of the various audit courses opted by the students. The audit course opted by the students could be interdisciplinary
- During the course students will be submitting the online assignments/report/course completion certificate etc. A copy of the same can be submitted as a part of term work for the corresponding Audit course.
- On the satisfactory submission of assignments/report/course completion certificate etc., the institute can mark as "Present" and the student will be awarded the grade AP on the mark-sheet.

| **402549: Embedded Systems in Robots** | | | | | |
|---|---|---|---|---|---|
| **Teaching Scheme** | | **Credits** | | **Examination Scheme** | |
| **Theory** | 03 Hr./Week | **Theory** | 03 | **In-Semester** | 30 Marks |
| **Practical** | 02 Hr./Week | **Practical** | 01 | **End-Semester** | 70 Marks |
| | | | | **Oral** | 25 Marks |
| | | | | **Term Work** | 25 Marks |

**Prerequisites:** Digital Systems, Microcontrollers.

**Course Objectives:**

1. UNDERSTAND architecture, characteristics and classification of embedded systems.
2. USE of 'Embedded C' programming language to maintain embedded systems.
3. INTERPRETE the communication standards and protocols of embedded systems.
4. SELECT the relevant microcontrollers for various industrial applications.
5. SELECT appropriate Open Source Embedded Development Board.
6. DESIGN of simple applications of embedded system.

**Course Outcomes:**

On completion of the course the learner will be able to;

CO1: DEFINE architecture, characteristics and classification of embedded systems.
CO2: UTILIZE 'Embedded C' programming language to maintain embedded systems.
CO3: EXPLAIN the communication standards and protocols of embedded systems.
CO4:ANALYZE selection of the relevant microcontrollers for various industrial applications.
CO5: ANALYZE selection of Open Source Embedded Development Board as Arduino.
CO6: DEVELOP various applications of embedded systems.

**Course Contents**

**Unit 1: Introduction to Embedded systems**

Block diagram of embedded system with hardware components, Harvard and Von-Neumann architecture, RISC and CISC processors, Characteristics of embedded system: Processor, power, memory, operating system, reliability, performance, power consumption, NRE cost, unit cost, size, flexibility, time-to-prototype, time-to-market, maintainability, correctness and safety, Classification of Embedded System: Small scale, medium scale, sophisticated, standalone, reactive/real time (soft and hard real time).

**Unit 2: Programming using 'Embedded C'**

Data transfer, Arithmetic and Logical operations. Decision Control & Looping. Timer/Counter programming with 'embedded C' for microcontroller, Serial communication programming with 'embedded C `for microcontroller, Interrupt control programming with 'embedded C' for microcontroller.

**Unit 3: Communication standards and Protocols**

Modes of data communication: Simplex, Duplex, Half Duplex, Serial, Parallel, Synchronous and Asynchronous Communication, Serial communication standards: RS232. MAX232 bidirectional

level converter. Communication protocols: Serial Communication Protocol: I2C, CAN, USB, Serial Peripheral Interface (SPI), Synchronous Serial Protocol (SSP). Parallel Communication Protocol: PCI, PCI-X. Overview of advanced serial protocol: IrDA, Bluetooth, Zigbee.

**Unit 4: Microcontrollers Architecture**

Microcontroller Types: PIC, AVR, ARM, MSP430: Introduction, features and applications, AVR microcontroller: Types, Architecture. Internal Architectural Block diagram of controller (ATmega 8). Functions of each pins of ATmega 8. 6-channel ADC Working, Essential Peripheral circuits: Crystal Circuit, Power supply, Oscillator Circuit, Initial programming configurations of ATmega8: port, counter, timer.

**Unit 5: Open Source Embedded Development Board**

Arduino: Birth, Open Source community, Functional Block Diagram of Arduino. Functions of each Pin of Arduino, Arduino Development Board diagram (including different blocks only): IDE, I/O Functions, Looping Techniques, Decision Making Techniques, Designing of 1st sketch Programming of an Arduino (Arduino ISP), Arduino Boot loader, Serial Protocol (serial port Interfacing), Initialization of Serial Port using Functions, Basic Circuit For Arduino.

**Unit 6: Embedded system Applications**

Motor Driver L293D, IR Sensor, Interfacing L293D with Arduino, Code for Line Follower Robot, Interfacing Accelerometer with Arduino, Record Gestures, Code For Accelerometer based Robot, Interfacing of RF Tx/RF Rx with Arduino, Interfacing of Relay Driver, ULN2803 with Arduino, Code for Home automation and its Control.

**Books and other resources**

**Text Books:**


1. "PIC Microcontroller and Embedded Systems Using Assembly and C for PIC18" by Muhammad Ali Mazidi, Rolind D. McKinley, Danny Causey, Pearson Education.
2. "Fundamentals of Microcontrollers and Applications in Embedded Systems with PIC" by Ramesh Gaonkar, Thomson and Delmar learning, First Edition.
3. "The 8051 Microcontroller & Embedded Systems using Assembly and C" by K. J. Ayala, D. V. Gadre (Cengage Learning, India Edition).
4. Joseph Yiu The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors, 3rd Edition, Kindle Edition, 2013.
5. "MSP430 Microcontroller Basics" by John H. Davies, British Library Cataloguing-in-Publication Data.
6. "Exploring Arduino" by Jeremy Blum, Wiley Publications.
7. "30 Arduino Projects for Evil Genius" by Simon Monk, McGraw-Hill Professional Publications.


**References Books:**


1. Raj Kamal, "Embedded Systems – Architecture, Programming and Design" 2nd edition, McGraw Hill.
2. Frank Vahid and Tony Givargis, " Embedded System Design – A Unified hardware/ Software introduction " 3rd edition, Wiley.
3. Singh. I.P., "Microprocessor Systems", Module 9: Microcontrollers and their Applications", IMPACT Learning Material Series IIT, New Delhi, 1997.
4. Steve Furber , "ARM System –On –Chip architecture", Addision Wesley, 2000.
5. "Microcontrollers: theory and applications" by Ajay V Deshmukh, McGraw Hill Education, New Delhi 2011, ISBN- 9780070585959.
6. Datasheets and application notes of 8051 (P89C51RD2), AVR (ATMEGA32), PIC (16F877) and

TI MSP430 microcontrollers.

**Web References:**

1. NPTEL Course "Introduction to Embedded System Design"
https://archive.nptel.ac.in/courses/108/102/108102169/
2. NPTEL Course "Embedded Systems Design"
https://nptel.ac.in/courses/106105159
3. NPTEL Course "Embedded Systems Design"
https://www.youtube.com/watch?v=0xgvINDxXJI&list=PLbRMhDVUMngcJu5oUhgpgYqtOn7DmSfuU&index=1

**Guidelines for Laboratory Conduction**

1. Assessment must be based on understanding of theory, attentiveness during practical, and understanding.
2. There should be continuous assessment and Timely submission of journal.
3. Use suitable software wherever necessary to perform experiments.

**Note:** It is compulsory for each student to create their own Microcontroller Development Board for personal use.

**The student shall perform any 10 experiments of the following:**

1. Execute the C program to perform following arithmetic operations on 8-bit data:- addition, subtraction, multiplication and division for microcontroller.
2. Interface 16 x 2 LCD to 8051. Execute embedded C language program to display string on it.
3. Interface a 4 x 4 matrix keyboard and 7-segment display to 8051. Execute C language program to read and display key code on 7-segment di s slay.
4. Interface 8 bit DAC to 8051. Execute C language program to generate square, sawtooth and triangular waveforms.
5. Interface stepper motor to 8051. Execute C language program to rotate stepper motor with different speed in clockwise and counter clockwise direction.
6. Generate the triangular waveform using DAC and observe the status of control signals using IDE tool (MicroProC, Keil).
7. Test the different Arduino Boards, Open-Source and Arduino Shields
8. Interface DC motor using L293D Motor Driver.
9. Interface RF Tx/RF Rx with Arduino.
10. Make Line-Follower Robot using Arduino.
11. Build Digital thermometer using LM35 and LCD 16x2.
12. Build Gesture Control Robot using Accelerometer.
13. Build a Home security system application.
14. Speed Control of Dc Motor using MSP430.
15. Traffic light controller/Real-time clock display.

**Term Work**

**The student shall complete the following activity as a Term Work:**

Six assignments based on unit 1 to unit 6.

**Guidelines for Assignments:**

Assessment must be based on attendance, understanding of theory, assignment neatness and timely submission.

## 402550: Fundamentals of Autonomous System

| Teaching Scheme | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|
| **Theory** | 3 Hrs/Week | **Theory** | 3 | **In-Semester** | 30 Marks |
| **Practical** | 2 Hrs/Week | **Practical** | 1 | **End-Semester** | 70 Marks |
| | | | | **Oral** | 25 Marks |
| | | | | **Term Work** | 25 Marks |

**Prerequisites:** Knowledge in Engineering mathematics and basic programming tool.

**Course Objectives:**

1. Introduce the concept of autonomy and its significance in various domains.
2. Understand the fundamental components of autonomous systems.
3. Familiarize students with the technologies and algorithms used in perception, decision-making, control, and planning.
4. Explore the challenges and ethical considerations in the development and deployment of autonomous systems.
5. Develop critical thinking and problem-solving skills relevant to autonomous systems.

**Course Outcomes:**

On completion of the course the learner will be able to;

CO1: DISTINGUISH between systems, agents, and issues when modelling autonomous systems.
CO2: VALIDATE the principles of fundamental structure and artificial organism kinds.
CO3: EXAMINE the effects of autonomous system layers with agentification.
CO4: DISCUSS the importance of understanding systems and behavioral learning.
CO5: RECOGNIZE existing representations and trends in autonomous systems.
CO6: UNDERSTAND the concept of notions of scaled-down autonomous systems.
CO7: EXPLAIN distributed autonomous systems' autonomy.

**Course Contents**

| **Unit 1** | **Introduction to Autonomous Systems** |
|---|---|

Definition and characteristics of autonomous systems, Historical development and evolution of autonomous systems, Importance and applications of autonomous systems in various fields, Overview of key components and technologies in autonomous systems

| **Unit 2** | **Perception for Autonomous Systems** |
|---|---|

Role of perception in autonomous systems, Introduction to various sensors used in autonomous systems (e.g., cameras, LiDAR, radar, ultrasonic sensors), Data acquisition and processing techniques for sensor inputs, Object detection, recognition, and tracking algorithms, Localization techniques for determining the position of the system within its environment

| **Unit3** | **Decision-Making in Autonomous Systems** |
|---|---|

Basics of decision making in autonomous systems, Overview of decision-making architectures and algorithms, Introduction to path planning and trajectory generation, Techniques for obstacle

avoidance and collision detection, Integration of decision-making algorithms with perception systems.

| **Unit 4** | **Control and Navigation for Autonomous Systems** |
|---|---|

Fundamentals of control systems in autonomous systems, Overview of feedback control and its importance in maintaining system stability, Introduction to PID (Proportional-Integral-Derivative) controllers, Motion control techniques for precise movement and navigation, Adaptive and learning control approaches for autonomous systems. Introduction to Machine Learning in Autonomous Systems: Overview of machine learning and its applications in autonomous systems, Supervised, unsupervised, and reinforcement learning algorithms, Training and validation of machine learning models for autonomous systems, Integration of machine learning techniques in perception, decision making, and control.

| **Unit 5** | **Autonomous Systems Architectures** |
|---|---|

Communication and Networking: Communication requirements in autonomous systems, Introduction to communication protocols and standards used in autonomous systems, Wireless communication technologies and their applications, Distributed systems and network architectures for coordinating multiple autonomous systems.

Simulations and Virtual Environments: Importance of simulations in the development and testing of autonomous systems, Overview of simulation tools and frameworks used for autonomous systems

Creating virtual environments for testing and validating autonomous system behavior, Integration of simulated environments with real-world systems for testing and evaluation.

Human-Robot Interaction: Principles of human-robot interaction in autonomous systems, User interfaces and control mechanisms for interacting with autonomous systems, Safety considerations and regulations for human-robot interaction, Designing intuitive and user-friendly interfaces for autonomous systems.

| **Unit 6** | **Ethics and Safety in Autonomous Systems** |
|---|---|

Autonomy in Different Domains: Autonomous vehicles (land, aerial, maritime), Autonomous drones and Unmanned Aerial Vehicles (UAVs), Autonomous industrial robots and manufacturing systems, Emerging trends and applications in specific domains.

Safety challenges and considerations in autonomous systems, Importance of fail-safe mechanisms and redundancy in ensuring system reliability, Ethical implications of autonomous systems and considerations for responsible deployment, Privacy and data protection considerations in autonomous systems.

