VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

## SCHOOL OF ELECTRICAL ENGINEERING

# M. Tech Control and Automation

(M.Tech CA)

Curriculum

(*2024-2025 admitted students*)

## VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

Transforming life through excellence in education and research.

## MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

**World class Education**: Excellence in education, grounded in ethics and critical thinking, for improvement of life.
**Cutting edge Research**: An innovation ecosystem to extend knowledge and solve critical problems.
**Impactful People**: Happy, accountable, caring and effective workforce and students.
**Rewarding Co-creations:** Active collaboration with national & international industries & universities for productivity and economic development.
**Service to Society:** Service to the region and world through knowledge and compassion.

## VISION STATEMENT OF THE SCHOOL OF ELECTRICAL ENGINEERING

To offer an education in electrical engineering that provides strong fundamental knowledge, skills for employability, cross-disciplinary research and creates leaders who provide technological solutions to societal and industry problems.

## MISSION STATEMENT OF THE SCHOOL OF ELECTRICAL ENGINEERING

- Provide personalized experiential learning in industry sponsored laboratories to prepare students in electrical engineering with strong critical thinking and employability skills.
- Foster design thinking, creativity and cross-disciplinary research with highly qualified faculty to create innovators and entrepreneurs in the broad area of electrical engineering.
- Collaborate with national and international partners to provide innovative solutions to societal and industry challenges.

# M. Tech Control and Automation

## PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates will be engineering practitioners and leaders, who would help solve industry's technological problems.

2. Graduates will be engineering professionals, innovators or entrepreneurs engaged in technology development, technology deployment, or engineering system implementation in industry.

3. Graduates will function in their profession with social awareness and responsibility.

4. Graduates will interact with their peers in other disciplines in industry and society and contribute to the economic growth of the country.

5. Graduates will be successful in pursuing higher studies in engineering or management.

6. Graduates will pursue career paths in teaching or research.

# M. Tech Control and Automation

## PROGRAMME OUTCOMES (POs)

PO_01: Having an ability to apply mathematics and science in engineering applications

PO_02: Having an ability to design a component or a product applying all the relevant standards and with realistic constraints

PO_03: Having an ability to design and conduct experiments, as well as to analyze and interpret data

PO_04: Having an ability to use techniques, skills and modern engineering tools necessary for engineering practice

PO_05: Having problem solving ability- solving social issues and engineering problems

PO_06: Having adaptive thinking and adaptability

PO_07: Having a clear understanding of professional and ethical responsibility

PO_08: Having a good cognitive load management [discriminate and filter the available data] skills

# M. Tech Control and Automation

## ADDITIONAL PROGRAMME OUTCOMES (APOs)

APO_01: Having an ability to be socially intelligent with good SIQ (Social Intelligence Quotient) and EQ (Emotional Quotient)

APO_02: Having Sense-Making Skills of creating unique insights in what is being seen or observed (Higher level thinking skills which cannot be codified)

APO_03: Having design thinking capability

APO_04: Having computational thinking (Ability to translate vast data in to abstract concepts and to understand database reasoning

APO_05: Having Virtual Collaborating ability

APO_06: Having an ability to use the social media effectively for productive use

APO_07: Having critical thinking and innovative skills

APO_08: Having a good digital footprint

# M. Tech Control and Automation

## PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of M. Tech. (Control and Automation) programme, graduates will be able to

- PSO1: Apply technical knowledge, skills and analytical ability to design and develop controllers as well as employ techniques for automation of systems using modern tools and technologies.

- PSO2: Analyse, interpret and solve problems related to process control, automation, measurement and control etc.

- PSO3: Solve research gaps and provide solutions to socio-economic, and environmental problems.

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# M. Tech Control and Automation

## CREDIT STRUCTURE

### Category-wise Credit distribution

| Credits Breakup | |
|---|---|
| | **CREDITS** |
| Discipline Core | 24 |
| Discipline Elective | 12 |
| Projects and Internship | 26 |
| Open Elective | 3 |
| Skill Enhancement | 5 |
| **Total** | 70 |

# M. Tech Control and Automation

# DETAILED CURRICULUM

## Discipline Core

| Sl.no | Course Code | Course Title | L | T | P | Credit |
|---|---|---|---|---|---|---|
| 1 | MCOA501L | Applied Mathematical Methods in Control Engineering | 3 | 1 | 0 | 4.0 |
| 2 | MCOA502L | System Theory | 3 | 0 | 0 | 3.0 |
| 3 | MCOA502P | System Theory Lab | 0 | 0 | 2 | 1.0 |
| 4 | MCOA503L | Random Variables and State Estimation | 3 | 0 | 0 | 3.0 |
| 5 | MCOA504L | Smart Sensor Systems | 3 | 0 | 0 | 3.0 |
| 6 | MCOA505L | Process Dynamics and Control | 3 | 0 | 0 | 3.0 |
| 7 | MCOA505P | Process Dynamics and Control Lab | 0 | 0 | 2 | 1.0 |
| 8 | MCOA506L | Real Time Embedded Systems | 2 | 0 | 0 | 2.0 |
| 9 | MCOA506P | Real Time Embedded Systems Lab | 0 | 0 | 2 | 1.0 |
| 10 | MCOA507L | Industrial Automation | 2 | 0 | 0 | 2.0 |
| 11 | MCOA507P | Industrial Automation Lab | 0 | 0 | 2 | 1.0 |

