HANDBOOK

COURSE STRUCTURE AND DETAILED SYLLABUS

M. Tech Programme

in

AUTOMATION & ROBOTICS

Batch: 2020-22

INSTITUTE OF ENGINEERING AND TECHNOLOGY

JK LAKSHMIPAT UNIVERSITY

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JK Lakshmipat University, Jaipur
Institute of Engineering and Technology
Department of Electrical & Electronics Engineering
Course Structure for the M. Tech in Automation & Robotics (Batch 2020-2022)

Sem	Courses							(L T P) Credits	Hrs/ Week
I	Statistical Data Analysis (AS2101)	Critical Thinking for Developing Perspectives **(CC2171)**	Robotic Process Automation (CS2103)	Industrial Automation and IoT - I (EE2101)	Instrumentation and Embedded System Laboratory (EE2102)	Optimisation and Control **(EE2104)**	Project-I (PR2101)	(16 0 14) 23	30
	AS2101	CC2171	CS2103	EE2101	EE2102	EE2104	PR2101		
	(3 0 4) 5	(2 0 0) 2	(3 0 4) 5	(3 0 2) 4	(0 0 4) 2	(3 0 0) 3	(2 0 0) 2		
II	Industrial Automation and Internet of Things - II **(EE2105)**	Intelligent Control System (EE2106)	ME1207: **Mechatronics**	EE2201: **Computer Vision**	CC2114: Critical Thinking for Decisions **at Workplace**	PR2102: **Project -II**		(16 1 10) 22	27
	EE2105	EE2106	ME1207	EE2201	CC2114	PR2102			
	(3 0 2) 4	(3 0 4) 5	(3 0 4) 5	(3 0 0) 4	(2 1 0) 2	(2 0 0) 2			
III									
IV									

Course Title and Code	**Statistical Data Analysis (AS2101)**
Hours per Week	**L-T-P: 3-0-4**
Credits	**5**
Students who can take	**M.Tech Semester-I**

Course Objective:
This course aims to introduce basic concepts in descriptive and inferential statistics, as well as data exploration methods. Topics covered include probability distributions, hypothesis testing, frequency analysis, correlation, regression and design of experiments.

After course completion, the student will be able to:

1. Frame real world analysis problems using statistical concepts and solve them using standard techniques.
2. Use professional level tools to support the study of statistics.
3. Communicate quantitative ideas to a range of audiences.
4. Apply recommended practices for data analysis.

Prerequisites		
Sr. No	**Specifications**	**Marks**
1	Attendance	Nil
2	Assignment	Nil
3	Class Participation	10
4	Quiz	15
5	Theory Exam-I	Nil
6	Theory Exam-II	Nil
7	Theory Exam-III	30
8	Report-I	Nil
9	Report-II	Nil
10	Report-III	Nil
11	Project-I	25
12	Project-II	Nil
13	Project-III	Nil
14	Lab Evaluation-I	20
15	Lab Evaluation-II	Nil
16	Course Portfolio	Nil
	Total (100)	Nil

SYLLABUS

Theory:

Principles of Statistical Data Analysis: Data Elements, Variables, and Data categorization, Levels of Measurement: Nominal, Ordinal, Interval, or Ratio, Data management and indexing, Tabular data, Measures of dispersions, Skewness – Karl Pearson and Bowley, Skewness – Kelly coefficient of Skewness and Kurtosis

Probability Theory, Mathematical expectation, moments, probability and moment generating function, Chebyshev's inequality, Mean and Variance of a Random Variable, product moments,

independence of random variables, Joint, marginal and conditional distributions, Discrete and continuous distribution function, Introduction to statistical learning using R-Programming/Python

Basic Statistical Techniques: Sampling Theory and Distributions for Normal and Non-normal Populations, Central Limit Theorem, Point and Interval Estimates, Estimator and Estimates, Sample size calculations Sample Size for Estimating Means and Proportions, Maximum likelihood test, The Central Limit Theorem, p-values and power, Parametric and Non-Parametric test of Hypothesis, Goodness of fit, Analysis of contingency tables, Non-parametric tests of location and dispersion, Statistical inference using R/Python

Analysis of Continuous and Categorical Data: Estimation Using the Regression Line, Method of Least Squares, Standard Error of Estimate, Prediction Intervals, Multi Variate regression, generalized linear models, Logistic regression, Ordinal logistic regression, Proportional odds models, Multinomial logistic regression, Poisson regression, negative binomial regression, zero-inflated models, Log linear models for (paired) tables. Procedures for stepwise building of a regression model, Introduction to random intercept models, penalized linear regression methods, Graphical and formal diagnostic methods for the inspection of residuals, Correlation Analysis, autocorrelation and cross correlation, Regression and Correlation analysis using R/Python

Design of experiments: Basic principles of experimental designs, Analysis of variance: one-way, Two-way classifications, Latin square design, Two Factorial Design.

Practical: Solve the problems mentioned in theory classes using packages like Python, Numpy, Pandas, statistical package Scipy.Stats, scikit-learn, plotting packages Matplotlib and Seaborn.

Text Book(s)

1. Prem S Mann. Introductory statistics. Wiley. Edition: 7th ed. 2010.
2. Ronald E Walpole, Raymond H Myers, Sharon L Myers and Keying Ye. Probability and statistics for engineers and scientists. 8th ed - New Delhi. Pearson. 2007.