**Books and other resources**

**Text Books:**


1. "Autonomous Systems: Developments and Trends" by Alejandro Gonzalez, Giancarlo Antonucci, et al.
2. "Introduction to Autonomous Mobile Robots" by Roland Siegwart, Illah Nourbakhsh, et al.
3. "Autonomous Systems and Intelligent Agents in Power System Control and Operation" by Carlos A. Murillo-Sánchez, Tomonori Sadamoto, et al.
4. "Robotics, Vision and Control: Fundamental Algorithms in MATLAB" by Peter Corke.
5. “New Autonomous Systems” by Alain Cardon, Mhamed Itmi, Wiley-ISTE- 2016.
6. “Introduction to Autonomous Robots” by Nikolaus Correll, Magellan Scientific, 2016.


**Reference Books:**


1. Kannappan D, Mechanical Estimating and Costing, Tata McGraw Hill, New Delhi, 2003.
2. Kesavon R and others, Process Planning and Cost Estimation, New Age International, Chennai, 2005.
3. Thomas E. Vollmann et al., Manufacturing Planning and Control Systems, Galgotia Publications, Delhi,

1998.
4. Samuel Eilon, Elements of Production Planning and Control, MacMillan, London, 1985.
5. ASME, Manufacturing Planning and Estimation-Hand Book, McGraw Hill, New Delhi, 1963.
6. Frederic C Jelen and James H Black, Cost and Optimization Engineering, McGraw Hill, New Delhi, 1983.
7. "Mobile Intelligent Autonomous Systems" by Jitendra R. Raol, Ajith K. Gopal, CRC Press, 2017.

**Web References:**

1. "Robotics Software Engineer" Online course by Udacity: http://www.udacity.com/online-learning-for-individuals.
2. "Decision-Making for Autonomous Systems" Online course by eDX: https://www.edx.org/learn/engineering?linked_from=sitenav&list=subjects.
3. "Wheeled Mobile Robots" Online NPTEL Course: https://onlinecourses.nptel.ac.in/noc22_me38/preview.

**Term Work**

The student shall complete the following activity as a Term Work: General Guidelines for Term work Conduction:

1. Assessment must be based on understanding of theory, attentiveness during practical work, and timely submission of all the tasks.
2. There should be continuous assessment and Timely submission of term work journal.
3. Use suitable open source software and simulation tools wherever necessary to perform experiments.

Total 10 activities from the following list must be performed. Activity number 15 is compulsory:

1. **Fundamentals of Autonomous System**: Analysis of real-world autonomous system applications across various industries.
2. **Robotics Platform Familiarization:** An introduction to the hardware and software components of a basic robotics platform. Students may learn how to set up the robot, calibrate sensors, and comprehend its capabilities.
3. **Sensor Integration:** Students can experiment with several sensors often used in autonomous systems, such as LiDAR, cameras, ultrasonic sensors, and IMUs. They will learn how to communicate with and incorporate these sensors into a robot or autonomous vehicle.
4. **Path Planning and Navigation:** Implement path planning algorithms (e.g., A*, Dijkstra's) for a robot to navigate through a predefined maze or obstacle course autonomously.
5. **Simulated Environments:** Use robotics simulation software (e.g., ROS/Gazebo) to create simulated environments for testing autonomous algorithms without the need for physical robots.
6. **Localization Techniques:** Implement localization algorithms like SLAM (Simultaneous Localization and Mapping) to help the robot map its surroundings and estimate its position.
7. **Machine Learning for Autonomous Systems:** Integrate machine learning algorithms like Deep Learning, Reinforcement Learning, or SVM to train the robot to recognize objects, lanes, or obstacles.
8. **Control Systems:** Teach students about control theory and how it applies to autonomous systems. They can design controllers for various tasks like tracking a trajectory or stabilizing the robot.
9. **Autonomous Drone Flight:** If feasible, conduct practicals involving autonomous drone flight, including takeoff, landing, and waypoint navigation.
10. **Communication and Networking:** Explore the communication protocols and networking principles required for coordination between multiple autonomous agents or vehicles.
11. **Safety and Fail-Safe Mechanisms:** Educate students about safety considerations in autonomous

systems and implement fail-safe mechanisms to handle critical situations.

12. **Autonomous Vehicle Simulation:** If available, work with autonomous vehicle simulators to understand real-world scenarios and test autonomous driving algorithms.

13. **Ethics and Legal Implications:** Engage students in discussions about ethical dilemmas and legal implications related to the deployment of autonomous systems.

14. **Industrial visits**: Industrial visit to provide awareness and understanding of the course – student must submit a properly documented industrial visit report.

15. **Real-world Project:** Divide students into teams and assign them real-world projects involving autonomous systems. This could be an open-ended challenge that requires them to apply the concepts they've learned throughout the course.

# Savitribai Phule Pune University

**Board of Studies - Mechanical and Automobile Engineering**

**Undergraduate Program – Final Year Automation and Robotics (2019 pattern)**

| **402551A: Industrial Robotics & Material Handling systems (Elective- V)** | | | | | |
|---|---|---|---|---|---|
| **Teaching Scheme** | | **Credits** | | **Examination Scheme** | |
| **Theory** | 3 Hrs/Week | **Theory** | 3 | **In-Semester** | 30 Marks |
| | | | | **End-Semester** | 70 Marks |

**Prerequisites:** Basic Engineering Science - Physics, Principles of robotics, Engineering Metallurgy, Manufacturing processes, Artificial Intelligence in Robots, Sensors and Vision Systems in Robots

**Course Objectives:**

To explain student's significance of

1. Introduction to Product Design and Development in Robotics
2. Material Handling, storage and data capturing system
3. End Effectors
4. Robots For Inspection
5. Numerous robot applications
6. Emerging Trends in Industrial Robotics

**Course Outcomes:**

On completion of the course the learner will be able to;

CO1: LEARN about Industrial Robotics and Material Handling systems.

CO2: APPLY their knowledge in Material Handling, storage and data capturing system.

CO3: DESCRIBE the basic concepts, and types of End Effectors.

CO4: UNDERSTAND the Robots for Inspection.

CO5: KNOW the Numerous applications of robots.

CO6: UNDERSTAND the Emerging Trends in Industrial Robotics.

**Course Contents**

| **Unit 1** | **Introduction to Industrial Robotics and Material Handling systems** |
|---|---|

Topics- Automation and Robotic System, Anatomy and work volumes, Classification, Material Handling system- Definition, scope, basic concepts, principles of material handling, economics of handling, Load handling capacity, general considerations in Robotic material handling, material transfer, machine loading and unloading, CNC machine tool loading, Robot centered cell.

| **Unit 2** | **Material Handling, storage and data capturing system** |
|---|---|

Topics- Concepts of material handling, principles and considerations in material handling systems design, conventional material handling systems - industrial trucks, monorails, rail guided vehicles, conveyor systems, cranes and hoists, advanced material handling systems, automated guided vehicle systems, automated storage and retrieval systems(ASRS), Carousel Storage system. Automatic data capturing system (ADC), Radio frequency identification (RFID), Optical character recognition, Magnetic stripes, bar code technology.

| **Unit 3** | **End Effectors** |
|---|---|

Topics- Classification, Design consideration, Materials for hostile operation. Cylindrical Cam type; Grippers using pneumatic, hydraulic and electrical motor for transmission; Vacuum Grippers, Ultrasonic grippers. Gripper force analysis and gripper design, design of multiple degrees of

freedom, active and passive grippers. Selection of Robot: Factors influencing the choice of a robot, robot performance testing, economics of robotisation, Impact of robot on industry and society.

| **Unit 4** | **Robots For Inspection** |
|---|---|

Topics- Robotic vision systems, image representation, object recognition and categorization, depth measurement, image data compression, visual inspection, software considerations.

| **Unit 5** | **Numerous robot applications** |
|---|---|

Topics- Application of Robots in continuous arc welding, Spot welding, Spray painting, assembly operation, cleaning, robot for underwater applications, Applications in manufacturing, material transfer, machine loading and unloading, processing operations, assembly and inspections, robotic cell design and control, applications in other areas: toxic, hazardous and inaccessible, service industry, industrial robots and automatically guided vehicles., Advanced application of robots.

| **Unit 6** | **Emerging Trends in Industrial Robotics** |
|---|---|

Topics- Emerging Trends in Industrial Robotics-Introduction, need and scope, Collaborative robots (cobots), Mobile robots and autonomous systems, Energy efficiency, Reshoring, Artificial intelligence and machine learning in robotics, Second life for industrial robots, Cyber Security Robotics, Robotic Process Automation (RPA), Robotics as a Service (RaaS).

**Books and other resources**

**Text Books:**


1. Richaerd D Klafter, Thomas Achmielewski and Mickael Negin, “Robotic Engineering – An integrated Approach” Prentice HallIndia, New Delhi, 2001.
2. Mikell P. Groover,”Automation, Production Systems, and Computer Integrated Manufacturing“, 2nd Edition, John Wiley & sons, Inc, 2007
3. Ganesh Hegade, “INDUSTRIAL ROBOTICS” Laxmi Publication, Delhi, 2015.
4. Mark R. Miller ,Rex Miller, “Robots and Robotics: Principles, Systems, and Industrial Applications”, McGraw-Hill Education, 2017.
5. Fu K.S., Gonzalex R.C., Lee C.S.G., "Robotics Control Sensing, Vision and intelligence", McGraw Hill Book Co. ISBN 10: 0070226253 / ISBN 13: 9780070226258
6. Hall A.S., & quot; Kinematics and Linkage Design", Prentice Hall. ISBN-10: 0881332720, ISBN-13: 978- 0881332728
7. Todd D.J., “Fundamentals of Robot Technology”, Wiley Publications, ISBN:978-0-470-20301-9
8. Groover M.P., Weiss M., Nagel R.N., Odrey N.G., "Industrial Robotics Technology - Programming and Applications & quot;, McGraw Hill Book Co. ISBN-10: 1259006212, ISBN-13: 978-1259006210


**References Books:**


1. James A Rehg, “Introduction to Robotics in CIM Systems”, Prentice Hall of India, 2002.
2. Deb S R, "Robotics Technology and Flexible Automation", Tata McGraw Hill, New Delhi, 1994.
3. Groover M. P., “Automation, Production Sysytems, and Computer –Integrated Manufacturing”,Pearson 2. Education,ISBN-81-7808-511-9 3.
4. Deb S.R., “Robotics”, Tata McGraw Hill Publications, New Delhi. ISBN 13: 9780070077911
5. Yoram Koren, & quot; Robotics for Engineers", McGraw Hill Book Co. ISBN-10: 0070353999, ISBN-13: 978-0070353992

## 402551B: Supply Chain Management (Elective- V)

| Teaching Scheme | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|
| **Theory** | 03 Hrs/ Week | **Theory** | 3 | **In-Semester** | 30 Marks |
| | | | | **End-Semester** | 70 Marks |

**Prerequisites:**

Basics of Management, Fundamentals of Operations Management, Mathematics and Statistics, Information Technology, Logistics and Transportation.

**Course Objectives:**

1. To impart basic skills of supply chain management.
2. To understand the role of information technology in SCM.
3. To learn the concept of reverse and agile supply chain with case studies.

**Course Outcomes:**

On completion of the course the learner will be able to;

CO1: IMPLEMENT information system in supply chain.
CO2: UNDERSTAND about SCM.
CO3: ANALYZE Mathematical modeling of Supply Chain.
CO4: UNDERSTAND basics of Reverse & Agile supply chain.
CO5: ANALYZE various case studies on supply chain.

**Course Contents**

| **Unit 1** | **Introduction** |
|---|---|

Introduction, Generic Types of supply chain, Various Definitions and Implications, Major Drivers of Supply chain.

**Strategic Decisions- in Supply Chain Management**

Introduction, Business Strategy, Core Competencies in Supply Chain, Strategic SC Decisions, Customer Reletationship Management Strategy, Supplier Relationship Management Strategy.

**Source of Management in Supply Chain**

Introduction, Elements of Strategic Sourcing, A Collaborative Perspective, Development of Partnership.

| **Unit 2** | **Inventory Management in Supply Chain** |
|---|---|

Introduction, Types of Inventory, Supply/ Demand Uncertainties, Inventory costs, Selective Inventory Control, Vendor Manage Inventory system, Inventory Performance Measure

**Logistics In Supply Chain Management**

Introduction, Strategy, Transportation Selection, Trade-off, Models for Transportation and Distribution, Third Party Logistics, Overview of Indian Infrastructure for Transportation.

| **Unit3** | **Information Technology in Supply Chain** |
|---|---|

Introduction, Types of IT Solutions like Electronic Data Inter change (EDI), Intranet/ Extranet, Data Mining/ Data Warehousing and Data Marts, E-Commerce, E- Procurement, Bar Coding Technology.