## Discipline Elective

| Sl.no | Course Code | Course Title | L | T | P | Credit |
|---|---|---|---|---|---|---|
| 1 | MCOA601L | Building Automation | 3 | 0 | 0 | 3.0 |
| 2 | MCOA602L | Industrial Robotics | 3 | 0 | 0 | 3.0 |
| 3 | MCOA603L | Control of Electric Drives | 3 | 0 | 0 | 3.0 |
| 4 | MCOA604L | Machine Learning | 2 | 0 | 0 | 2.0 |
| 5 | MCOA604P | Machine Learning Lab | 0 | 0 | 2 | 1.0 |
| 6 | MCOA605L | Advanced Python Programming | 1 | 0 | 0 | 1.0 |
| 7 | MCOA605P | Advanced Python Programming Lab | 0 | 0 | 4 | 2.0 |
| 8 | MCOA606L | Optimal Control Systems | 3 | 0 | 0 | 3.0 |
| 9 | MCOA607L | Adaptive and Robust Control | 3 | 0 | 0 | 3.0 |
| 10 | MCOA608L | Discrete Control Systems | 3 | 0 | 0 | 3.0 |
| 11 | MCOA609L | Multivariable Control System | 3 | 0 | 0 | 3.0 |
| 12 | MCOA610L | Industrial Data Networks | 3 | 0 | 0 | 3.0 |
| 13 | MCOA611L | Data Acquisition and Hardware Interfaces | 3 | 0 | 0 | 3.0 |

## Projects and Internship

| Sl.no | Course Code | Course Title | L | T | P | Credit |
|---|---|---|---|---|---|---|
| 1 | MCOA696J | Study Oriented Project | 0 | 0 | 0 | 2.0 |
| 2 | MCOA697J | Design Project | 0 | 0 | 0 | 2.0 |
| 3 | MCOA698J | Internship I/ Dissertation I | 0 | 0 | 0 | 10.0 |
| 4 | MCOA699J | Internship II/ Dissertation II | 0 | 0 | 0 | 12.0 |

## Open Elective

| Sl.no | Course Code | Course Title | L | T | P | Credit |
|---|---|---|---|---|---|---|
| 1 | MFRE501L | Francais Fonctionnel | 3 | 0 | 0 | 3.0 |
| 2 | MGER501L | Deutsch fuer Anfaenger | 3 | 0 | 0 | 3.0 |
| 3 | MSTS601L | Advanced Competitive Coding | 3 | 0 | 0 | 3.0 |

## Skill Enhancement

| Sl.no | Course Code | Course Title | L | T | P | Credit |
|---|---|---|---|---|---|---|
| 1 | MENG501P | Technical Report Writing | 0 | 0 | 4 | 2.0 |
| 2 | MSTS501P | Qualitative Skills Practice | 0 | 0 | 3 | 1.5 |
| 3 | MSTS502P | Quantitative Skills Practice | 0 | 0 | 3 | 1.5 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA501L | Applied Mathematical Methods in Control Engineering | 3 | 1 | 0 | 4 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives:**

To present a clear exposition of basics of linear algebra, matrix theory, differential equations to represent the nonlinear systems through mathematical methods including,

1. Understanding of their physical significance and mathematical representation of nonlinear systems through modelling.
2. Existence and uniqueness of the solution of the models, computation of equilibrium points and visualize their behaviour through phase plane analysis.
3. Stability analysis and controller design for nonlinear systems.

**Course Outcome:**

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

1. Analyse and interpret the physical significance of different mathematical tools such as vector space, convergence, continuity, eigen values, eigen vectors and matrix norm to represent the dynamical systems and their applications to control theory as well as visualize the behaviour of the dynamical system in different coordinate dimensional coordinates.
2. Represent the dynamical systems in the form of differential equation and check the existence of the solution of the differential equation and learn different methods for solving it.
3. Analyse the behaviour and properties of nonlinear systems such as equilibrium points, limit cycles through phase plane technique.
4. Utilize different mathematical tools such as convergence, continuity and differentiability to analyse the stability criteria of the nonlinear systems, describing function method to analyse stability in frequency domain.
5. Utilize different design techniques such as feedback linearization, back stepping method and feedback control to design controller for nonlinear dynamical systems.