Web Resources

1. Statistics full Course for Beginners. https://www.youtube.com/watch?v=74oUwKezFho
2. Introduction to R and R Studio. https://www.youtube.com/watch?v=lL0s1coNtRk

Course Title and Code	**Critical Thinking for Developing Perspectives (CC2171)**
Hours per Week	**L-T-P: 2-0-0**

Credits	**2**
Students who can take	**M.Tech Semester-I**

Course Description

The ability to clearly reason through problems and to present arguments in a logical, and compelling way, have become a key skill for survival in today's world. In this course, students will learn to dissect and evaluate the components of argument. Students will learn to raise vital questions, think from multiple perspectives, become aware of their biases, gather and assess information and come to a well-reasoned position.

Learning Outcomes:

The students will be able to:

- Explain the relevance of critical thinking
- Formulate significant questions for inquiry.
- Evaluate information and evidence for correctness, consistency, and relevance.
- Compose well-structured and well-reasoned arguments.
- Recognize their own beliefs, biases, claims and assumptions by viewing the issues from multiple perspectives

Reference Books:

1. Moore, B. N., & Parker, R. (2009). Critical thinking. Boston, MA: McGraw-Hill. eBook
2. Sinnott-Armstrong, W., & Fogelin, R. J. (2014). Cengage Advantage Books: Understanding Arguments: An Introduction to Informal Logic. Cengage Learning eBook

Pedagogy

This course will be an amalgamation of lectures and activity-based learning i.e. films, group discussions, debates, and case studies. The objective behind utilizing activity-based learning is for the learners to have a more hands on experience.

❖ **Topics to be Covered**

I. Introduction to the concept of critical thinking:

· Evolution of the concept: Philosophy and Cognitive psychology as origins of critical thinking

· Revisit Paul-Elder Critical Thinking Framework

II. Questioning for Critical Thinking

· Importance of questioning

· Models of Questioning: Questioning Circles Model, Christenbury and Kelly (1983), Webb's Depth of Knowledge (1997). Elder & Paul (2007). Socratic Questioning Taxonomy.

III. Understanding Arguments

The sessions under this topic will make use of the context of current media, social and political debates to comprehend the topics.

· Meaning and Elements of Reasoning

· Formation of Arguments: Premise and Conclusion

· Inductive –Deductive reasoning: Difference between valid and invalid arguments/ between sound and unsound arguments.

· Evaluating Arguments: Examining data and information critically

· Cognitive Biases and Fallacies: Distinguishing between fact and opinion

Readings/Video(s)

1. The Evolution of Critical Thinking (Research project by Barba Albers, Washington, State University ,2004

2. Bowker, M. H., & Fazioli, K. P. (2016). Rethinking Critical Thinking: A Relational and Contextual Approach. Pedagogy and the Human Sciences, 6(1), 1-26.

3. Bauer, N. J. (1991). Dewey and Schon: An Analysis of Reflective Thinking.

4. Nappi, J. S. (2017). The importance of questioning in developing critical thinking skills. Delta Kappa Gamma Bulletin, 84(1), 30.

5. https://cpb-us e1.wpmucdn.com/cobblearning.net/dist/6/3101/files/2018/05/The-Importance-of-Questioning-2aqkc5j.pdfBloom, B. S. (1956). Taxonomy of educational objectives. Vol. 1: Cognitive domain. New York: McKay, 20-24.

6. Paul, R., & Binker, A. J. A. (1990). Socratic questioning. Critical thinking. Center for Critical Thinking and Moral Critique. http://www.criticalthinking.org/files/SocraticQuestioning2006.pdf

7. The Art of Asking Questions | Dan Moulthrop | TEDxSHHS
https://www.youtube.com/watch?v=hZSY0PssqH0

8. Analysing the argument - Part 1 of 2 (Video)

Evaluation Scheme

Prerequisites		**N/A**
Hours per Week		**L-T-P: 2-0-1**
Credits		**2**
Sr. No	**Specifications**	**Weightage**
01	Attendance	Nil
02	**Assignment**	**40**
03	**Class Participation**	**20**
04	**Quiz**	**20**
05	Theory Exam	Nil
06	Theory Exam	Nil
07	**Theory Exam**	**20**
08	Report-1	Nil
09	Report-2	Nil
10	Report-3	Nil
11	Project -1	nil
12	Project -2	Nil
13	Project -3	Nil
14	Lab Evaluation	Nil
15	Lab Evaluation	Nil
16	Course portfolio	Nil
	Total (100)	**100**

Course Title and Code	**Robotic Process Automation (CS2103)**
Hours per Week	**L-T-P: 3-0-4**
Credits	**5**
Students who can take	M.Tech A&R 1st Sem

Course Objective:

- The course aim is to develop understanding about Robotic Process Automation for automating business processes using software robots with cost efficient digital delivery.

Learning Outcome:

On successful completion of this course, the students should be able to:

- Use and understand the various functionalities and features of UiPath Studio and Orchestrator.
- Design, implement, and use RPA activities.
- Develop basic robots using UiPath Community Edition.
- Explore various data extraction techniques.
- Deploy, monitor and control robots with UiPath Orchestrator.
- Identify processes which can be automated.
- Apply best practices in RPA projects.