**Information System in Supply Chain**

Introduction, Computer Based Information Systems, Computer Models and Perceptions about ERP,

ERP & SCM.

| **Unit 4** | **Application of Mathematical Modeling in Supply Chain** |
|---|---|

Introduction, Modeling, Consideration in Modeling SCM System, Structuring the Logistic chain, Concept of Modeling.

| **Unit 5** | **Reverse Supply Chain** |
|---|---|

Introduction, Reverse Supply Chain v/s Forward Supply Chain, Types of Reverse Flows, Issues in Management of Reverse Supply Chain, Reverse Supply Chain for Food items, Reverse Logistic and Environment Impact.

**Integration & Collaborative Supply Chain**

Introduction, Evolution of collaborative SCM, Efficient Customer response, Collaboration at various levels, Imperatives for Successful Integrative Supply Chains.

| **Unit 6** | **Agile Supply Chain** |
|---|---|

Introduction, Source of Variability, Characteristics of Agile Supply Chain, Achieving Agility in Supply Chain.

**Cases of Supply Chain**

Cases of Supply Chain like, News Paper Supply Chain, Book Publishing, Mumbai Dabbawala, Disaster management, Organic Food, Fast Food.

**Books and Other Resources**

**Text Books:**

1. Supply Chain Management Theories & Practices, R. P. Mohanty, S. G. Deshmukh, Dreamtech Press, 19-A, Anari Road, Daryaganj, New Delhi.

**References Books:**

1. Supply Chain Management Strategy, Planning & Operation by Sunil Chopra, Peter Meindl.
2. Total Supply Chain Management by Ron Basu, J. Nevan Wright.
3. Supply Chain Management, Chopra, Pearson.
4. Logistics Engineering and Management, Blanchard, Pearson.

| **402045A: Product Design & Development (Elective- V)** | | | | | |
|---|---|---|---|---|---|
| **Teaching Scheme** | | **Credits** | | **Examination Scheme** | |
| **Theory** | **3Hrs/Week** | **Theory** | 3 | **In-Semester** | 30 Marks |
| | | | | **End-Semester** | 70 Marks |

**Prerequisites:** Basic Engineering Science - Physics, Chemistry, Material Science, Solid Modeliling and Drafting, Engineering Metallurgy, Manufacturing processes Etc.

**Course Objectives:**

To explain student's significance of

1. Introduction to Product Design and Development in Robotics
2. Product Specification Finalization and Market Survey
3. Concept Generation, Validation, Selection, and Exploration
4. Economics Considerations and Value Engineering
5. Robust Design and Development for Robots
6. Design Documentation and Organization

**Course Outcomes:**

On completion of the course the learner will be able to;

CO1: UNDERSTAND Product Design and Development process in Robotics

CO2: USE Processes, tools and techniques for Market Survey & Product Specification Finalization

CO3: EXPLAIN the Processes, tools and techniques for Concept Generation, Validation, Selection, and Exploration

CO4: UNDERSTAND the concept of Economics Considerations and Value Engineering

CO5: APPLY Processes, tools and techniques for Robust Design and Development for robots

CO6: : USE Processes, tools and techniques for Design Documentation and Organization

**Course Contents**

| **Unit 1** | **Introduction to Product Design and Development in Robotics** |
|---|---|

Topics- Product design and Development definition, Objectives of Product design and development, Engineering Design Process, Engineering Development Process (Gateway System), Product Design Vs Product Development, Features of successful product design and development, Essential Factors for product design, The challenges of product development, ASIMOW Model/Morphology of product design, Who design and develops product-Concurrent engineering approach/CFT Approach, Product Life Cycle, Modern product development process, Innovative thinking.

| **Unit 2** | **Product Specification Finalization and Market Survey** |
|---|---|

Topics- Product definition, Types of products, Types of Design information and the Various Sources of information, Product planning and its Phases, Mission statement and Technical Questioning, Technology forecasting and S-curve, Tools for gathering Customer needs, QFD and House of quality, Customer Population and Market segmentation Types of customers and Needs, Customer need Models- Introduction to Kano Model, Design Thinking, etc.

| **Unit3** | **Concept Generation, Validation, Selection, and Exploration** |
|---|---|

Topics- Idea generation and Idea generation approaches- Benchmarking, Brainstorming, Alternate

thinking, Reverse Engineering etc, Product Policy of an organization, Selection of Profitable Concept- SWOT Analysis, Concept Selection Process, Pugh's Concept selection process, Concept Analysis- Marketing aspect, Product characteristics (Functional/ Operational/Durability/Aesthetic/Ergonomic Aspects), Economic analysis, Production aspect, -Solid Modelling of part and assembly, Product architecture, Digital product design of part and assembly with respect to Engineering drawing definition.

| **Unit 4** | **Economics Considerations and Value Engineering** |
|---|---|

Classification of engineering drawing, Elements of production drawing, Bill of material, Types of dimensions, Arrangement of dimensions, Principles of dimensioning, Limits, Fits and Tolerances, Geometric Tolerances, Datum System, Design for Assembly, Design for manufacturing, Designs for Maintainability, Designs for Environment, Design for processes, Product design Steps, Design Review/Part Print Analysis, Value Engineering / Value Analysis. : Definition, Methodology, Economic analysis: Qualitative & Quantitative.

| **Unit 5** | **Robust Design and Development for Robots** |
|---|---|

Tools and Techniques for Robust design and Development- Advance Product Quality Planning, Design Failure Mode Effect Analysis, Product Life cycle management and Product data Management, Introduction of Ergonomics in product design,, Ergonomics and Industrial Safety, Introduction of Aesthetic in product design, aesthetics consideration etc.

Case studies on

1. DFMEA (Minimum Three parts)
2. Process Flow Chart (Minimum Three Parts)
3. Part Print analysis (Minimum Three Parts)

| **Unit 6** | **Design Documentation and Organization** |
|---|---|

Purchase order, Product costing, Product Testing and Validation, Introduction to Production part approval process tools (PPAP), Organization structure, designer's position, drawing office procedure, standardization, record keeping, and legal product of design patents.

**Books and other resources**

**Text Books:**


1. K. Chitale; R.C. Gupta, Product Design and Manufacturing, Prentice Hall India.
2. Dieter George E., Engineering Design McGraw Hill Pub. Company, 2000.
3. How Products are made by Jocqueline L. Longe
4. Creating Innovative products Using Total Design by Don Clausing and Ron Andrade
5. Metrics and Case Studies For Evaluating engineering designs by Jay Alan Moody
6. Understanding Engineering Design by Richard Birmingham
7. Designing for quality by Robert H. Lochner
8. New Product development by Barclay Z. Dann P. Holroyd
9. Developing an Ergonomics Processes by Alison Heller


**References Books:**


1. Kevin Otto and Kristin Wood, Product Design: Techniques in Reverse Engineering and New Product Development, Pearson Education Inc.
2. Grieves, Michael, Product Lifecycle Management McGraw Hill
3. Bralla, James G., Handbook of Product Design for Manufacturing, McGraw Hill Pub.
4. Karl Ulrich, product design and development, TMH.

| **402050C: Manufacturing System and Simulation (Elective- V)** | | | | | |
|---|---|---|---|---|---|
| **Teaching Scheme** | | **Credits** | | **Examination Scheme** | |
| **Theory** | 3 Hrs./Week | **Theory** | 3 | **In-Semester** | 30 Marks |
| | | | | **End-Semester** | 70 Marks |

**Prerequisites:** Understanding of manufacturing and business processes, industrial engineering principles and concepts.

**Course Objective:**

1. To help mechanical engineers understand broadly the functioning of manufacturing systems.
2. To describe the role of facilities and support systems.
3. To enable students understand various types of simulations used in manufacturing environment.
4. To acquaint with the methodology of manufacturing simulation using computer software and the repercussions of changes & variability therein, over time.
5. To showcase the areas of simulation applications in manufacturing and allied field.

**Course Outcomes**

On completion of the course the learner will be able to;

CO1. **UNDERSTAND** the concepts of manufacturing system, characteristics, type, etc.
CO2. **UNDERSTAND** the concepts of Facilities, manufacturing planning & control and Support System.
CO3. **UNDERSTAND** the concepts of manufacturing towards solving productivity related problems.
CO4. **DEVELOP** a virtual model to solve industrial engineering related issues such as capacity. utilization, line balancing.
CO5. **BUILDING** tools to view and control simulations and their results.
CO6. **PLAN** the data representation & Evaluate the results of the simulation.

## Course Contents

| **Unit 1** | **Manufacturing System** |
|---|---|

**Preamble**: Industrial Revolutions, Smart manufacturing, Challenges, Digitalization, Manufacturing System, Simulation, Data Analysis & Predictive decision-making, Types and classification of production systems and their characteristics, Introduction to manufacturing systems (manual, worker-machine and automated), Components & classifications, principles of manufacturing systems

**Characteristics, requirements and operation of Manufacturing Systems**: Custom manufacturing system, Intermittent manufacturing system, Continuous manufacturing system, Flexible manufacturing system, Mass customization, Assembly systems: Manual assembly systems,

Automated assembly systems, Hybrid assembly systems, and Reconfigurable manufacturing systems, Laws of Manufacturing, Manufacturing Systems as a Foundations of World-Class Practices, Performance measures of manufacturing systems and approaches to enhance the performance

| **Unit 2** | **Facilities and Manufacturing Support System** |
|---|---|

Overview, characteristics, principles and requirements of following facilities and manufacturing support systems:

**Facilities**: Material Handling Equipment, Quality control approaches, Computer systems to control manufacturing operations, Factory and Plant Layout, Group Technology (GT) & Cellular Layout, Robotics

**Manufacturing Planning**: Process Planning, Production Planning, Master Scheduling, Material requirement planning and capacity planning

**Manufacturing Control**: Shop floor control, Inventory control, Quality Control and Maintenance strategies

**Business Functions**: Business functions and Sequence of information processing activities.

| **Unit 3** | **Manufacturing Simulation: Introduction** |
|---|---|

History of simulation, basic simulation concept, purpose, appropriateness and considerations, advantages and disadvantages of simulation, areas of application, Overview of types of simulations [Discrete event simulation (DES), System dynamics (SD), Agent-based modeling (ABM), Intelligent simulation using artificial intelligence (AI) techniques, Petri net, Monte Carlo simulation (MCS), Virtual simulation], Steps in simulation study, simulation as a decision making tool

| **Unit 4** | **Discrete Event Simulation: Introduction** |
|---|---|

**Problem Formulation**: Formulating problem statement, Tools for Developing the Problem Statement, Orientation Process, simulation project objectives, evaluation of simulation project

**System Definition**: Discrete versus Continuous, Components and Events to Model, Manufacturing System Processes and Events

**Input Data Collection and Analysis**: Sources for input data, collecting input data, deterministic vs. probabilistic input data, discrete vs. continuous input data, random numbers, variables, common input data distributions, analyzing input data

| **Unit 5** | **Discrete Event Simulation: Model Translation, Validation and Analysis** |
|---|---|

**Simulation Program Selection**: Overview of various simulation software like AutoMod, ProModel, Arena, WITNESS Horizon, Quest, SIMFACTORY, FlexSim etc. Case study on translation to showcase model box, elements, building the model, attributing the data, queuing, material handling and conveyors, etc., output data)

**Verification, and Validation**: Verification of Simulation Models, Calibration and Validation of Models, Face Validity, Validation of Model Assumptions, Validating Input-Output Transformations (Using Historical Input Data, Using a Turing Test), Design of Simulation Experiments, What if analysis, Sensitivity Analysis, Predictive decision-making

**Interpretation of Outputs**: Measures of Performance and their estimation, Analysis of terminating and non-terminating systems

| **Unit 6** | **Discrete Event Simulation: Applications and Case Studies** |
|---|---|

**Applications**: Assembly line balancing (Design and balancing of assembly lines), Capacity planning (Uncertainty due to changing capacity levels, increasing the current resources, improving current operations to increase capacity), Cellular manufacturing (Comparing planning and scheduling in CM, comparing alternative cell formation), Just-in-time (Design of Kanban systems), Scheduling (rules, capacity, layout, analysis of bottlenecks, performance measurement), Production planning and inventory control (Safety stock, batch size, bottlenecks, forecasting, and scheduling rules), Resource allocation (Allocating equipment to improve process flows, raw materials to plants, resource selection), Scheduling (Throughput, reliability of delivery, job sequencing, production scheduling, minimize idle time, demand, order release), Robotics, PLCs, Material Handling Equipments (Electronic Monorail System, Power & Free Conveyors, AGVs,)

**Case Studies**: 1-2 detailed case studies on above applications

## Books and other resources

**Text Books:**


1. Obi S. C., Introduction to manufacturing systems, Author House, 2013.
2. Banks J. and Carson J.S., Nelson B.L., "Discrete event system simulation", 4th Edition, Pearson., United Kingdom, 2005.
3. Christopher A. Chung, Simulation Modeling Handbook: A Practical Approach, CRC Press, 2004
4. Al-Aomar, R., Williams, E. J., & Ulgen, O. M. (2015). Process simulation using witness. John Wiley & Sons.