| Module:1 | Basics of Linear Algebra: | 7 hours |
|---|---|---|

Introduction to set theory, vector fields, Physical Interpretation of Linear Vector Spaces, Supremum and infimum, Physical Interpretation of Normed Linear Spaces, Banach and Hilbert Spaces, Physical Interpretation of Convergence, Continuity, Differentiability and Applications

| Module:2 | Matrix Theory: | 8 hours |
|---|---|---|

Physical Interpretation of Eigenvalues and Eigenvectors and its applications, Matrix Transformations, Physical Interpretation of Induced Norms and Matrix Measures, Similarity Transformation-Diagonalization, Singular values, Singular Value Decomposition (SVD) and its Applications, Pseudo Inverse, Jacobian matrix, Linear matrix inequalities, concept of rank, and nullity

| Module:3 | Differential Equations: | 6 hours |
|---|---|---|

Existence, Physical Interpretation of Uniqueness, Physical Interpretation of Well-posedness of Solutions, Approximation of Solutions, Lipchitz condition, Comparison functions and their applications

| Module:4 | Analysis of Dynamical Systems: | 8 hours |
|---|---|---|

Introduction, Features of Linear and Nonlinear Systems: Examples of phenomena, models &

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| derivation of system equations. Fundamental properties: Existence & uniqueness, Dependence on initial conditions & parameters, Equilibrium points, Taylor's series, Types of non-linearity, Common nonlinearities in control systems, Typical Examples | | |
| | | |
| **Module:5** | **Phase Plane Analysis:** | **8 hours** |
| Concepts of phase plane analysis, Construction of phase portrait, Phase plane analysis of linear system and nonlinear system, Existence of limit cycles | | |
| **Module:6** | **Stability Analysis:** | **10 hours** |
| Lyapunov stability of autonomous and nonautonomous systems, LaSalle's invariance Principle, Stability analysis of nonlinear systems in frequency domain: Describing function fundamentals, describing functions of common nonlinearities, Describing function analysis of nonlinear systems, Limit cycles, Stability of Oscillations | | |
| | | |
| **Module:7** | **Case Studies: Controller Design Problems and Solutions** | **10 hours** |
| Feedback linearization method, Backstepping method, Feedback control technique, Introduction to Linear programming. | | |
| | | |
| **Module:8** | **Contemporary Issues** | **3 hours** |
| | | |
| | **Total Lecture hours:** | **60 hours** |

| **Textbook(s)** | |
|---|---|
| 1. | Alexander S. Poznyak, "Advanced Mathematical Tools for Automatic Control Engineers", Elsevier, First Edition, 2008 |
| 2. | Slotine and Li, "Applied Nonlinear Control", Prentice Hall Inc., 2005. |
| **Reference Books** | |
| 1. | H. K . Khalil, "Nonlinear Systems", Prentice Hall, 2015. |
| 2. | M. Vidyasagar, "Nonlinear Systems Analysis", Prentice Hall, 2002. |
| 3. | D. Smith, M. Eggen and R. St. Andre, "A Transition to Advanced Mathematics" Cengage Learning International Edition, 2014. |
| 4. | K A. Ross "Elementary Analysis" Springer, 2013. |
| 5. | H. Logemann and E. P. Ryan "Ordinary Differential Equations", Analysis, Qualitative Theory and Control, Springer, 2014. |
| Mode of Evaluation**:** CAT / Assignment / Quiz / FAT / Project / Seminar | |

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| Recommended by Board of Studies | 09-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA502L | System Theory | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives:**

To present a clear exposition of the basics of modern control including

1. Create state models of practical systems after understanding state modelling concepts
2. Analyse the models for the five properties of stability, controllability, observability, stabilizability and detectability
3. Design a controller, observer and reduced-order observer for the models of the systems

**Course Outcome:**

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

1. Model dynamical systems and realize them in different canonical forms
2. Solve the linear and nonlinear state equations
3. Analyze the state models for the five properties of the systems
4. Design a state feedback controller and state observer for simple practical dynamic systems.
5. Analyze linear and nonlinear system models for stability

| Module:1 | State Variable Representation: | 6 hours |
|---|---|---|

Introduction-Concept of State-State equation for Dynamic Systems-Time invariance and linearity-Non uniqueness of state model-canonical forms - State Diagrams-Physical System and State Assignment

| Module:2 | Solution of State Equation: | 6 hours |
|---|---|---|

Existence and uniqueness of solutions to continuous-time state equations-Solution of linear time varying and linear time invariant state equations-Evaluation of matrix exponential-System modes-Role of Eigenvalues and Eigenvectors.

| Module:3 | Properties of the System: | 6 hours |
|---|---|---|

Stability, Controllability and Observability - Stabilizability and Detectability-Test for Continuous time systems- Time varying and Time invariant case.