Prerequisites: To understand and complete the course successfully the student must have basic programming skills.

Sr. No	Specifications	Marks
01	Attendance	Nil
02	Assignments	10
03	Class Participation	10
04	Quiz	20
05	Theory Exam	Nil
06	Theory Exam	Nil
07	Theory Exam(Final)	Nil
08	Report-1	Nil
09	Report-2	Nil
10	Report-3	Nil
11	Project-1	20
12	Project-2	20
13	Project-3	Nil
14	Lab Evaluation-1	10
15	Lab Evaluation-2	Nil
16	Course portfolio	10
	Total (100)	**100**

Retest

1	Quiz	20
2	Lab Evaluation-1	10

Syllabus (Theory):

Unit I: Programming Basic & Recap: Programming concept basic; **Introduction to RPA:** scopes and techniques of automation, RPA components and various RPA platforms, Introduction to UiPath as RPA platform, Applications and Benefits of RPA, Introduction to UiPath Studio, UiPath robot, types of robots, and UiPath Orchestrator. Brief on Studio interface and components.

Unit II: **RPA Projects:** Types of Projects in RPA: Sequence, Flowcharts, and State machines; Variables, Arguments, Data Types and Control flow: flow chart activities and sequences activities. **Data Manipulation:** Text and Data Manipulation**,** Data tables, clipboard management, file operation, importing from and exporting to CSV/Excel file and data table.

Unit III: **Control of Controls:** Attach window activity, Finding the control, Waiting for a control, Act on Control- mouse and keyboard activity. Handling event driven controls as working with UiExplorer handling events. Introduction to Recorder, OCR, types of OCR and Screen Scrapping Using OCR. **Selectors:** Selectors, Defining and Assessing Selectors, Customization, Debugging, Dynamic Selectors, Partial Selectors, RPA Challenge.

Unit IV: **Application with Plugins and Extensions:** Java plugins, Citrix automation, Mail plugins, PDF plugins, Web integration, excel and word plugins. Extensions- Java, chrome, firefox, and Silverlight. **UiPath Advanced Automation concepts and techniques:** Image, Text and introduction of Citrix Automation; **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. **Email Automation:** Incoming Email automation, Sending Email automation.

Unit V: **Debugging and Exception Handling:** Common exceptions and ways to tackle them, Strategies for solving issues, Catching errors. **Introduction to Orchestrator:** Tenants, Authentication, Robots, Environments, Asset. **Capstone Project.**

Syllabus (Practical):

1. Setup, configuration, and introduction of components of UiPath Studio.
2. Execution of prebuilt examples of sequence, flow chart and state machines projects.

Create a sequence/Flow chart activity defining various types of variable as:

3. Generic Value Variables, Text Variables, Boolean Variables, Number Variables,
4. Array Variables, Date and Time Variables, Data Table Variables

Managing Arguments:

5. Create two activities, one activity defined with arguments and second activity which manages the argument to receive value from first activity.

6. Create an activity to manage importing active namespaces.

Create a project to Manage the control Flow:

7. The Assign Activity, The Delay Activity, The Do While Activity, The If Activity
8. The Switch Activity, The While Activity, The For-Each Activity, The Break Activity.

The Recording toolbar Activity:

9. Exercises using basic, web, and Desktop recoding.
10. Automate manual recording projects on Left-click on buttons, check boxes, drop-down lists, GUI elements, and Text typing

Data Scrapping:

11. Bot to extract structured data from your browser, application or document to a database, .csv file or even Excel spreadsheet.
12. Image and Text Automation
13. Excel Data Tables & PDF
14. Email Automation
15. Deployment of plugins and extensions.
16. Deploying and maintaining the BOT.

Text Books:

T1 Tripathi, Alok Mani. Learning Robotic Process Automation: Create Software robots and automate business processes with the leading RPA tool–UiPath. Packt Publishing Ltd, 2018.

T2. Murdoch, Richard. "Robotic Process Automation: Guide to Building Software Robots, Automate Repetitive Tasks & Become An RPA Consultant." Middletown, DE. Omakustanne (2018).

Reference Books:

R1. Abhinav Sabharwal, “Introduction To RPA”, Independently Published Kindle Edition on Amazon Asia-Pacific Holdings Private Limited, 201 8

R2. Gerardus Blokdyk, “Rpa Robotic Process Automation”, 5Starcook, Second Edition, 2018

R3. Kelly Wibbenmeyer, “The Simple Implementation Guide to Robotic Process Automation (Rpa): How to Best Implement Rpa in an Organization” Paperback, iUniverse, 2018

R4. Willcocks, Leslie P., Mary Lacity, and Andrew Craig. "The IT function and robotic process automation." (2015).

Course Title and Course Code	**Industrial Automation and IoT - I (EE2101)**
Hours per Week	**L T P: 3 0 2**
Credits	**4**
Students who can take	**B. Tech Semester-VII, M. Tech Semester-I**

Course Objectives

Industrial automation is the application of technology to control the production and delivery of industrial products and services. On the other hand, the Internet of Things (IoT) is transforming the way we work and live, extending the power of Internet to a whole range of objects different from computers or smartphones. This course aims to provide an introduction to industrial automation and IoT technologies and standards.