**References Books:**


1. Peiter Mosterman, Discrete-Event Modeling and Simulation: A Practitioner's Approach, Taylor & Francis Group, 2009
2. David Elizandro and Hamdy Taha , Performance Evaluation of Industrial Systems: Discrete Event Simulation in Using Excel/VBA, Second Edition, CRC Press, 2012
3. Evon M. O. Abu-Taieh, Asim Abdel Rahman El Sheikh, Handbook of Research on Discrete Event Simulation Environments: Technologies and Applications, Information science reference, 2010
4. Steffen Bangsow (Ed.), Use Cases of Discrete Event Simulation: Appliance and Research, Springer 2012
5. Byoung Kyu Choi, Donghun Kang, Modeling And Simulation Of Discrete-Event, Systems, John Wiley & Sons, Inc, 2013

6. Ernst G. Ulrich, Vishwani D. Agrawal, Jack H. Arabian, Concurrent And Comparative Discrete Event Simulation, Springer Science+Business Media, 1992
7. Lawrence Leemis, Steve Park, Discrete-Event Simulation: A First Course, Prantice Hall, 2004
8. Theodore T. Allen, Introduction to Discrete Event Simulation and Agent-based Modeling, Springer.

**Web References:**

1. https://archive.nptel.ac.in/courses/110/106/110106044/
2. https://archive.nptel.ac.in/courses/112/107/112107220/
3. https://www.youtube.com/user/WitnessSimulation/videos
4. https://vimeo.com/lanner
5. https://www.lanner.com/en-gb/insights/customer-stories/
6. https://onlinecourses.nptel.ac.in/noc19_me45/preview

# Savitribai Phule Pune University

## Board of Studies - Mechanical and Automobile Engineering

Undergraduate Program – Final Year Automation & Robotics (2019 pattern)

| 402050D: Engineering Economics and Financial Management (Elective- V) | | | | | |
|---|---|---|---|---|---|
| **Teaching Scheme** | | **Credits** | | **Examination Scheme** | |
| **Theory** | 3 Hrs./Week | **Theory** | 3 | **In-Semester** | 30 Marks |
| | | | | **End-Semester** | 70 Marks |

**Prerequisites:** Understanding of economics & Finance in organizational functions and zeal to learn the subject

**Course Objectives:**

1. To introduce the concepts of economics & finance in industry.
2. To understand cost analysis and pricing
3. To acquire knowledge on basic financial management aspects and develop the skills to analyze financial statements
4. To understand the budgetary process and control.
5. To understand the international business process and associated financial facets
6. To introduce the entrepreneurial financial aspects.

**Course Outcomes**

On completion of the course, students will be able to -

CO1. **UNDERSTAND** the business environment, concepts of economics and demand-supply scenario.

CO2. **APPLY** the concepts of costing and pricing to evaluate the pricing of mechanical components.

CO3. **UNDERSTAND** accounting systems and analyze financial statements using ratio analysis

CO4. **SELECT** and **PREPARE** the appropriate type of budget and understand the controlling aspects of budget.

CO5. **UNDERSTAND** the international business and trade system functioning

CO6. **DEMONSTRATE** understanding of financing decisions of new ventures and performance

**Course Contents**

| **Unit 1** | **Introduction to Business and Economics** |
|---|---|

**Business:** Structure of Business Firm, Theory of Firm, Types of Business Entities, Limited Liability Companies, Sources of Capital for a Company, Non-Conventional Sources of Finance

**Economics:** Significance of Economics, Micro and Macro Economic Concepts, Various terms and

Concepts, Importance of National Income, Inflation, Money Supply in Inflation, Factors of Production, Business Cycle, Features and Phases of Business Cycle. Nature and Scope of Business Economics, Role of Business Economist, Multidisciplinary nature of Business Economics

**Market Structures:** Nature of Competition, Features of Perfect competition, Monopoly, Oligopoly, Monopolistic Competition

**Demand and Supply:** Elasticity, Types of Elasticity, Law of Demand, Measurement and Significance of Elasticity of Demand, Factors affecting Elasticity of Demand, Elasticity of Demand in decision making, Demand Forecasting: Characteristics of Good Demand Forecasting, Steps in Demand Forecasting, Methods of Demand Forecasting. Determinants of Supply, Supply Function & Law of Supply. Utility and Laws of returns

| **Unit 2** | **Costs and Cost Accounting** |
|---|---|

**Costs**: Standard cost, estimated cost, First cost, Fixed cost, Variable cost, Incremental cost, Differential cost, Sunk and marginal cost, Cost curves, Breakeven point and breakeven chart, Limitations of breakeven chart, Interpretation of breakeven chart, margin of safety, Angle of incidence and multi product break even analysis, Cost Output Decision and Estimation of Cost, Zero Based Costing and numerical

**Cost Accounting:** Objectives of cost accounting, elements of cost: material cost, labor cost, and expenses, allocation of overheads by different methods, Costing based on direct and indirect costs, Overheads apportionment and absorption, Different Models of Depreciation. Numerical on costing

**Pricing:** Contribution, P/V-ratio, profit-volume ratio or relationship, Types of Pricing, Pricing policies, Pricing methods, Product Life Cycle based Pricing, Price fixation, depreciation and methods of calculating depreciation

| **Unit 3** | **Financial Accounting** |
|---|---|

Accounting, Cost accounting & Management accounting, Various types of business entities, Accounting principles, postulates & meaning of accounting standards, Accounting cycle, Capital and revenue, Revenue, Expenses, Gains & Losses, Types of accounts & their rules, Journal Entries Create ledger, Preparation of Trial Balance, Finalizations, Preparation of Trading & Profit & Loss account, Understanding of Assets & Liabilities

**Balance sheet and related concepts** - Profit & Loss Statement and related concepts, Financial Ratio Analysis, Cash flow analysis, Funds flow analysis, Comparative financial statements, Analysis & Interpretation of financial statements, Concept of Ratio Analysis, Preparation of Balance sheet (numerical)

**Investments:** Risks and return evaluation of investment decision, Average rate of return, Payback Period, Net Present Value, Internal rate of return

| **Unit 4** | **Budget and Budgetary Control** |
|---|---|

**Budgeting and Budgetary Control:** Concept of budget, Types and classification of budgets,

Advantages and limitations, Methods of budgeting

**Budgetary Control:** objectives, merits and limitations, Budget administration. Functional budgets. Fixed and flexible budgets, Installation of Budgetary Control System, Zero base budgeting, Taxes and Financial Planning, Impact of Taxation and Inflation on Financial Management

| **Unit 5** | **International Business and Finance** |
|---|---|

Concept of globalization, factors influencing globalization, concept of international business and motives, international trade, institutional framework in international business, the significance of foreign trade policy, export-import procedures

Definition and function of money, Qualities of a good money, classification of money, value of money, index numbers, appreciation and depreciation of money, Gresham's Law and its limitations, Theory of exchange, barter, stock exchange, Speculation Taxation and Insurance

Balance of Trade and Balance of Payments, Barriers to Trade, Benefits of Trade/Comparative Advantage, Foreign Currency Markets/Exchange Rates, Monetary, Fiscal and Exchange rate policies, Economic Development

| **Unit 6** | **Entrepreneurial Finance** |
|---|---|

**Sources of Funds for Entrepreneurs and Start Ups**: Entrepreneurial Finance Vs. Corporate Finance; Traditional Sources of Funds, Early-Stage Sources of Funds- Incubators, Accelerators, Crowd Funding, Business Angels, Mezzanine Funds, Venture Capitals, Private Equity, LBO, Funding Process - Deal Sourcing, Deal Negotiation, Deal Agreement, Term Sheet

**Investment Decisions for Start Ups:** Time Value of Money, Types of Investment Decisions, Capital Budgeting Process - Investment Evaluation, Risk Analysis in Capital Budgeting - Risk Adjusted Discount Rate, Certainty Equivalent, Decision Tree, Sensitivity Analysis, Scenario Analysis

**Valuation and Measurement of Financial Performance**: Pre Money and Post Money Valuation, Factors Influencing Valuation, Valuation Methods, Dilution and Valuation of Equity, Metrics used for Performance Evaluation, Harvesting-Exit Strategies

## Books and other resources

**Text Books:**


1. Hay, Donald A. and Derek J. Morris. Industrial Economics and Organization: Theory and Evidence, 2nd Edition (Oxford: Oxford University Press), 1991.
2. Lall, Sanjaya. Competitiveness, Technology and Skills (Cheltenham: Edward Elgar), 2001. 4. Scherer, F. M. and D. Ross. Industrial Market Structure and Economic Performance, 3rd Edition (Houghton: Mifflin), 1990.
3. Financial Accounting", Dr. Kaustubh Sontakke [Himalaya Publishing House]
4. Chandra, Prasanna (2004). Financial Management: Theory and Practice. New Delhi: TATA McGraw Hill


**References Books:**


1. Accounting Theory & Practice Prof Jawahar Lal [Himalaya Publishing House]

2. Brearley, Richard A. and Myers, Stewart C. (1988). “Principles of Corporate Finance”, New Delhi: McGraw-Hil
3. Engineering Economics, Tara Chand, Nem Chand and Brothers, Roorkee
4. Engineering Economy, Thuesen, G. J. and Fabrycky, W. J., Prentice Hall of India Pvt. Ltd.
5. Mechanical Estimating and Costing, T. R. Banga and S. C. Sharma, Khanna Publishers, Delhi
6. Industrial Organization and Engineering Economics, T. R. Banga and S. C. Sharma, Khanna Publishers, New Delhi
7. Mechanical Estimating and Costing, D. Kannappan et al., Tata McGraw Hill Publishing Company Ltd., New Delhi
8. A Text Book of Mechanical Estimating and Costing, O. P. Khanna, Dhanpat Rai Publications Pvt. Ltd., New Delhi
9. Industrial Engineering and Management, O. P. Khanna, Dhanpat Rai and Sons, New Delhi
10. Financial Management, I. M. Pandey, Vikas Publishing House Pvt. Ltd., New Delhi
11. Engineering Economics, James L. Riggs, David D. Bedworth and Sabah U. Randhawa, Tata McGrawHill Publishing Co. Ltd., New Delhi
12. Engineering Economy, Paul DeGarmo, Macmillan International Inc., New York
13. Entrepreneurial Finance-The Art and Science of Growing Ventures, Edited by Alemany L. and Andreoli, J.J, 2018, Cambridge University Press.
14. Rogers, S and Makonnen, R, Entrepreneurial Finance: Finance and Business Strategies for the Serious Entrepreneur, 4th Ed., Mc Graw Hill Education, 2020

**Web References:**

1. https://onlinecourses.nptel.ac.in/noc22_ma44/
2. https://onlinecourses.nptel.ac.in/noc22_hs72/
3. https://onlinecourses.nptel.ac.in/noc22_mg63/
4. https://onlinecourses.nptel.ac.in/noc22_mg108/
5. https://onlinecourses.nptel.ac.in/noc22_hs113/
6. https://onlinecourses.nptel.ac.in/noc22_ma44/

# Savitribai Phule Pune University

**Board of Studies - Mechanical and Automobile Engineering**

**Undergraduate Program – Final Year Automation and Robotics (2019 pattern)**

| **402044E: Internet of Things (Elective VI)** | | | | | |
|---|---|---|---|---|---|
| **Teaching Scheme** | | **Credits** | | **Examination Scheme** | |
| **Theory** | 3 Hrs./Week | **Theory** | 3 | **In-Semester** | 30 Marks |
| | | | | **End-Semester** | 70 Marks |