| Module:4 | Controller and Observer Design: | 6 hours |
|---|---|---|

Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems- The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

| Module:5 | Lyapunov Stability: | 6 hours |
|---|---|---|

Introduction-Equilibrium Points-Stability in the sense of Lyapunov-BIBO Stability-Stability of LTI Systems-Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems.

| Module:6 | Lyapunov's Direct Method: | 6 hours |
|---|---|---|

The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems-Krasovskii and Variable-Gradient Method.

| Module:7 | Realization: | 6 hours |
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Output Controllability-Reducibility- System Realizations minimal realization, balanced realization

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| **Module:8** | **Contemporary Issues** | **3 hours** |
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| | **Total Lecture hours:** | **45 hours** |

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| **Textbook(s)** | |
| 1. | Ogata, "Modern Control Engineering", 5th Edition, Prentice Hall India, 2010. |
| 2. | M. Gopal, “Modern Control System Theory”, 3rd edition, New Age International, 2014. |
| **Reference Books** | |
| 1. | Slotine and Li, "Applied Nonlinear Control", Prentice Hall Inc., 2005. |
| 2. | Hassan K Khalil, “Nonlinear Control", Pearson, Boston, 2015. |

Mode of Evaluation**:** CAT / Assignment / Quiz / FAT / Project / Seminar

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|---|---|---|---|
| Recommended by Board of Studies | 09-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA502P | System Theory Lab | 0 | 0 | 2 | 1 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Analyse the behaviour of linear and nonlinear dynamic systems
2. Design controller, observer and reduced-order observer

**Course Outcomes**

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

1. Analyse the response and properties of linear and nonlinear dynamic systems
2. Design controller, observer, and reduced-order observer for linear systems

| List of Challenging Experiments (Indicative) | | |
|---|---|---|
| 1. | State modelling of armature-controlled motor | 2 hours |
| 2. | State modelling of field-controlled motor | 2 hours |
| 3. | State modelling of dc generator | 2 hours |
| 4. | State modelling of balancing broomstick | 2 hours |
| 5. | State modelling of bridge circuit | 2 hours |
| 6. | State modelling of magnetic suspension system | 2 hours |
| 7. | State modelling of ball on beam system | 2 hours |
| 8. | Controllability and observability of armature-controlled dc motor | 2 hours |
| 9. | Controllability and observability of balancing broomstick | 2 hours |
| 10. | Controllability and observability of bridge circuits | 2 hours |
| 11. | Controllability and observability of magnetic suspension system | 2 hours |
| 12. | Design of state feedback controller for balancing broomstick problem | 2 hours |
| 13. | Design of observer for balancing broomstick problem | 2 hours |
| 14. | Design of state feedback controlled balancing broomstick problem with observer | 2 hours |
| 15. | Stability analysis of straight and inverted pendulum | 2 hours |
| | | |
| | **Total Laboratory Hours** | **30 hours** |

Mode of assessment: Continuous assessment, FAT

**Text Book**

| | |
|---|---|
| 1. | Ogata, "Modern Control Engineering", 5th Edition, Prentice Hall India, 2010. |
| 2. | Dorf and Bishop, ‘Modern Control Systems’, 14th Ed., Pearson, 2022 |
| | |

**Reference Books**

| | |
|---|---|
| 1. | Norman S. Nise, “Control Systems Engineering’, 8th Ed., Wiley, 2019 |
| 2. | M. Gopal, “Modern Control System Theory”, 3rd Ed., New Age International, 2014. |

Mode of Evaluation: Assignment, FAT

| | | | |
|---|---|---|---|
| Recommended by Board of Studies | 09-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA503L | Random Variables and State Estimation | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Impart knowledge on random processes and the estimation process
2. Explore prediction and identification methods to recognize and control random processes
3. Estimate a system model using parametric and non-parametric approaches

**Course Outcome**

On the completion of this course the student will be able to:

1. Characterize the random variables based on single and multiples random variables functions
2. Analyze the behavior of a random process using statistical tools
3. Design optimal estimators for variables and systems having stochastic nature
4. Apply the concepts of filtering and prediction for a random process
5. Conduct experiments to build and test parametric and non-parametric system models

| Module:1 | Random Variables | Hours: 6 |
|---|---|---|

Probability**:** Sample space, Conditional probability, Bayes theorem; Random variable: Cumulative Distribution Function (CDF), Probability Density Function (PDF), Conditional CDF; Multiple random variable: Joint Cumulative Distribution Function, Joint Probability Density Function; Computation of Expected Values

| Module:2 | Random Process and their characteristics | Hours: 7 |
|---|---|---|

Random Process Characterization: Densities & Joint densities, Mean, Variance, Expectation of a Random Process; Classification of Random Processes: SSS, WSS, Ergodic, joint stationary; Correlation functions: Autocorrelation, autocovariance, cross-correlation, cross-covariance function; Temporal and Spatial Characteristics; White Noise