Learning Outcomes:

On successful completion of this course, the students should be able to:

1. Analyze the link between Information Technology and Operational Technology.
2. Specify the key components to design an Industrial automation & IoT system.
3. Choose technologies for communication and real time data collection.
4. Design, deploy and test a basic Industrial automation & IoT system.
5. Apply recommended engineering practices to meet desired requirements for applications, considering sustainability, security and safety as design constraints.

Sr. No	Specifications	Marks
1	Attendance	NIL
2	Assignment	10
3	Class Participation	05
4	Quiz	05
5	Theory Exam-I	10
6	Theory Exam-II	10
7	Theory Exam-III	20
8	Report-I	NIL
9	Report-II	NIL
10	Report-III	NIL
11	Project-I	10
12	Project-II	NIL
13	Project-III	NIL
14	Lab Evaluation-I (Continuous)	10
15	Lab Evaluation-II (Exam)	10
16	Course Portfolio (MOOC Course)	10
Total (100)		**100**

Evaluation Scheme for Retest:

S. No.	Specifications	Marks
1	Theory Exam-III (End Term)	20

2	Lab Evaluation-II (Exam)	10
3	**Total**	**30**

Syllabus

Theory

UNIT1: Introduction. Classical hierarchical industrial automation model. Essential functions of each level. Elements of industrial control (sensors, actuators, transmitters, controllers, etc.). ISA 95 / ISA S88 – Enterprise integration. Emergent architectures.

UNIT2: Instrumentation. Characteristics of instruments: accuracy, precision, sensitivity, etc. Units and standards. Voltage, current and electrical power measurements. Measurement of temperature, position, speed, force, pressure, light, level, humidity and other variables. Signal conditioning and transmission. Indicators, recorders. Actuators. Valves and motors. Instrumentation symbols. Functional identification. Standards: ISA 5.1 – Instrument symbols and identification. IEC 61511 Safety Instrumented Systems.

UNIT3: IoT fundamentals, Architecture and protocols,

UNIT4: Industrial IoT fundamentals. Convergence of IT and OT. Industrial communication: principles, protocols and technologies. Design methodology. Design of IoT systems for industrial safety processes.

UNIT5: CASE STUDIES

Design and test a basic IIoT system involving prototyping, programming and data analysis. Application to sustainability problems: health, energy, water, smart cities, etc.

Practical

1. Characteristics of sensors. Calibration. Temperature, moisture, displacement, voltage, current, etc. Signal conditioning and processing.
2. Interfacing LEDs. Serial port. DC-motor.
3. IoT communication. Standards: MODBUS, OPC, MQTT, etc.
4. PLC programming.
5. Mini-project

Text Book(s)

- Krishna Kant. "*Computer-based Industrial Control*". PHI Learning Private Limited, 2010.
- Hanes, Salgueiro, Grossetete, Barton and Henry (2017). "*IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things*". Cisco Press
- Curtis Johnson. "*Process Control Instrumentation Technology*". PHI Learning Private Limited, 2013.

Reference Book(s)

- Gilchrist (2016). "*Industry 4.0: The Industrial Internet of Things*". Apress.
- John P. Bentley. Principles of Measurement Systems. 4th Edition, Addison Wesley Longman Ltd.,UK, 2004

Web Resources

https://nptel.ac.in/courses/108/105/108105062/
https://nptel.ac.in/courses/106/105/106105195/

Online Courses:

Developing Industrial Internet of Things

https://www.coursera.org/programs/j-k-lakshmipat-university-on-coursera-kzogk/browse?index=prod_enterprise_products&productId=84QbLYtsEeicuBLWaYsl_g&productType=s12n&query=industrial+iot&showMiniModal=true

Design of Internet of Things
https://nptel.ac.in/courses/108/108/108108098/

Course Title and Course Code	**Instrumentation and Embedded System Laboratory (EE2102)**
Hours per Week	**L T P: 0 0 4**
Credits	**2**
Students who can take	**M. Tech Semester-I**

Course Objectives: This course imparts hands-on skill for characterizing sensors used for measurement of physical parameters like strain, temperature, capacitance, position, proximity, pH. The course will introduce various interfacing techniques for sensors using low power microcontroller MSP430. It will also teach embedded C programming techniques**.**

Learning Outcomes:

On successful completion of this course, the students should be able to:

1. Characterize the temperature sensor (RTD), LVDT, strain gauge, thermocouple
2. Measure pH using chemical sensor
3. Measure the flow and level of water using ultrasonic sensor
4. Design an orifice plate for a typical application
5. Generate Pulse Width Modulation for controlling intensity of LED (and simulate speed control of servomotors).
6. Write embedded C programs for interrupt service routines. .

Sr. No	Specifications	Marks
1	Attendance	NIL
2	Assignment	20
3	Class Participation	05
4	Quiz	00
5	Theory Exam-I	Nil
6	Theory Exam-II	Nil
7	Theory Exam-III	Nil
8	Report-I	NIL
9	Report-II	NIL
10	Report-III	NIL
11	Project-I	NIL
12	Project-II	NIL
13	Project-III	NIL
14	Lab Evaluation-I (Continuous)	25
15	Lab Evaluation-II (Exam)	30
16	Course Portfolio (Swayam MOOC: Introduction to Embedded System Design by Prof Dhananjay Gadre and Prof Badri Subudhi)	20
Total (100)		**100**

Evaluation Scheme for Retest:

S. No.	Specifications	Marks
1	Lab Evaluation-II (Exam)	30
	Total	**30**

Syllabus:

1. Characterize the temperature sensor (RTD).
2. Characterize the LVDT.
3. Water level and flow measurement using ultrasonic sensor.
4. Simulate the performance of a chemical sensor.
5. Characterize the strain gauge sensor.
6. Characterize the temperature sensor (Thermocouple).
7. PWM generation using MSP 430 to change LED intensity.
8. Write ISR for Hardware interrupt through pushbutton switch to glow LED.