**Prerequisites:** Systems in Mechanical Engineering**,** Programming and Problem Solving, Basic Electronics Engineering, Solid Mechanics, Solid Modeling and Drafting, Electrical and Electronics Engineering, Mechatronics, Measurement Laboratory, Fluid Power & Control Laboratory

**Course Objectives:**

1. Introduction to IoT, Overview of IoT Building Blocks
2. Build small applications in IoT for Mechanical Engineering Applications using Sensors, Actuators, Microcontrollers and Cloud
3. Learn commonly used IoT Simulation Hardware platforms
4. Understand different Communication Technologies used in IoT
5. Development of application level protocol and Security of IoT Ecosystem
6. Understand IoT applications in different domains

**Course Outcomes:**

On completion of the course the learner will be able to;

CO1. **EXPLAIN** the Applications/Devices, Protocols and Communication Models of IoT

CO2. **DEMONSTARTE** small Mechanical Engineering IoT oriented applications using Sensors, Actuators, Microcontrollers and Cloud

CO3. **SELECT** commonly used IoT Simulation Hardware platforms

CO4. **APPLICATION** of Interfacing and Communication Technologies for IoT

CO5. **ILLUSTRATE** IoT Application Development and Security of IoT Ecosystem

CO6. **EVALUATE** Present and Future Domain specific Applications of IoT Ecosystem

**Course Contents**

| **Unit 1** | **Introduction to the Internet of Things (IoT)** |
|---|---|

Overview, History, Definition and Characteristics, Connectivity Terminologies, Building blocks, Types of technologies used in IoT System, Baseline Technologies (Machine-to-Machine ($M_2M$) communications, Cyber-Physical-Systems (CPS)), IoT Vs $M_2M$, IoT enabled Technologies, IoT Levels and Templates, Design Methodology, The Physical Design Vs Logical Design of IoT, Functional blocks of IoT and Communication Models/Technologies, Development Tools used in IoT, IoT Architecture and Protocols, Various Platforms for IoT, Real time Examples of IoT, Challenges in IoT, The process flow of an IoT application, Evolution of Connected Devices,

| | |
|---|---|
| Applications of IoT, IoT Enablers, Overview of Governance, Privacy and Security Issues. | |
| **Unit 2** | **Sensors, Actuators and Microcontrollers** |
| Measuring physical and virtual quantities in digital world, Overview of Sensors working, Analog Vs Digital Sensors, Wired Vs Wireless Sensors, Types of Sensors, Types of Converters<br><br>Types of Transducers and Actuator, Controlling Hardware, Types of Controller**,** Role of microcontroller as gateway to interfacing sensors and actuators, Microcontroller Vs Microprocessor, Type of microcontrollers in embedded System | |
| **Unit 3** | **IoT Simulation Environment Hardware platforms and Endpoint Interfacing** |
| **IoT supported Hardware platforms:** Introduction to IoT Simulation Environment and Devices (Raspberry Pi, Espressif Processors, Arduino), Architecture, Setup, IDE, Installation, Interfaces (serial, SPI, $I_2C$), Programming with focus on interfacing for reading input from pins, connecting external gadgets/sensors/actuators, Controlling and Displaying Output, Libraries, Basics of Embedded C programming<br><br>**Interfacing:** Interfacing Input, Intermediate, Output and Display Sensors, Converters, Actuators, Controlling Hardware, Controllers and Network Devices,<br><br>**IoT Architecture:** Building architecture and Open source architecture (OIC), Main design principles and needed capabilities, An IoT architecture outline, Standards Considerations | |
| **Unit 4** | **Interfacing and Communication for Building IoT Applications** |
| **Communication:** Overview and Working of Controlled Systems, Connectivity models - TCP/IP Vs OSI model, IoT Communication Models, IoT Communication APIs, Serial Vs Parallel Communication, Wires Vs Wireless Communication, their Technologies and Hardware<br><br>**IoT Communication Protocols:** Protocol Standardization for IoT, Role of $M_2M$ in IoT, $M_2M$ Value Chains, IoT Value Chains, $M_2M$ and WSN Protocols (SCADA and RFID)<br><br>**Physical Servers and Cloud Platforms:** Web server, Posting sensor(s) data to web server, Introduction to Cloud Storage models and Communication APIs Webserver, API Virtualization concepts and Cloud Architecture, Advantages and limitations of Cloud computing, IoT Cloud platforms, Cloud services | |
| **Unit 5** | **IoT Application Development and Security of IoT Ecosystem** |
| **Application Protocols:** MQTT, REST/HTTP, SQL Back-end Application Designing (Designing with Apache, MySQL, HTML, CSS), Non SQL Back-end Application Designing (MongoDB Object Type Database, jQuery for UI Designing), JSON lib for data processing<br><br>**Security:** Need of security in IoT, Security & Privacy during development, Privacy for IoT | |

enabled devices, IoT security for consumer devices, Security levels, protecting IoT devices, Security, Privacy and Trust in IoT-Data-Platforms

| **Unit 6** | **Present and Future Domain specific Applications of IoT Ecosystem** |
|---|---|

**IoT applications for industry:** Future Factory Concepts, Brownfield IoT, Smart Objects, Smart Applications. Study of existing IoT platforms /middleware, Business, Manufacturing, Smart Homes/Home automation, Surveillance applications, Connected Vehicles, Agriculture, Healthcare, Activity Monitoring, Retail, Logistics, Security, Health and Lifestyle, Legal challenges, IoT in Environmental Protection Modern Day IoT Applications, Smart Grid, Smart Cities - Security, Privacy and Trust in IoT-Data-Platforms for Smart Cities, First Steps Towards a Secure Platform, Smartie Approach. Data Aggregation for the IoT in Smart Cities

**Future:** Future IoT ecosystem, Need of powerful core for building secure algorithms, Examples for new trends (AI, ML penetration to IoT)

**Books and other resources**

**Text Books:**


1. Bahga, A. and Madisetti, V., (2015), "Internet of Things - A Hands-on Approach," Universities Press, ISBN: 9788173719547
2. Hajjaj, S S H. and Gsangaya, K. R., (2022), "The Internet of Mechanical Things: The IoT Framework for Mechanical Engineers," CRC Press, ISBN: 9781032110950
3. Raj, P. and Raman, A. C., (2017), "The Internet of Things: Enabling Technologies, Platforms, and Use Cases," Auerbach Publications/CRC Press, ISBN: 9781498761284
4. Adrian McEwen, A. and Cassimally, H., (2013), "Designing the Internet of Things," John Wiley and Sons, ISBN:
5. Veneri, G., Capasso, A., (2018), "Hands-On Industrial Internet of Things: Create a powerful Industrial IoT infrastructure using Industry 4.0," Packt Publishing, ISBN: 9781789537222
6. Hersent, O, Boswarthick, D., Elloumi, O., (2012), "The Internet of Things: Key Applications and Protocols", Wiley, ISBN: 9781119994350
7. Uckelmann, D., Harrison, M., Michahelles, F., (2011), "Architecting the Internet of Things," Springer, ISBN: 9781119994350


**References Books:**


1. daCosta, F., (2013), "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", Apress Publications, ISBN: 9781430257417
2. Waher, P., (2015), "Learning Internet of Things," Packt Publishing, ISBN: 9781783553532
3. Ovidiu, V. and Friess, P., (2014), "Internet of Things - From Research and Innovation to Market Deployment," River Publishers, ISBN: 9788793102941, https://www.riverpublishers.com/pdf/ebook/RP_E9788793102958.pdf
4. Ida, N., (2020), "Sensors, Actuators and Their Interfaces," SciTech Publishers, ISBN: 9781785618352
5. Pfister, C., (2011), "Getting Started with the Internet of Things," O'Reilly Media, ISBN:

9781449393571
6. Wallace, S., Richardson, M., Wolfram Donat, W., (2021), "Getting Started With Raspberry Pi: Getting to Know the Inexpensive ARM-Powered Linux Computer," Make Community, LLC, ISBN: 9781680456998
7. Elangovan, U., (2019), "Smart Automation to Smart Manufacturing: Industrial Internet of Things," Momentum Press, ISBN: 9781949449266
8. Jha, S., Tariq, U., Joshi, G. P., Solanki, V. K., (2022), "Industrial Internet of Things: Technologies, Design, and Applications," CRC Press, ISBN: 9780367607777
9. Schwartz, M., (2016), "Internet of Things with Arduino Cookbook," Packt Publishing, ISBN: 9781785286582
10. Kurniawan, A., (2019), "Internet of Things Projects with ESP32: Build exiting and powerful IoT projects using the all-new Expresif ESP32," Packt Publishing, ISBN: 9781789956870

**Web References:**

1. https://nptel.ac.in/courses/106105166
2. https://www.udemy.com/internet-of-things-iot-for-beginners-getting-started/
3. http://playground.arduino.cc/Projects/Ideas
4. http://www.megunolink.com/articles/arduino-garage-door-opener
5. http://www.willward1.com/arduino-wifi-tutorial
6. http://www.toptechboy.com/arduino-lessons
7. https://www.eprolabs.com
8. http://www.makeuseof.com/tag/pi-overdose-heres-5-raspberry-pi-alternatives

## 402552A: Data Science (Elective VI)

| Teaching Scheme | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|
| **Theory** | 3 Hr/week | **Theory** | 3 | **In-Semester** | 30 Marks |
| **Tutorial** | --- | **Tutorial** | --- | **End-Semester** | 70 Marks |

**Prerequisites:** Discrete Mathematics

**Course Objectives:**

1. To understand the need of Data Science
2. To understand computational statistics in Data Science
3. To study and understand the different technologies used for Data processing
4. To understand and apply data modeling strategies
5. To learn Data Analytics using Python programming
6. To be conversant with advances in analytics

**Course Outcomes:**

On completion of the course the learner will be able to;

CO1: ANALYZE needs and challenges for Data Science
CO2: APPLY statistics for Data Analytics
CO3: APPLY the lifecycle of Data analytics to real world problems
CO4: IMPLEMENT Data Analytics using Python programming
CO5: IMPLEMENT data visualization using visualization tools in Python programming
CO6: DESIGN and IMPLEMENT Big Databases using the Hadoop ecosystem

**Course Contents**

| **Unit 1** | **Introduction to Data Science** |
|---|---|

Basics and need of Data Science, Applications of Data Science, Relationship between Data Science and Information Science, Business intelligence versus Data Science, Data: Data Types, Data Collection. Need of Data wrangling, Methods: Data Cleaning, Data Integration, Data Reduction, Data Transformation, and Data Discretization.

| **Unit 2** | **Statistical Inference** |
|---|---|

Need of statistics in Data Science, Measures of Central Tendency: Mean, Median, Mode, Mid-range. Measures of Dispersion: Range, Variance, Mean Deviation, Standard Deviation. Bayes theorem, Basics and need of hypothesis and hypothesis testing, Pearson Correlation, Sample Hypothesis testing, Chi-Square Tests, t-test

| **Unit 3** | **Data Analytics Life Cycle** |
|---|---|

Introduction, Data Analytic Lifecycle: Introduction, Phase 1: Discovery, Phase 2: Data Preparation, Phase 3: Model Planning, Phase 4: Model Building, Phase 5: Communication results, Phase 6: Operationalize.

| **Unit 4** | **Predictive Data Analytics with Python** |
|---|---|

Introduction, Essential Python Libraries, Basic examples. Data Preprocessing: Removing Duplicates, Transformation of Data using function or mapping, replacing values, Handling Missing Data. Analytics Types: Predictive, Descriptive and Prescriptive. Association Rules: Apriori

Algorithm, FP growth. Regression: Linear Regression, Logistic Regression. Classification: Naïve Bayes, Decision Trees. Introduction to Scikit-learn, Installations, Dataset, mat plotlib, filling missing values, Regression and Classification using Scikit-learn.

| **Unit 5** | **Data Analytics and Model Evaluation** |
|---|---|

Clustering Algorithms: K-Means, Hierarchical Clustering, Time-series analysis. Introduction to Text Analysis: Text-preprocessing, Bag of words, TF-IDF and topics. Need and Introduction to social network analysis, Introduction to business analysis. Model Evaluation and Selection: Metrics for Evaluating Classifier Performance, Holdout Method and Random Sub sampling, Parameter Tuning and Optimization, Result Interpretation, Clustering and Time-series analysis using Scikit- learn, sklearn. metrics, Confusion matrix, AUC-ROC Curves, Elbow plot.

| **Unit 6** | **Data Visualization and Hadoop** |
|---|---|

Introduction to Data Visualization, Types of data visualization, Data Visualization Techniques, Tools used in Data Visualization, Challenges to Big data visualization, Visualizing Big Data, Analytical techniques used in Big data visualization, Hadoop ecosystem, Map Reduce, Pig, Hive,. Data Visualization using Python: Line plot, Scatter plot, Histogram, Density plot, Box- plot