| Module:3 | Parameter Estimation | Hours: 8 |
|---|---|---|

Bayes Performance Measure, Statistical Characterizations of Data; Cramer-Rao bounds; Bayes Estimation: Maximum a posteriori (MAP) estimation, Minimum Mean Square Error (MMSE) Estimate: Linear MMSE Estimation, Nonlinear MMSE Estimation; Estimation of Nonrandom Parameters: Maximum Likelihood Estimation

| Module:4 | Wiener Estimation | Hours: 6 |
|---|---|---|

Optimum Filter Formulation: Prediction of a Random Process, Filtering out Noise, Interpolation for Random Processes; Wiener Hoff Equation; Wiener filter design: FIR Wiener filter, Linear Time-Invariant Noncausal Filter (IIR), Linear Time-Invariant Causal Filter (IIR); Application of Weiner's theory in feedback control system

| Module:5 | Kalman Estimation | Hours: 6 |
|---|---|---|

State Dynamics with Random Excitations, Markov Sequence Model, Observation Model; Kalman Filter estimator: Anatomy and Physiology of the Kalman Filter; Prediction: Fixed lead prediction, sliding window; Steady state equivalence of the Kalman and Wiener filter: Kalman filter formulation, Wiener filter formulation

| Module:6 | Nonparametric Model Estimation | Hours: 5 |
|---|---|---|

Correlation and spectral analysis for non-parametric model identification, obtaining estimates of the plant impulse, step and frequency responses from identification data.

| Module:7 | Parametric Model Estimation | Hours: 5 |
|---|---|---|

Prediction Error Model Structures, parametric estimation using one-step ahead prediction error model structures and estimation techniques for ARX, ARMAX, Box-Jenkins, FIR, Output Error models. Nonlinear model estimation: NAR, NARX, NARMA, NARMAX models

| Module:8 | Contemporary Issues | 2 hours |
|---|---|---|
| | | |
| | Total Lecture hours: | 45 hours |

| Text Books | |
|---|---|
| 1. | Ludeman, L. C. (2010). Random processes: filtering, estimation, and detection. John Wiley & Sons, Inc. |
| 2. | Lennart Ljung, (2012). System Identification: A Theory for the User, Prentice-Hall, 2nd edition |
| **Reference Books** | |
| 1. | Stark, H., & Woods, J. (2012). Random Processes. Probability, Statistics, and Random Variables for Engineers. |
| 2. | Tangirala, A. K. (2018). Principles of system identification: theory and practice. CRC Press. |
| 3. | Papoulis, A., & Pillai, S. U. (2014). Probability, random variables, and stochastic processes. Tata McGraw-Hill Education. 4th Edition |

| Mode of Evaluation **:** Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test | | | |
|---|---|---|---|
| Recommended by Board of Studies | 09-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA504L | Smart Sensor Systems | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives:**

1. To impart knowledge on Smart sensing technology and its applications.
2. To introduce the standards and protocols used for smart sensing.

**Course Outcome:**

On the completion of this course the student will be able to:

1. Select the right sensor for a given application.
2. Design basic building blocks for a Smart sensor.
3. Design compensators and perform calibration for smart sensors.
4. Design, synthesize and layout a VLSI sensor and design micro power generation systems
5. Interpret the standards and protocols used for the smart sensor design and apply smart sensors for Health, Industrial and Home related applications.

| Module:1 | Smart Sensor Introduction: | 6 hours |
|---|---|---|

Classic vs Smart sensors, Architecture of Smart Sensors: Important components, their features. Monolithic integrated smart sensor, Hybrid integrated smart sensor, Micro Sensors; Impedance sensing system, Smart temperature sensor, Smart Wind sensor, Smart Hall sensor.

| Module:2 | Linearization: | 7 hours |
|---|---|---|

Linearization using shunt resistance, Divider circuit, higher order linearizing circuit. Linear interpolation, Piecewise linearization, Lookup table approach, Adaptive filters based approach.

| Module:3 | Calibration and Compensation: | 6 hours |
|---|---|---|

Calibration and Self Calibration of smart sensors, Offset compensation, Error and Drift compensation, Lead wire compensation, Temperature effect and compensation. Uncertainties

| Module:4 | VLSI Sensors: | 6 hours |
|---|---|---|

Analog Numerical computation - CORDIC Computation. Adaptive filtering – LMS algorithm, Bit stream multiplication. Analog VLSI based Neural Network.

| Module:5 | Micro-power Generation: | 6 hours |
|---|---|---|

Introduction, Energy storage system, Thermoelectric energy harvesting, Vibration and Motion energy harvesting, Far-Field RF energy harvesting, Photovoltaic.