Web Resources:

1.Sensor modelling and Simulation Lab :COE Pune (https://www.vlab.co.in/broad-area-electrical-engineering).

2. Swayam MOOC -Introduction to Embedded System Design by Prof Dhananjay Gadre and Prof Badri Subudhi (https://onlinecourses.nptel.ac.in/noc20_ee98).

Course Title and Code	**Optimisation and Control (EE2104)**
Hours per Week	**L-T-P: 3-0-0**
Credits	**3**
Students who can take	**M.Tech Semester-I**

Course Name:

This course aims at equipping students with the conceptual tools necessary to solve basic estimation and control problems, maximizing performance and minimizing cost.

Learning Outcomes

On successful completion of this course, the students should be able to:
1) analyze the requirements of a given estimation and control problem.
2)propose, implement and assess a solution for a given estimation and control problem.

Syllabus:

1) Mathematics refresher: linear algebra, optimization, dynamic systems, modelling identification and simulation.
2) Discrete-event control systems. Typical models, counters, and timers. State machines, Petri nets, Sequential Flow Charts.
3) Continuous control systems: Stability, time domain, frequency domain, design specifications, compensation. State variable modelling of linear continuous systems, controllability and observability. Introduction to LQR/LQG and robust control. Performance assessment.

Course Feedback: Online - Every Fortnight

Evaluation Scheme

Sr. No	Specifications	Marks
01	Assignment (4)	40
02	Case study	30
03	Theory Exam	30
	Total (100)	**100**

Books:

R. F. Stengel (1994). Optimal control and estimation. Dover Publications.

B. Hrúz and M. Zhoum (2007). Modeling and control of discrete-event dynamical systems: with Petri nets and other tools. London: Springer.

IT Resources

https://nptel.ac.in/courses/107/106/107106081/
https://nptel.ac.in/courses/108/105/108105019/

Course Title and Code	**Project-I (PR2101)**
Prerequisites	**Nil**
Hours per Week	**L-T-P: 2-0-0**
Credits	**02**
Students who can take	**M.Tech. Semester I**

Course Objective: The course aims to equip the students with knowledge of the nuances of building a project utilizing the concepts either attained in undergraduate or in parallel being attained in semester I. The course includes basics of preparation of project proposal, project creation and management cycle, teamwork, converting into a usable application and test cases to evaluate the project and preparation of report of project.

Learning Outcome

- Identify project goals, constraints, deliverables, performance criteria, control needs, and resource requirements to serve requirement
- Implement project management knowledge, processes, lifecycle and the embodied concepts, tools and techniques in order to achieve project success
- Utilize technology tools for communication, collaboration, information management, and decision support
- Apply appropriate legal and ethical standards.
- Test the Project with varied test cases.

Sr. No	**Specifications**	**Marks**
01	Attendance	NIL
02	Assignment	NIL
03	Class Participation (Day to Day work)	30
04	Quiz	NIL
05	Theory Exam	NIL
06	Theory Exam	NIL
07	Theory Exam (Final)	NIL
08	Report-1 (Synopsis)	10
09	Report-2 (Final report)	20
10	Report-3	NIL
11	Project -1	40
12	Project -2	NIL
13	Project -3	NIL
14	Lab Evaluation – I	NIL
15	Lab Evaluation – II	NIL
16	Course portfolio	NIL
	Total (100)	**100**

Course Title and Code	**Industrial Automation and Internet of Things - II (EE2105)**
Hours per Week	**L-T-P: 3-0-2**
Credits	**4**
Students who can take	**M.Tech Semester-II**

Course Objective

This course aims at creating the fundamentals skills required to design, implement, and maintain industrial IoT systems.

Learning Outcomes

1. On successful completion of this course students will be able to:
2. Explain the key components that make up an Industrial IoT system.
3. Discuss protocols and standards employed at each layer of the IIoT stack.
4. Design, deploy and test a basic Industrial IoT system, including data analysis functionalities.
5. Apply best practices to meet desired requirements for IIoT applications.
6. Analyze the environmental effects and incorporate robustness in design of IIoT system.
7. Choose technology for constrained nodes and network while maintaining real time data collection.
8. Explain the importance of cybersecurity for IIoT networks.

Syllabus:

Unit 1 IoT Fundamentals

Industrial communication: principles, protocols and technologies. IIoT definition, architectures and use cases. Convergence of IT and OT. Design methodology.

Unit 2 Interfacing sensors and actuators

Interfacing proximity sensor, vibration sensor, colour sensors. Controlling AC motor.

Unit 3 Programming with Node Red

Injecting nodes, debugging**,** managing palettes, designing dashboard.

Unit 4 Cloud services

Basic concepts. Applications: predictive maintenance, quality monitoring, personalized dashboards.

Practical work: Design and test a basic IIoT system involving prototyping, programming, and data analysis.