**Books and other resources**

**Text Books:**


1. David Dietrich, Barry Hiller, “Data Science and Big Data Analytics”, EMC education services, Wiley publication, 2012, ISBN0-07-120413-X.
2. Jiawei Han, Micheline Kamber, and Jian Pie, “Data Mining: Concepts and Techniques” Elsevier Publishers Third Edition, ISBN: 9780123814791, 9780123814807


**References Books:**


1. EMC Education Services, “Data Science and Big Data Analytics- Discovering, analyzing Visualizing and Presenting Data” Ist Edition.
2. DT Editorial Services, “Big Data, Black Book”, DT Editorial Services, ISBN: 9789351197577, 2016 Edition.
3. Chirag Shah, “A Hands-On Introduction To Data Science”, Cambridge University Press, (2020), ISBN : ISBN 978-1-108-47244-9.
4. Wes McKinney, “Python for Data Analysis ”, O' Reilly media, ISBN: 978-1-449-31979-3.
5. Trent Hauk, “Scikit-learn Cookbook”, Packt Publishing, ISBN: 9781787286382.
6. Jenny Kim, Benjamin Bengfort, “Data Analytics with Hadoop”, OReilly Media, Inc., ISBN: 9781491913703


**Web References:**


1. An Introduction to Statistical Learning by Gareth James
https://www.ime.unicamp.br/~dias/Intoduction%20to%20Statistical%20Learning.pdf
2. Python Data Science Handbook by Jake VanderPlas
https://tanthiamhuat.files.wordpress.com/2018/04/pythondatasciencehandbook.pdf
3. Hadoop Tutorial :
https://www.tutorialspoint.com/hadoop/hadoop_tutorial.pdf?utm_source=7_&utm_medium=affiliate&utm_content=5f34cd37cdf1050001b09537&utm_campaign=Admitad&utm_term=761c575424fc4a6b48d02f72157eb578
4. Learning with Python; How to think like a computer scientist:
http://openbookproject.net/thinkcs/python/english3e/
5. Scikit Learn Tutorial https://scikit-learn.org/stable/
6. Python for everybody:http://do1.dr-chuck.com/pythonlearn/EN_us/pythonlearn.pdf

7. An introduction to data Science :
https://docs.google.com/file/d/0B6iefdnF22XQeVZDSkxjZ0Z5VUE/edit?pli=1

# Savitribai Phule Pune University

**Board of Studies - Mechanical and Automobile Engineering**

**Undergraduate Program – Final Year Automation and Robotics (2019 pattern)**

## 402552B: Data Visualization (Elective VI)

| Teaching Scheme | | Credits | | Examination Scheme | |
|---|---|---|---|---|---|
| **Theory** | 3 Hrs/Week | **Theory** | 3 | **In-Semester** | 30 Marks |
| | | | | **End-Semester** | 70 Marks |

**Prerequisites:** Artificial Intelligence and Statistics

**Course Objectives:**

1. Conceptualized representation of Data objects.
2. Create associations between different data objects, and the rules.
3. Organized data description, data semantics, and consistency constraints of data
4. Identifying data trends
5. Incorporate data visualization tools and reap transformative benefits in their critical areas of operations.

**Course Outcomes:**On completion of the course the learner will be able to;

CO1: UNDERSTAND the basic features of data visualisation.
CO2: USE data analysis tools in the pandas library.
CO3: ANALYZE the characteristics and requirements of data and select an appropriate data model.
CO4: CREATE informative visualization and summarize data sets.
CO5: ANALYZE and MANIPULATE time series data.
CO6: SOLVE real world data analysis problems.

**Course Contents**

| **Unit 1** | **Introduction** |
|---|---|

Introduction to Data Science, Exploratory Data Analysis and Data Science Process. Motivation for using Python for Data Analysis, Introduction of Python shell iPython and Jupyter Notebook. Essential Python Libraries: NumPy, pandas, matplotlib, SciPy, scikit-learn, statsmodels

**Computational Statistics and Data Visualization**, Types of Data Visualization, Presentation and Exploratory Graphics, Graphics and Computing, Statistical Historiography, Scientific

**Design Choices in Data Visualization**, Higher-dimensional Displays and Special Structures,

**Static Graphics** : Complete Plots, Customization, Extensibility,

**Other Issues** : 3-D Plots , Speed , Output Formats , Data Handling

| **Unit 2** | **Introduction to Pandas** |
|---|---|

Getting Started with Pandas: Arrays and vectorized computation, Introduction to pandas Data Structures, Essential Functionality, Summarizing and Computing Descriptive Statistics. Data Loading, Storage and File Formats. Reading and Writing Data in Text Format, Web Scraping, Binary Data Formats, Interacting with Web APIs, Interacting with Databases Data Cleaning and Preparation. Handling Missing Data, Data Transformation, String Manipulation

Data Aggregation and Group operations: Group by Mechanics, Data aggregation, General split-apply-combine, Pivot tables and cross tabulation

| **Unit3** | **Data Wrangling** |
|---|---|

Hierarchical Indexing, Combining and Merging Data Sets Reshaping and Pivoting. Data Visualization matplotlib: Basics of matplotlib, plotting with pandas and seaborn, other python

visualization tools

**Data Visualization Through Their Graph Representations :** Data and Graphs Graph Layout Techniques, Force-directed Techniques Multidimensional Scaling, The Pulling Under Constraints Model , Bipartite Graphs

| **Unit 4** | **Testing and Data Modeling** |
|---|---|

Random Numbers and Simulation: Sampling of continuous distributions, Monte Carlo methods

Hypothesis Testing: Type I and II errors, rejection regions; Z-test, T-test, F-test, Chi-Square test, Bayesian test

Stochastic Processes and Data Modeling: Markov process, Hidden Markov Models, Poisson Process, Gaussian Processes ,Auto-Regressive and Moving average processes, Bayesian Network, Regression, Queuing systems

| **Unit 5** | **Time Series Data Analysis** |
|---|---|

Date and Time Data Types and Tools, Time series Basics, date Ranges, Frequencies and Shifting, Time Zone Handling, Periods and Periods Arithmetic, Resampling and Frequency conversion, Moving Window Functions

| **Unit 6** | **Data Aggregation and Analysis** |
|---|---|

Data Aggregation and Group operations: Group by Mechanics, Data aggregation, General split-apply-combine, Pivot tables and cross tabulation 67 Time Series

Data Analysis: Date and Time Data Types and Tools, Time series Basics, date Ranges, Frequencies and Shifting, Time Zone Handling, Periods and Periods Arithmetic, Resampling and Frequency conversion, Moving Window Functions.

**Books and other resources**

**Text Books:**


1. Chun-houh Chen Wolfgang Härdle Antony Unwin Editors Handbook of Data Visualization, Springer
2. Visualizing Data Ben Fry Beijing , Published by O'Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, CA 95472.
3. Fundamentals of Data Visualization - A Primer on Making Informative and Compelling Figures , Clous O.Wilke , Published by O'Reilly Media, Inc.
4. Data Visualization - A Practical Introduction by Kieran Healy
5. McKinney, W.(2017). Python for Data Analysis: Data Wrangling with Pandas, NumPy and IPython. 2nd edition. O'Reilly Media
6. Gelman, Andrew, and Jennifer Hill. Data Analysis Using Regression and Multilevel /Hierarchical Models. 1st ed. Cambridge, UK: Cambridge University Press, 2006. ISBN: 9780521867061.
7. Gelman, Andrew, John B. Carlin, Hal S. Stern, and Donald B. Rubin. Bayesian Data Analysis. 2nd ed. New York, NY: Chapman & Hall, 2003. ISBN: 9781584883883


**Reference Books:**


1. Gelman, Andrew, and Jennifer Hill. Data Analysis Using Regression and Multilevel/Hierarchical Models. 1st ed. Cambridge, UK: Cambridge University Press, 2006. ISBN: 9780521867061.
2. Gelman, Andrew, John B. Carlin, Hal S. Stern, and Donald B. Rubin. Bayesian Data Analysis. 2nd ed. New York, NY: Chapman & Hall, 2003. ISBN: 9781584883883.
3. David Dietrich, Barry Hiller, "Data Science and Big Data Analytics", EMC education services, Wiley publication, 2012, ISBN0-07-120413-X.
4. Trent Hauk, "Scikit-learn Cookbook", Packt Publishing, ISBN: 9781787286382.
5. Chirag Shah, "A Hands-On Introduction To Data Science", Cambridge University Press, (2020), ISBN : ISBN 978-1-108-47244-9..

6. C. Gupta, V.K. Kapoor,"Fundamentals of Mathematics Statistics (A Modern Approach) " Sultan Chand & Sons Educational Publishers, Tenth revised edition , ISBM: 81-7014-791-3
7. Medhi "Statistical Methods: An Introductory Text", Second Edition , New Age International Ltd, ISBN:8122419577

MOOC / NPTEL/YouTube Links :

1. https://www.youtube.com/watch?v=WSNqcYqByFk
2. https://www.youtube.com/watch?v=eFByJkA3ti4
3. Computer Science and Engineering - NOC:Data Science for Engineers
4. Computer Science and Engineering - NOC:Python for Data Science
5. Introduction to Data Analytics : https://nptel.ac.in/courses/110106072

| **402552C: Network Science (Elective–VI)** | | | | | |
|---|---|---|---|---|---|
| **Teaching Scheme** | | **Credits** | | **Examination Scheme** | |
| **Theory** | 3Hrs/Week | **Theory** | 3 | **In-Semester** | 30 Marks |
| | | | | **End-Semester** | 70 Marks |

**Prerequisites:** Introduction to Manufacturing

**Course Objectives:**

1. Understand the fundamental principles and concepts of network science, including the representation and analysis of complex networks.
2. Develop a comprehensive knowledge of different types of networks, such as social networks, biological networks, technological networks, and economic networks.
3. Gain proficiency in network analysis techniques, including centrality measures, community detection algorithms, and network visualization methods.
4. Apply network science principles to analyze real-world networks, identify patterns and structures, and extract meaningful insights.
5. Explore the dynamics of networks, including diffusion processes, information propagation, and the spread of epidemics, to understand the behavior of interconnected systems.
6. Understand the role of network science in various domains, such as social sciences, biology, computer science, and economics, and appreciate its interdisciplinary nature.

**Course Outcomes:**

On completion of the course the learner will be able to;

CO1: DEMONSTRATE a solid understanding of the fundamental principles, theories, and concepts of network science.

CO2: APPLY network analysis techniques to study and interpret the structure and dynamics of complex networks from various domains, including social networks, biological networks, technological networks, and economic networks.

CO3: ANALYZE and INTERPRET network properties and measures, such as centrality, clustering coefficient, and community structure, to gain insights into the organization and behavior of networks.

CO4: USE network visualization tools and techniques to effectively communicate and present network data and analysis results.

CO5: APPLY network modeling and simulation methods to study the dynamic processes occurring on networks, including information diffusion, cascading failures, and opinion dynamics.

CO6: DESIGN and CONDUCT network-based research projects, including data collection, preprocessing, analysis, and interpretation, to investigate and solve real-world problems using network science methodologies.

**Course Contents**

| **Unit 1** | **Introduction to Network Science** |
|---|---|

Overview of Network Science: Definitions, concepts, and applications. Types of networks: Social

networks, technological networks, biological networks, etc. Network representation: Nodes, edges, and their attributes. Basic measures in network analysis: Degree centrality, betweenness centrality, and clustering coefficient. Network visualization and analysis using software tools.

| **Unit 2** | **Network Models** |
|---|---|

Random graph models: Erdős-Rényi model, Watts-Strogatz model, and Barabási-Albert model. Small-world networks and scale-free networks. Community detection algorithms: Modularity, Girvan-Newman algorithm, and Louvain method. Network motifs and their significance. Introduction to dynamic networks: Temporal networks and evolving networks.

| **Unit3** | **Centrality and Connectivity** |
|---|---|

Centrality measures: Eigenvector centrality, closeness centrality, and Katz centrality. Local and global connectivity measures: Clustering coefficient, average path length, and diameter.
Connectivity analysis: Strongly connected components, weakly connected components, and giant connected component. Influence and spread dynamics on networks: Epidemic models, cascading failures, and information diffusion.

| **Unit 4** | **Network Dynamics** |
|---|---|

Random walks and Markov processes on networks. PageRank algorithm and its applications. Network resilience and robustness. Opinion dynamics and social influence models. Game theory on networks: Prisoner's dilemma, evolutionary games, and network formation games.

| **Unit 5** | **Network Communities and Structure** |
|---|---|

Community detection methods: Modularity optimization, spectral clustering, and hierarchical clustering. Network motifs and their role in community structure. Role discovery in networks: Structural equivalence, homophily, and assortativity. Network embedding techniques: Node2Vec, DeepWalk, and GraphSAGE. Multiplex networks and their analysis.

| **Unit 6** | **Applications of Network Science** |
|---|---|

Social network analysis: Influence networks, online social networks, and recommendation systems. Biological network analysis: Protein-protein interaction networks, gene regulatory networks, and brain networks. Technological network analysis: Internet networks, transportation networks, and power grids. Economic and financial networks: Stock market networks, interbank networks, and supply chain networks. Ethical considerations and privacy concerns in network science.