| Module:6 | Standards and protocols: | 7 hours |
|---|---|---|

Introduction, IEEE 1451 Standard, Network technologies, LonTalk, CEBUS Communication protocol for smart home, J1850 Bus, Plug-n-Play Smart Sensor Protocol.

| Module:7 | Case Studies: | 5 hours |
|---|---|---|

Design and Implementation of IoT for Environmental Condition Monitoring, Development of Smart Bed for Health Care Application, Study of Smart City and its Design, Wearable smart sensors, Biosensors and applications.

| Module:8 | Contemporary Issues | 2 hours |
|---|---|---|

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|---|---|---|
| | **Total Lecture hours:** | **45 hours** |
| **Text Book(s)** | | |
| 1. | Manabendra Bhuyan, “Intelligent Instrumentation: Principles and Applications”, CRC Press, 2011. | |
| 2. | Gerard Meijer, Kofi Makinwa, Michiel Pertijs, “Smart Sensor Systems: Emerging Technologies and Applications”, IEEE press, Wiley, 2014. | |
| **Reference Books** | | |
| 1. | Kevin Yallup, Krzysztof Iniewski, “Technologies for Smart Sensors and Sensor Fusion”, CRC Press, 2014. | |
| 2. | Krzysztof Iniewski, “Smart Sensors for Industrial Applications”, CRC Press, 2013. | |

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| **Mode of Evaluation:** CAT / Assignment / Quiz / FAT / Project / Seminar | | | |
| Recommended by Board of Studies | 09-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA505L | Process Dynamics and control | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives:**

1. Introduce the modelling of various physical processes using first principle
2. Understand various control modes and tuning of controller.
3. Study advanced control strategies based on process model.

**Course Outcome:**

On the completion of this course the student will be able to:

1. Develop mathematical models for dynamic processes
2. Select and tune PID controllers for the given systems.
3. Choose necessary final control element for a given application.
4. Design a control strategy for a process involving multiple variables and constraints.
5. Design and Conduct experiments, as well as analyse and interpret data

| Module:1 | Process Dynamics: | 7 hours |
|---|---|---|

Need for Process Control; objective of modelling: models of level, thermal and flow processes; Integrating and non-integrating systems; Degrees of Freedom; Continuous and batch processes; Self-regulation; Lumped and Distributed parameter models; Linearization of nonlinear systems; P&ID diagram

| Module:2 | Dynamic and Steady State Behaviour of Process: | 4 hours |
|---|---|---|

Dynamic response of a first order process; First order plus dead time process; Second order process; Pure capacitive process; Pure dead time; Higher order process; Inverse response; Pade approximation.

| Module:3 | Control Actions: | 7 hours |
|---|---|---|

Concept of servo and regulatory problems; Selection of measured, manipulated and controlled variables; Types of controller; Characteristic of on-off controller; proportional, integral and derivative controllers; P+I,P+D and P+I+D control modes; anti-reset windup; bumpless transfer; practical forms of PID control; selection of control modes for different processes.

| Module:4 | Design of feedback controller: | 6 hours |
|---|---|---|

Evaluation criteria: IAE, ISE, ITAE and ¼ decay ratio; Tuning methods: Process reaction curve method; Continuous cycling method; Direct synthesis

| Module:5 | Final Control Elements: | 6 hours |
|---|---|---|

I/P converter; Pneumatic and electric actuators; Valve Positioner; Control Valves; Characteristic of Control Valves: Inherent and Installed characteristics; Valve body; Commercial valve bodies; Control valve sizing; Cavitation and flashing; Selection criteria.

| Module:6 | Enhancement to single loop regulatory control: | 7 hours |
|---|---|---|

Feed forward controller: design with steady state model, design with dynamic model; combination of feed forward-feedback structure; Cascade control: analysis and design; Ratio control; Split range control; Override control; Inferential control.

| Module:7 | Model based control: | 6 hours |
|---|---|---|

| | | |
|---|---|---|
| IMC structure – development and design - IMC based PID control – MPC: Dynamic matric control, Generalized predictive control; Multi-loop Control: Introduction; Process Interaction; Pairing of Inputs and Outputs; The Relative Gain Array (RGA). | | |
| | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| | **Total Lecture hours:** | **45 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | Seborg, Dale E., Duncan A. Mellichamp, Thomas F. Edgar, and Francis J. Doyle, "Process dynamics and control", 4th edition, John Wiley & Sons, 2016. |
| 2. | Stephanopoulos, George, "Chemical Process Control: An Introduction to Theory and Practice", Pearson India Education Services, 2015 |