Evaluation Scheme

Sr. No	**Specifications**	**Marks**
1	Attendance	Nil
2	Assignment	15
3	Class Participation	Nil
4	Quiz	15
5	Theory Exam-1	Nil
6	Theory Exam-2	20
7	Theory Exam-3	30

8	Report-1	Nil
9	Report-2	Nil
10	Report-3	Nil
11	Project -1	20
12	Project -2	Nil
13	Project -3	Nil
14	Lab Evaluation1	Nil
15	Lab Evaluation2	Nil
16	Course portfolio (MOOC)	Nil
	Total (100)	**100**

Textbooks:

Bahga and Madisetti (2014). "*Internet of Things: a hands-on approach*". CreateSpace Independent Publishing Platform, 1st edition. ISBN: 978-0996025515.

Hanes, Salgueiro, Grossetete, Barton and Henry (2017). "*IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things*". Cisco Press

Reference book:

Gilchrist (2016). "*Industry 4.0: The Industrial Internet of Things*". Apress.

Course Title and Code	**Intelligent Control System (EE2106)**
Hours per Week	**L-T-P: 3-0-4**
Credits	**5**
Students who can take	**M.Tech Semester-II**

Course Objective

This course aims at introducing the fundamentals of control system analysis and design, based on fuzzy logic and artificial neural networks.

Learning Outcomes

On successful completion of this course, the students should be able to:
1) given a set of control system requirements, design, simulate and implement a controller based on fuzzy logic and/or artificial neural networks
2) assess the advantages and disadvantages of intelligent control systems, relative to other methods
3) assess, troubleshoot, improve, and fully document intelligent control systems

Syllabus:

Linear control systems – Review. Classical control theory. Discrete time control systems. State space analysis. Basic concepts. Full-state feedback. Observer design. Kalman filter. Integrated full-state feedback and observer. Introduction to system identification.

Introduction to intelligent control. Foundation of fuzzy logic. Fuzzy inference systems. Fuzzy PI control. PI controller tuning with fuzzy logic. Fuzzy Takagi-Sugeno modeling and control.

Learning process. Neural Networks (NN). Perceptron model. Multi-layer perceptron. Back propagation. Dynamically driven recurrent NN. Back propagation through time.

Introduction to control system performance assessment and fault detection, based on fuzzy logic and/or artificial neural networks.

Evaluation Scheme

Sr. No	**Specifications**	**Marks**
1	Attendance	Nil
2	Assignment	Nil
3	Class Participation	Nil
4	Quiz	Nil
5	Theory Exam-1	10
6	Theory Exam-2	Nil
7	Theory Exam-3	30
8	Report-1	Nil
9	Report-2	Nil
10	Report-3	Nil
11	Project -1	30
12	Project -2	Nil

13	Project -3	Nil
14	Lab Evaluation1	30
15	Lab Evaluation2	Nil
16	Course portfolio (MOOC)	Nil
	Total (100)	**100**

Books:

1. J-S. R. Jang, C-T. Sun, and E. Mizutani, Neuro-Fuzzy and Soft Computing, Prentice Hall, 1997
2. Kevin M. Passino and Stephen Yurkovich. Fuzzy Control. Addison-Wesley, 1997
3. Haykin, Simon (2008). "Neural Networks and Learning Machines". Third Edition. McMaster University. Hamilton, Ontario, Canada. Pearson.

IT Resources

1. https://nptel.ac.in/courses/108/104/108104049/

Course Code and Title	**ME1207: Mechatronics**
Scheme	**L T P: 3 0 4**
Credits	**5**
Students who can take	**M. Tech: Semester II, Automation & Robotics**

Course Objective:

To develop an understanding of basic and advanced topics of Mechatronics such as sensors and signal conditioning, actuators, microprocessor and microcontroller systems, system models, and industrial applications.

Learning Outcomes:

On successful completion of this course, the students will be able to:

1. acquire a mix of skills in mechanical engineering, electronics and computing which is necessary to comprehend and design mechatronics systems.
2. operate and communicate across the range of engineering disciplines necessary in mechatronics.
3. design mechatronic systems.

Prerequisite: Mathematics concepts, basic mechanical and electrical concepts.

Evaluation Scheme:

Sr. No.	Specifications	Marks
1	Attendance	NIL
2	Assignment	NIL
3	Class Participation	NIL
4	Quiz	10
5	Theory Exam-I	10
6	Theory Exam-II	10
7	Theory Exam-III	20
8	Report-I	NIL
9	Report-II	NIL
10	Report-III	NIL
11	Project-I	20
12	Project-II	NIL
13	Project-III	NIL
14	Lab Evaluation-I (Continuous)	20
15	Lab Evaluation-II (Examination)	10
16	Course Portfolio	NIL
	Total	**100**

Retest Scheme:		
1	Theory Exam-III	20
2	Project-I	20
	Total	**40**

COURSE SYLLABUS (Theory)

UNIT I: Introduction

Introduction to Mechatronics system, key elements, Mechatronics Design process, Design Parameters, Traditional and Mechatronics designs, Advanced approaches in Mechatronics, Industrial design ergonomics and safety.