**Books and other resources**

**Text Books:**

1. "Networks: An Introduction" by Mark Newman
2. "Network Science" by Albert-László Barabási
3. "Networks: A Very Short Introduction" by Guido Caldarelli and Michele Catanzaro
4. "Complex Networks: Principles, Methods, and Applications" by Reuven Cohen and Shlomo Havlin
5. "Network Science: Theory and Applications" by Ted G. Lewis
6. "Networks, Crowds, and Markets: Reasoning about a Highly Connected World" by David Easley and Jon Kleinberg

**References Books:**

1. Graph Theory and Complex Networks: An Introduction" by Maarten van Steen
2. "Scale-Free Networks: Complex Webs in Nature and Technology" by Guido Caldarelli
3. "Networks: A Primer" by Mark Newman
4. "Introduction to the Theory of Complex Networks" by Ernesto Estrada

**Web References:**

http://www.digimat.in/nptel/courses/video/106105154/L02.html

# Savitribai Phule Pune University

**Board of Studies - Mechanical and Automobile Engineering**

**Undergraduate Program – Final Year Automation and Robotics (2019 pattern)**

| **402051D: Industrial Psychology and Organizational Behavior (Elective–VI)** | | | | | |
|---|---|---|---|---|---|
| **Teaching Scheme** | | **Credits** | | **Examination Scheme** | |
| **Theory** | 3 Hrs./Week | **Theory** | 3 | **In-Semester** | 30 Marks |
| | | | | **End-Semester** | 70 Marks |

**Prerequisites:** Understanding psychology as natural science, Infancy and Preschool Years, Diversity and Social Interaction, zeal to contribute for individual, group, social and national development.

**Course Objectives:**

1. To develop an understanding of the nature, functioning and design of organization as social collectivities.
2. To orient the students to the application of principles of psychology in an industrial and organizational workplace
3. To demonstrate the understanding of job requirement and related fatigue, boredom and ways to handle it.
4. To develop the insights into performance management and understanding related improvement strategies.
5. To have an understanding of human behavior in groups and develop knowledge and skills in leadership, power, communication, negotiation and conflict management.
6. To develop the acumen to understand the organizational culture, change management and organizational development.

**Course Outcomes**

On completion of the course the learner will be able to;

CO1. **DEMONSTRATE** fundamental knowledge about need and scope of industrial - organizational psychology and behavior.

CO2. **ANALYZE** the job requirement, have understanding of fatigue, boredom and improve the job satisfaction.

CO3. **UNDERSTAND** the approaches to enhance the performance.

CO4. **KNOWLEDGE** of theories of organizational behavior, learning and social-system.

CO5. **UNDERSTAND** the mechanism of group behavior, various aspects of team, leadership and conflict management.

CO6. **EVALUATE** the organizational culture, manage the change and understands organizational development approaches.

**Course Content**

| **Unit 1** | **Industrial Psychology: Introduction** |
|---|---|

Introduction to Industrial Psychology, Brief History of Industrial Psychology, Nature, Scope and Problems, psychology as a science and areas of applications, Individual differences and their

evaluation, Role of heredity and environment, study of behavior and stimulus to response behavior, Types of individual differences, Scientific management and it's limitations

**Hawthorne Studies**: Introduction, Hawthorne Studies, Implication of Hawthorne Studies, Criticisms of Hawthorne Studies, Relevance of Industrial psychology in era of Industry 5.0

| **Unit 2** | **Job Analysis and Industrial Fatigue** |
|---|---|

Job Analysis and Evaluation, Employee Selection, Performance Evaluation, training and development

**Industrial Fatigue**: Introduction, Concept and Meaning, Types of Industrial Fatigue, Causes of Fatigue, Contents, Fatigue Symptoms, Industrial Studies on Fatigue, Causes and Remedies of Industrial Fatigue, Effects of Industrial Fatigue

**Industrial Boredom**: Introduction, Concept and Meaning, Causes and Remedies of Boredom, Effects of Boredom, Reducing Boredom

| **Unit 3** | **Performance Management** |
|---|---|

**Performance Management**: Introduction, Concept and Meaning, Objectives of Performance Management, Process of Performance Management, Approaches to Performance Development, Methods of Performance Management

Relevance of Leadership and supervision, Recruitment, Time and Stress Management, Occupational Health and Safety. Implication of Motivation Theories in Workplace, Factors Influencing Job Satisfaction, Reducing Dissatisfaction

| **Unit 4** | **Organizational Behavior: Introduction** |
|---|---|

Concept of organization & organizational behavior, Organizational structure, factors affecting behavior in organizations, Theories of Organization - Classic Organizational Theory, Human Relations Theory, Contingency Theories, Models and Approaches of Organizational Behavior.

Ethics and ethical behavior in organizations, Learning: meaning and definition, process and theories of learning, Understanding a social-system, Organizational Behavior in an Engineering Sector Organization

| **Unit 5** | **Group Behavior and Interpersonal Relationships** |
|---|---|

**Group Behavior**: Groups: Concept and Classification, Stages of Group Development, Group Structure, Roles and Norms, Premise and Issues. Group Decision-Making: Group vs Individual, Groupthink and Groups Shift, Group Decision Making Techniques and Process

**Team work**: meaning, concept, types, creating, an effective team

**Leadership**: Functions and approaches; trait, behavioral and contingency models; characteristics of successful leaders; role of power in leadership

**Interpersonal Relationships**: Understanding Self and Others, Developing Interpersonal

Relationships, Transactional Analysis, Johari Window

**Conflict Management**: Concept, Causes, Types, Stages, Effects, Management of Conflicts

| **Unit 6** | **Organizational Culture, Change Management and Organizational Development** |
|---|---|

**Organizational Culture**: Concept, Dominant Culture, Strong vs Weak Cultures, Creating and Sustaining Culture, Employees Learning of the Culture, Creating a Customer-Responsive Culture.

**Organizational Changes**: Concept and Forces for Change, Managing Planned Changes, Resistance to Change, Approaches to Manage Organizational Change, Organizational Development, Culture-Boundedness of Managing the Change.

**Organizational theory and development**:
**Organizational Theory**: Classical organizational THEORY, Humanistic Theory, Open-System Theory
**Organizational development**: Need, models of Organizational change, Organizational development interventions

**Books and other resources**

## Text Books:


1. Vikram Bisen and Priya, Indistrial Psychology, New Age Publication, 2010.
2. Michael Aamodt, Organizational/ Industrial Psychology, Wadsworth Cengage Learning, 2010
3. Robbins, S.P. Organizational Behaviour. Prenctice-Hall, latest edition.
4. Spector, P.E. Industrial and Organizational Psychology: Research and Practice. International Student Version. Latest Edition. Wiley.
5. Davis K. & Newstrom J.W., Human Behaviour at work, Mcgraw Hill International, 1985
6. Stephen P. Robbin & Seema Sanghi, Organizational behavior, Pearson, 2011
7. L.M. Prasad, Organizational behavior, S Chand & sons


## References Books:


1. Blum M.L. Naylor J.C., Horper & Row, Industrial Psychology, CBS Publisher
2. Luthans Fred, Organizational Behaviour, McGraw Hill International.
3. Morgan C.t., King R.A.,John Rweisz & John Schoples, Introduction to Psychology, McHraw Hill, 1966
4. Schermerhorn J.R.Jr., Hunt J.G &Osborn R.N., Managing, Organizational Behaviour, John Willy
5. Arnold J., Robinson, Iran, T. and Cooper, Cary L, Work Psychology, Macmillan IndiaLtd.
6. Muchincky (2009). Psychology applied to work. New Delhi: Cengage.
7. Griffin, Ricky W: Organizational Behaviour, Houghton Mifflin co., Boston.
8. Ivancevich; John and Micheeol T. Matheson, Organizational Behaviour and Management, Tata McGraw-Hill, New Delhi.
9. Newstrom, John W. and Keith Davis: Organizational Behavior: Human Behavior at Work, Tata McGraw-Hill, New Delhi.
10. Steers Richard m. and J. Stewart black: Organizational Behavior, Hrper Collins college

Publishers, New York.
11. Sukla, Madhukar: Understanding Organizations: Organization Theory and Practice in India, Prentice Hall, New Delhi.

**Web References:**

1. http://nptel.ac.in/cour ses/110105034/1
2. http://nptel.ac.in/cour ses/110105034/6
3. http://nptel.ac.in/cour ses/110105034/12
4. http://nptel.ac.in/cour ses/110105034/8
5. http://nptel.ac.in/cour ses/110105034/14
6. http://nptel.ac.in/course s/110105034/23
7. http://nptel.ac.in/course s/110105034/26
8. http://nptel.ac.in/course s/110105034/27
9. http://nptel.ac.in/cour ses/110105034/34
10. http://nptel.ac.in/cour ses/110105034/2
11. http://nptel.ac.in/cour ses/110105034/40

# Savitribai Phule Pune University

**Board of Studies - Mechanical and Automobile Engineering**

**Undergraduate Program – Final Year Automation and Robotics (2019 pattern)**

| **402553: Data Visualization and Analytics Laboratory** | | | | | |
|---|---|---|---|---|---|
| **Teaching Scheme** | | **Credits** | | **Examination Scheme** | |
| **Practical** | 2 Hrs/Week | **Practical** | 1 | **Practical** | 25 Marks |
| | | | | **Term Work** | 25 Marks |

**Prerequisites:** Data Visualization basics

**Practical Contents**

Use data set of your choice from Open Data Portal (https://data.gov.in/) for the following exercises.

**1. Practicals based on NumPy nd array and Pandas**

Problem Statement: Analyzing Housing Prices Dataset using NumPy ndarray and Pandas Data Structures

Dataset: "Housing_Prices.csv"

Description: The dataset contains information about housing prices in a specific area. It includes attributes such as house size, number of bedrooms, location, and sale price. The goal is to use NumPy ndarray and Pandas data structures to perform data manipulation, analysis, and visualization tasks on the housing prices dataset.

Tasks to Perform:

- Import the "Housing_Prices.csv" dataset using Pandas.
- Explore the dataset to understand its structure and content, including the data types of each attribute.
- Convert relevant columns into NumPy ndarrays for further analysis and manipulation.
- Use NumPy operations to calculate statistical measures such as mean, median, standard deviation, or range of housing prices.
- Perform data cleaning tasks, such as handling missing values, outliers, or inconsistent data entries.
- Use Pandas functions to filter and subset the dataset based on specific criteria, such as houses with a certain number of bedrooms or within a certain price range.
- Apply descriptive statistics using Pandas to summarize and analyze the housing price distribution, such as calculating percentiles or generating frequency tables.
- Perform data aggregation using Pandas to calculate average prices by specific categories, such as location or house size.
- Merge or join the dataset with additional data sources if available, such as demographic data or housing market indices, to gain more insights and perform advanced analysis.

**2. Practicals based on Data Loading, Storage and File Formats**

Problem Statement: Analyzing Sales Data from Multiple File Formats

Dataset: Sales data in multiple file formats (e.g., CSV, Excel, JSON)

Description: The goal is to load and analyze sales data from different file formats, including CSV, Excel, and JSON, and perform data cleaning, transformation, and analysis on the dataset.

Tasks to Perform:

- Obtain sales data files in various formats, such as CSV, Excel, and JSON.
- Load the sales data from each file format into the appropriate data structures or dataframes.
- Explore the structure and content of the loaded data, identifying any inconsistencies, missing values, or data quality issues.
- Perform data cleaning operations, such as handling missing values, removing duplicates, or correcting inconsistencies.
- Convert the data into a unified format, such as a common dataframe or data structure, to enable seamless analysis.
- Perform data transformation tasks, such as merging multiple datasets, splitting columns, or deriving new variables.
- Analyze the sales data by performing descriptive statistics, aggregating data by specific variables, or calculating metrics such as total sales, average order value, or product category distribution.
- Create visualizations, such as bar plots, pie charts, or box plots, to represent the sales data and gain insights into sales trends, customer behavior, or product performance.