**Reference Books**

| | |
|---|---|
| 1. | Coughanowr, Donald R., and Lowell B. Koppel, "Process systems analysis and control", McGraw-Hill, 2009. |
| 2. | Johnson, Curtis D, "Process control instrumentation technology", Prentice Hall, 2013. |
| 3. | Lipták, Béla G., ed. "Process Control: Instrument Engineers' Handbook. Butterworth-Heinemann, 2013. |
| 4. | Bequette, B.W., "Process Control Modeling, Design and Simulation", Prentice Hall of India, 2010. |

| | | | |
|---|---|---|---|
| Mode of Evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test | | | |
| Recommended by Board of Studies | 09-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA505P | Process Dynamics and Control Lab | 0 | 0 | 2 | 1 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Gain adequate knowledge on the practical implementation of various control strategies for real-time processes
2. Design and Implementation of Cascade, Ration, Feed-forward and advanced Control schemes using the facilities available in the Process Control lab.

**Course Outcomes**

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

1. Measure various process parameter and design suitable control schemes for industrial type process.
2. Design Feed Forward, Cascade and Multiloop PID controllers for the typical industrial process.

**Indicative Experiments**

| | |
|---|---|
| 1. | Identify the dynamics of first order, second order, interacting and non-interacting processes |
| 2 | Experimental Study of PID controller on Level process station |
| 3. | Modelling and Control of Pressure Process station |
| 4. | Experimental Study of ON-OFF and PID controller on Temperature Process |
| 5. | Analysis of inherent and installed characteristics of control valves |
| 6. | Experimental Study of Cascade / Ratio Control for a Level-Flow Process |
| 7. | Performance comparison of PID controller tuning methods using MATLAB |
| 8. | Simulation of nonlinear processes using MATLAB |
| 9. | Performance comparison of single and multi-loop controllers |
| 10 | Design and verification of Feed Forward controller |
| 11 | Disturbance rejection assessment of IMC-PI controller |
| 12 | Design and implementation of Velocity and Position form of PID Control algorithms using MATLAB |
| 13 | Realization of PID controllers using LabVIEW |
| 14 | Boiler drum level control using PID controller in LabVIEW |
| | **Total Laboratory Hours** **30 hours** |

Mode of assessment: Continuous assessment, FAT

**Text Book**

| | |
|---|---|
| 1. | Seborg, Dale E., Duncan A. Mellichamp, Thomas F. Edgar, and Francis J. Doyle, "Process dynamics and control", 4th edition, John Wiley & Sons, 2016. |
| 2. | Stephanopoulos, George, "Chemical Process Control: An Introduction to Theory and Practice", Pearson India Education Services, 2015 |

**Reference Books**

| | |
|---|---|
| 1. | Coughanowr, Donald R., and Lowell B. Koppel, "Process systems analysis and control", McGraw-Hill, 2009. |
| 2. | Johnson, Curtis D, "Process control instrumentation technology", Prentice Hall, 2013. |

Mode of Evaluation: Assignment, FAT

| | | | |
|---|---|---|---|
| Recommended by Board of Studies | 09-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA506L | Real Time Embedded systems | 2 | 0 | 0 | 2 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives:**

1. Identify modern embedded systems requirements and its' design constraints
2. Acquire hardware and software skills required for the role of embedded system engineer
3. Build automated control systems for real world problems using low cost embedded platforms

**Course Outcomes:**

On the completion of this course the student will be able to:

1. Identify a microcontroller based on application specifications.
2. Develop embedded software using commercial integrated development environments
3. Interface sensors and actuators using suitable communication protocols
4. Design data acquisition system for embedded measurement and control applications
5. Design and implement real-time embedded control applications

| Module:1 | Embedded systems | 2 hours |
|---|---|---|

Embedded system components; Examples of embedded system; Attributes; Characteristics; Challenges in embedded computing system design; Typical embedded system software operations

| Module:2 | ARM Cortex-M Architecture | 3 hours |
|---|---|---|

CPU core: Architecture, Registers, Operating modes; Memory organization; Instructions: Instruction formats, and addressing modes; Exceptions and Interrupts; Commercial ARM Cortex-M microcontrollers

| Module:3 | Programming Embedded Systems | 3 hours |
|---|---|---|

Embedded C programming: Number systems, Data types, Data structures, Functions, Bitwise operations; Improving responsiveness: Interrupts, Finite state machines; Concurrency; Scheduling; Context switching; Real-time systems; Embedded software development: Host and target, Compiler, Assembler, Linker, and Loader; Hardware and software debugging, In system programming

| Module:4 | Peripherals and Interfacing | 5 hours |
|---|---|---|

Memory mapped IO; GPIO programming: Push-Pull, Open-Drain modes, Pull up and Pull down modes, Input and output devices; Timing generation and measurements: Timers, and PWM, Input capture; ADC, DAC, Analog comparator; Block data transfer using DMA; Real Time Clock (RTC); Power management