UNIT II: Sensors and Actuators

Sensor and transducers, digital logic, signal processing devices, relays, contactors and timers. Actuation systems, pneumatic and hydraulic system, control valves, cylinders, rotary actuators, mechanical systems, drives, bearings, electrical systems, electrical and mechanical switches, solenoids, motors, signal conditioning, filtering, power transfer, digital signals, A-D and D-A converters.

Unit III: Microprocessor

Microprocessor, microcontroller, programming, application examples, interfacing and applications, PLC, ladder programming, timers and counters, PLC system.

Unit IV: System Models and Micro Mechatronic System

System Models
Mathematical models, building blocks for mechanical systems, electrical systems, fluid systems, thermal systems, description of PID controllers.

Micro Mechatronic System
Introduction, System principle, Component design, System design, Scaling laws, Micro actuation, Micro robot, Micro pump, Applications of micro mechatronic components.

Unit V: Case Studies

Introduction, Fuzzy based Washing machine, Motion control using DC Motor & Solenoids, Engine management systems, controlling temperature of a hot/cold reservoir using PID, Control of pick and place robot.

COURSE SYLLABUS (Laboratory)

1. Responses of First and Second Order Mechanical Systems
2. Basics of Frequency Domain Signal Analysis
3. Frequency Response of Mechanical Systems

4. Time-Frequency Analysis of Mechanical Systems
5. Gearbox Fault Detection
6. Pump Impeller Fault Detection
7. Vibration Monitoring of Machineries by Wireless Technique
8. Electrical Motor Fault Detection by MCSA Exp.

No. 1 to 8: http://vlabs.iitkgp.ernet.in/mssp/#

9. Identification and familiarisation of the following components: resistors, inductors, capacitors, diodes, transistors, LED's.
10. Familiarization with the following components: CRO, transformer, function generator, multimeter, power supply.
11. Familiarization with the following electrical machines: Induction motors, DC motors, synchronous motors, single phase motors.
12. Familiarization with the following mechanical components: gears, gear train, bearings, couplings, tachometer.
13. Implementation Logic Gates
14. Implementation of PID Controller

Exp. 13 and 14: http://plc-coep.vlabs.ac.in/List%20of%20experiments.html?domain=Electrical%20Engineering

15. Case study: modeling and control of combustion engines.
16. A case study: automotive transmission as a "gear reducer".

BOOKS

1. David G. Alciatore, "Introduction to Mechatronics and Measurement Systems", McGraw-Hill Education.
2. William Bolton, "Mechatronics electronic control systems in mechanical and electrical engineering", Pearson Education Limited.
3. Paul P. L. Regtien, "Sensors for Mechatronics", Elsevier.
4. Dean C. Karnopp, Donald L. Margolis, Ronald C. Rosenberg, "System Dynamics: Modeling, Simulation, and Control of Mechatronic Systems", John Wiley & Sons, Inc.

ONLINE COURSES

1. https://onlinecourses.nptel.ac.in/noc21_me27/preview
2. https://www.edx.org/course/mechatronics
3. https://www.coursera.org/specializations/embedding-sensors-motors

Course Code and Title	**EE2201: Computer Vision**
Scheme	**L T P: 3 0 0**
Credits	**4**
Students who can take	**M. Tech: Semester II**

Course Objectives: This course aims to develop skills for building computer vision applications with Python, OpenCV, and Deep Learning.

Learning Outcomes:

On successful completion of this course, the students should be able to:

1. Implement Image Processing Algorithms using OpenCV tools.
2. Use supervised and unsupervised machine learning algorithms for image classification.
3. Design, Train and Test Neural Networks and deploy suitable activation functions image processing function using Keras/Tensorflow libraries.
4. Identify suitable Performance Parameters and evaluate valuate technique for best performance.

Syllabus:

Module 1: Introduction to Image Processing system-Image Sampling, Quantization, Thresholding, Image Enhancement, Contrast Stretching- Linear, Logarithmic, Power Law, Image Histograms-Histogram Equalization, Histogram Processing, Filters-Median, Min, max, Nonlinear Filters-Smoothing /Weighted Smoothing, Image Sharpening. Edge Detection and Segmentation

Module 2: Deep Learning for Computer Vision, Image Classification and Segmentation using Machine Learning, Understanding Neurons, Activation functions, Gradient Descent and Backpropagation in neural Networks, Building a Neural Network Model for Classification problems, Limitations of Neural Networks.

Module 3: Convolutional Neural Networks, Keras Basics, CNN architecture-Convolution, Pooling and Fully connected layers.

Assessment Scheme:

Sr. No.	Evaluation Component	Marks
1	Attendance	Nil
2	Assignment	20
3	Class Participation	Nil
4	Quiz	20
5	Theory Exam-I	Nil
6	Theory Exam-II	Nil
7	Theory Exam-III	30
8	Report I	Included with Project
9	Report II	Nil
10	Report III	Nil
11	Project I	Nil

12	Project II	Nil
13	Project III	30
14	Lab Evaluation I	Nil
15	Lab Evaluation II	Nil
16	Course Portfolio	Nil
	Total (100)	100
Evaluation Scheme for Re-Test		
1	**Theory Exam - III**	30
	Total (30)	30

References:

1. Digital Image Processing- S Jayaraman, S Esakkirajan, T Veerakumar
2. Introduction to Statistical Learning-Garet James
3. Deep Learning book by Ian Goodfellow, Yoshua Bengio, and Aaron Courville.