**3. Practical based on Data Cleaning and Preparation**

1. Problem Statement: Analyzing Customer Churn in a Telecommunications Company

Dataset: "Telecom_Customer_Churn.csv"

Description: The dataset contains information about customers of a telecommunications company and whether they have churned (i.e., discontinued their services). The dataset includes various attributes of the customers, such as their demographics, usage patterns, and account information. The goal is to perform data cleaning and preparation to gain insights into the factors that contribute to customer churn.

Tasks to Perform:

- Import the "Telecom_Customer_Churn.csv" dataset.
- Explore the dataset to understand its structure and content.
- Handle missing values in the dataset, deciding on an appropriate strategy.
- Remove any duplicate records from the dataset.
- Check for inconsistent data, such as inconsistent formatting or spelling variations, and standardize it.
- Convert columns to the correct data types as needed.
- Identify and handle outliers in the data.
- Perform feature engineering, creating new features that may be relevant to predicting customer churn.
- Normalize or scale the data if necessary.
- Split the dataset into training and testing sets for further analysis.
- Export the cleaned dataset for future analysis or modeling.

**4 . Practical based on Data Wrangling**

Dataset: "RealEstate_Prices.csv"
Description: The dataset contains information about housing prices in a specific real estate market. It includes various attributes such as property characteristics, location, sale prices, and other relevant features. The goal is to perform data wrangling to gain insights into the factors influencing housing prices and prepare the dataset for further analysis or modeling.
Tasks to Perform:

- Import the "RealEstate_Prices.csv" dataset. Clean column names by removing spaces, special characters, or renaming them for clarity.
- Handle missing values in the dataset, deciding on an appropriate strategy (e.g., imputation or removal).
- Perform data merging if additional datasets with relevant information are available (e.g., neighborhood demographics or nearby amenities).
- Filter and subset the data based on specific criteria, such as a particular time period, property type, or location.
- Handle categorical variables by encoding them appropriately (e.g., one-hot encoding or label encoding) for further analysis.
- Aggregate the data to calculate summary statistics or derived metrics such as average sale prices by neighborhood or property type.
- Identify and handle outliers or extreme values in the data that may affect the analysis or modeling process.

**4. Practical based on Data Visualization using matplotlib**

Analyzing Air Quality Index (AQI) Trends in a City

Dataset: "City_Air_Quality.csv"
Description: The dataset contains information about air quality measurements in a specific city over a period of time. It includes attributes such as date, time, pollutant levels (e.g., PM2.5, PM10, CO), and the Air Quality Index (AQI) values. The goal is to use the matplotlib library to create visualizations that effectively represent the AQI trends and patterns for different pollutants in the city.

Tasks to Perform:

- Import the "City_Air_Quality.csv" dataset.
- Explore the dataset to understand its structure and content.
- Identify the relevant variables for visualizing AQI trends, such as date, pollutant levels, and AQI values.
- Create line plots or time series plots to visualize the overall AQI trend over time.
- Plot individual pollutant levels (e.g., PM2.5, PM10, CO) on separate line plots to visualize their trends over time.
- Use bar plots or stacked bar plots to compare the AQI values across different dates or time periods.
- Create box plots or violin plots to analyze the distribution of AQI values for different pollutant categories.
- Use scatter plots or bubble charts to explore the relationship between AQI values and pollutant levels.
- Customize the visualizations by adding labels, titles, legends, and appropriate color schemes.

**6. Practical based on Data Aggregation**

Analyzing Sales Performance by Region in a Retail Company

Dataset: "Retail_Sales_Data.csv"

Description: The dataset contains information about sales transactions in a retail company. It includes attributes such as transaction date, product category, quantity sold, and sales amount. The goal is to perform data aggregation to analyze the sales performance by region and identify the top-performing regions.

Tasks to Perform:

- Import the "Retail_Sales_Data.csv" dataset.
- Explore the dataset to understand its structure and content.
- Identify the relevant variables for aggregating sales data, such as region, sales amount, and product category.
- Group the sales data by region and calculate the total sales amount for each region.
- Create bar plots or pie charts to visualize the sales distribution by region.
- Identify the top-performing regions based on the highest sales amount.
- Group the sales data by region and product category to calculate the total sales amount for each combination.
- Create stacked bar plots or grouped bar plots to compare the sales amounts across different regions and product categories.

**7. Practical based on Time Series Data Analysis**

Dataset: "Stock_Prices.csv"
Description: The dataset contains historical stock price data for a particular company over a period of time. It includes attributes such as date, closing price, volume, and other relevant features. The goal is to perform time series data analysis on the stock price data to identify trends, patterns, and potential predictors, as well as build models to forecast future stock prices.
Tasks to Perform:

- Import the "Stock_Prices.csv" dataset.
- Explore the dataset to understand its structure and content.
- Ensure that the date column is in the appropriate format (e.g., datetime) for time series analysis.
- Plot line charts or time series plots to visualize the historical stock price trends over time.
- Calculate and plot moving averages or rolling averages to identify the underlying trends and smooth out noise.
- Perform seasonality analysis to identify periodic patterns in the stock prices, such as weekly, monthly, or yearly fluctuations.
- Analyze and plot the correlation between the stock prices and other variables, such as trading volume or market indices.
- Use autoregressive integrated moving average (ARIMA) models or exponential smoothing models to forecast future stock prices.

# Savitribai Phule Pune University

## Board of Studies - Mechanical and Automobile Engineering

## Undergraduate Program – Final Year Automation and Robotics (2019 pattern)

<table>
<tr><th colspan="6">402554: Project (Stage-II)</th></tr>
<tr><td colspan="2">Teaching Scheme</td><td colspan="2">Credits</td><td colspan="2">Examination Scheme</td></tr>
<tr><td>Practical</td><td>10 Hrs/Week</td><td>Practical</td><td>5</td><td>Term Work</td><td>100 Marks</td></tr>
<tr><td></td><td></td><td></td><td></td><td>Oral</td><td>50 Marks</td></tr>
<tr><td colspan="6">Prerequisites: Project Based Learning, Internship/Mini Project, Laboratory works, Skill Development, Audit Courses, Industrial Visits, Project (Stage I)</td></tr>
<tr><td colspan="6">Project Stage II is the extension of Project Stage I.<br><br>Course Objectives, Course Outcomes, Course Contents and Guidelines for Project Execution are same as that of Project Stage I</td></tr>
<tr><td colspan="6">Term Work Evaluation</td></tr>
<tr><td colspan="6">1. In Project Stage II, two reviews shall be taken for total 100 marks (50 marks each)<br>2. Review III shall be based on the approximate end of fabrication / design validation etc. in front of an expert panel from the department.<br>3. Review IV shall be third party evaluation by Faculty/Student/Industry person/Alumni<br>4. Evaluation committee shall consist of Guide, One Industry person and One Faculty appointed by the Institution.<br>5. Students shall be encouraged to publish a research paper/patent/technical note. Their credential shall be considered while term work evaluation.</td></tr>
<tr><td colspan="6">Examination Scheme</td></tr>
<tr><td colspan="6">1. Examination committee shall consist of Internal Examiner and External Examiner appointed by University. (External Examiner shall be a competent Industry/Research/Laboratory person. A list shall be provided by Board of Studies)<br>2. Well in advance soft copies of the project shall be shared with examination committee.</td></tr>
<tr><td colspan="6">Presentation of Project Work</td></tr>
<tr><td colspan="6">Presentation of work in the form of Project Report (s), Understanding individual capacity, Role & involvement in the project, Team Work (Distribution of work, intra-team communication and togetherness), Participation in various contests, Publications and IPR, Manuals (Project Report, Quick reference, System, Installation guide) among other parameters. Team members with guide information shall be added at the end of the report</td></tr>
<tr><td colspan="6">Project Report<br>1. The report shall be both side print hard bound. A hardbound report shall be made after examination and examiner and guide’s expected correction, before that report must be loosely bound.<br>2. Plagiarism check is must, and certificate shall be attached in the report.<br>3. A group activity shall be presented in report.<br>4. Report copies shall be submitted in the department, one for university and one for supervisor.<br>5. For standardization of the project reports the following format shall be strictly followed.<br>Page size: Trimmed A4<br>Top Margin: 1”<br>Bottom Margin: 1.32”<br>Left Margin: 1.5”</td></tr>
</table>

Right Margin: 1”
Para Text: Times New Roman 12-point font
Line Spacing: 1.15 Lines
Page Numbers: Right aligned at footer. Font 12 point Times New Roman
Headings: Times New Roman, 14 Points, Boldface 10.

**Certificate**

1. All students shall attach a standard format of Certificate as described by the department.
2. Certificates shall be awarded to project groups and not individual students of the group.
3. Certificates shall have signatures of Guide, External Examiner, HOD and Principal.

**Index of Report**

1. Title Sheet
2. Certificate (Institution)
3. Certificate (Company, if sponsored by company)
4. Acknowledgement
5. Abstract of the Project
6. List of Figures
7. List of Photographs / Plates
8. List of Tables
9. Table of Contents
10. Introduction
11. Literature Survey / Theory
12. Design / Experimentation / Fabrication / Production / Actual work carried out for the same
13. Observation Results
14. Discussion on Result and Conclusion
15. Student and Guide details. (A common photograph with project)

# Savitribai Phule Pune University
## Board of Studies - Mechanical and Automobile Engineering
## Undergraduate Program – Final Year Automation and Robotics (2019 pattern)

| 402555: Audit Course-VIII | | | | |
|---|---|---|---|---|
| **Teaching Scheme** | | **Credits** | **Examination Scheme** | |
| | | **No credit** | | |

**GUIDELINES FOR CONDUCTION OF AUDIT COURSE**

**Faculty mentor shall be allotted for individual courses and he/she shall monitor the progress for successful accomplishment of the course. Such monitoring is necessary for ensuring that the concept of self-learning is being pursued by the students 'in true letter and spirit'**

- If any of the following listed course is selected through Swayam/ NPTEL/ virtual platform, the minimum duration shall be of 8 weeks.
- However, if any of the course duration is less than the desired (8 weeks) the mentor shall ensure that other activities in form of assignments, quizzes, group discussion etc. (allied with the course) for the balance duration should be undertaken.
- Students can join any online platform or can participate any online/offline workshop to complete the Audit course with prior-permission of mentor.

In addition to credits courses, it is mandatory that there should be an audit course (non-credit course) from Final year of Engineering. The student will be awarded grade as AP on successful completion of the audit course. The student may opt for any one of the audit courses in each semester. Such audit courses can help the student to get awareness of different issues which make an impact on human lives and enhance their skill sets to improve their employability. List of audit courses offered in the semester is provided in the curriculum. Students can choose one of the audit courses from the list of courses mentioned. Evaluation of the audit course will be done at institute level. The student registered for audit course shall be awarded the grade AP and shall be included such grade in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the Savitribai Phule Pune University and satisfactory in-semester performance and secured a passing grade in that audit course. No grade points are associated with this 'AP' grade and performance in these courses is not considered in the calculation of the performance indices SGPA and CGPA. Evaluation of the audit course will be done at institute level itself

## List of Courses to be opted (Any one) under Audit Course

**A.** Managing Innovation
**B.** Operations Management

Note:-The title indicated above are subject to change in time to come and such an alteration (if any) should be brought to the notice of the BoS.

## Using NPTEL Platform: (preferable)

NPTEL is an initiative by MHRD to enhance learning effectiveness in the field of technical education by developing curriculum based video courses and web based e-courses. The details of NPTEL courses are available on its official website www.nptel.ac.in

- Students can select any one of the courses mentioned above and has to register for the corresponding online course available on the NPTEL platform as an Audit course.
- Once the course is completed the student can appear for the examination as per the guidelines on the NPTEL portal.
- After clearing the examination successfully; student will be awarded with a certificate.

## Assessment of an Audit Course

- The assessment of the course will be done at the institute level. The institute has to maintain the record of the various audit courses opted by the students. The audit course opted by the students could be interdisciplinary
- During the course students will be submitting the online assignments/report/course completion certificate etc. A copy of the same can be submitted as a part of term work for the corresponding Audit course
- On the satisfactory submission of assignments/report/course completion certificate etc., the institute can mark as "Present" and the student will be awarded the grade AP on the mark-sheet.