Web resource:

https://github.com/machine-perception-robotics-group/GoogleColabNotebooks/tree/eng1/MLDL_lecture_notebooks
https://www.tensorflow.org/api_docs/python/tf/keras/layers/Dense
https://www.tensorflow.org/api_docs/python/tf/keras/initializers

Course Code and Title	**CC2114: Critical Thinking for Decisions at Workplace**
Scheme	**L T P: 2 1 0**
Credits	**2**
Students who can take	**M. Tech: Semester II**

Course Objective: In today's world, the idea of right and wrong is being challenged by businesses, use of technology, economic conditions, and norms of societies. The relevance of a well-reasoned decision is crucial. This course intends to make students take better decisions keeping in mind purpose, context, and ethics.

Learning Outcomes

The students will be able to:

- Apply techniques of Critical Thinking to analyse organisational problems through positive inquiry
- Describe and analyse appropriate problem-solving and ethical decision-making processes
- Choose the most effective and logical decision among multiple alternatives
- Evaluate solutions and anticipate likely risks based on purpose, context and ethics

Pre-requisites	**N/A**

Sr. No	**Specifications**	**Weightage**
01	Attendance	Nil
02	Assignment	**20**
03	Class Participation	**20**
04	Quiz	Nil
05	Theory Exam-1	Nil
06	Theory Exam-2	Nil
07	End term Viva	**30**
08	Report-1	Nil
09	Report-2	Nil
10	Report-3	Nil
11	Presentation	**30**
12	Project -2	Nil
13	Project -3	Nil
14	Lab Evaluation	Nil
15	Lab Evaluation	Nil

16	Course portfolio	Nil
	Total (100)	**100**

Evaluation scheme for re-test

Sr. No	**Specifications**	**Weightage**
01	End term viva	**30**
	Total (30)	**30**

SYLLABUS

	Topic	**Sub-topics**
1	Decision Making: Definition and Type	• Organisational decision-making • Concept of thinking triangle • Importance of decision-making at work place
2	Barriers to Sound Reasoning	• Identifying barriers to Critical Thinking • Biases, prejudices, facts, opinions, assumptions. • Overcoming the obstacles
3	Steps of Decision Making	• Factors impacting decision-making • Concept of enquiry circle • Understanding arguments in business parlance
4	Ethics and Decisions	• Theories of ethics (Teleological, Deontological, Virtue Ethics, Conduct Ethics, Rights based, Utilitarianism, Hedonism, Egoism) • Concept of Moral reasoning • Role of ethics and values in Decision Making
5	Importance of purpose and context	• Role of Stakeholders in decision making.
6	Problem analysis best practices	• Root cause analysis • Identifying questions at the heart of a problem • Thinking checklist
7	Decision Implementation Techniques	• Developing intellectual virtues • Paul Elder's model (Intellectual humility, courage, empathy, integrity and confidence.
8	Comparing alternative solutions	• Ladder of Inference • Meta-thinking • Perspectives

MOOC courses:

1. Effective Problem Solving and Decision Making by Rob Stone, University of California
2. Think Again IV- How to avoid Fallacies, Duke University

Suggested Readings

1. Jonah Lehrer, 2009: **How we Decide.** Houghton Mifflin Harcourt, Boston, New York
2. Chip Heath and Dan Heath, 2013. **Decisive: How to Make Better Choices in Life and Work.** Crown Business, ISBN 0307956393
3. John S. Hammond, Howard Raiffa, Ralph L. Keeney, 2002. **Smart Choices: A Practical Guide to Making Better Decisions.** Crown Business, ISBN 0767908864
4. Ramesh K. Arora, **Ethics, Integrity and Values in Public Service.** New Age International Publishers, New Delhi.
5. Bradley H. Dowden, 1993. **Logical Reasoning.** Wadsworth Publishing Company, Belmont, California, ISBN 0534176887

Course Code and Title	**PR2102: Project-II**
Prerequisites	**Nil**
Hours per Week	**L-T-P: 2-0-0**
Credits	**02**
Students who can take	**M.Tech. Semester II**

Course Objective: The course aims to equip students with knowledge of the nuances of building a project utilizing the concepts either attained in undergraduate or in parallel being attained in Sem I. The course includes basics of preparation of project proposal, project creation and management cycle, team work, converting into a usable application and test cases to evaluate the project and preparation of report of project.

Learning Outcome

- Identify project goals, constraints, deliverables, performance criteria, control needs, and resource requirements to serve requirement
- Implement project management knowledge, processes, lifecycle and the embodied concepts, tools and techniques in order to achieve project success
- Utilize technology tools for communication, collaboration, information management, and decision support
- Apply appropriate legal and ethical standards.
- Test the Project with varied test cases.

Evaluation Scheme:

Sr. No	**Specifications**	**Marks**
01	Attendance	NIL
02	Assignment	NIL
03	Class Participation	30
04	Quiz	NIL
05	Theory Exam(Mid Term)	NIL
06	Theory Exam	NIL
07	Theory Exam(Final)	NIL
08	Report-1	10
09	Report-2	20
10	Report-3	NIL
11	Project -1	40
12	Project -2	NIL
13	Project -3	NIL
14	Lab Evaluation – I	NIL
15	Lab Evaluation – II	NIL
16	Course portfolio	NIL
	Total (100)	**100**