| Module:5 | Serial Communication Protocols | 5 hours |
|---|---|---|

Serial communication protocols: UART, I2C, SPI, and CAN; Architecture; electrical considerations; message formats; message types; transmission and arbitration; Data visualization using logic analysers

| Module:6 | Data acquisition System Design | 5 hours |
|---|---|---|

Analog interfacing and data acquisition; Transducers; Current to voltage circuit, Instrumentation amplifier, isolation, Anti-aliasing filters; Nyquist theory to determine sampling rate; Measurement of voltage, current, and temperature; Analysis of noise; Techniques to reduce noise; Optical encoders for speed and position measurement; Data acquisition case studies

| Module:7 | Embedded Control System | 5 hours |
|---|---|---|

Closed loop control system: Set-point control and trajectory tracking; Design process for a PID controller; Fixed point vs. Floating point representation, Implementation of PID controller; Implementation of digital filters, Quantization, Overflow and resource issues; Case

| | | | |
|---|---|---|---|
| studies: Digital power supply design and motor control | | | |
| **Module:8** | **Contemporary Issues** | | **2 hours** |
| | | | |
| | **Total Lecture hours:** | | **30 hours** |
| **Text Book(s)** | | | |
| 1. | Alexander G Dean, Embedded Systems Fundamentals with Arm Cortex-M based Microcontrollers: A Practical Approach, ARM Education Media, 2021. | | |
| 2. | Jonathan W. Valvano, Embedded Microcomputer Systems: Real Time Interfacing, Third Edition, Cengage Learning, 2010. | | |
| **Reference Books** | | | |
| 1. | Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C, Third Edition, 2018. | | |
| 2. | Marilin Wolf, Computers as Components: Principles of Embedded Computing Design, Third Edition, Morgan Kaufmann, 2012. | | |
| 3. | Raj Kamal, Embedded Systems- Architecture, Programming and Design, Third Edition, McGraw Hill Education India, 2017. | | |
| **Mode of Evaluation**: CAT, Laboratory Assessment/Assignment / Quiz / FAT | | | |
| Recommended by Board of Studies | 09-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA506P | Real Time Embedded Systems Lab | 0 | 0 | 2 | 1 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Acquire programming and hardware skills in typical embedded system development cycle
2. Demonstrate the different embedded system design concepts using cortex-M microcontroller

**Course Outcomes**

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

1. Use modern software and hardware development tools for embedded system design
2. Develop embedded system to solve real world control and automation problems

**Indicative Experiments**

| | |
|---|---|
| 1. | Implementation of simple C programming concepts in IDE: Bitwise operations, control blocks and functions |
| 2. | GPIO Programming: Interfacing input and output devices |
| 3. | Study of polling and interrupts using a Cortex-M microcontroller |
| 4. | Generation of PWM signals for the given frequency and duty cycle using timers |
| 6. | Implementation of analog interfacing using ADC Programming with potentiometer |
| 6. | Measurement of voltage and current for data acquisition system design |
| 7. | Measurement of process variables: Temperature, level, position and speed |
| 8. | Interfacing I2C based 3-axis accelerometer sensor |
| 9. | Implementation of CAN network and analysis using logic analyzer |
| 10. | Implementation of digital FIR filter and FFT in Cortex-M microcontrollers |
| 11. | Design and implementation of real-time PID control system for speed or position control of motor |
| 12. | Pre-emptive task scheduling using RTOS kernel for multitasking applications |
| | |

**Total Laboratory Hours** **30 hours**

Mode of assessment: Continuous assessment, FAT

**Text Book**

| | |
|---|---|
| 1. | Alexander G Dean, Embedded Systems Fundamentals with Arm Cortex-M based Microcontrollers: A Practical Approach, ARM Education Media, 2021. |
| 2. | Jonathan W. Valvano, Embedded Microcomputer Systems: Real Time Interfacing, Third Edition, Cengage Learning, 2010. |
| | |

**Reference Books**

| | |
|---|---|
| 1. | Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C, Third Edition, 2018. |
| 2. | Geoffrey Brown, Discovering the STM32 Microcontroller, Indiana University, 2016. |

Mode of Evaluation: Assignment, FAT

| | | | |
|---|---|---|---|
| Recommended by Board of Studies | 09-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA507L | Industrial Automation | 2 | 0 | 0 | 2 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives:**

1. Deliver a strong foundation to solve batch process and continuous process control
2. Technical competence through hands-on experience with industrial automation tools like PLC, DCS, and SCADA.
3. Exposure to various communication protocols used in industrial automation

**Course Outcomes:**

On the completion of this course the student will be able to:

1. Outline the basic concepts of computer-based automation, data communication and Industry 4.0.
2. Identify the main parts of PLC and describe their functions.
3. Develop a PLC ladder logic and Function block diagram to automate the process.
4. Elaborate the requirements of PLC enclosure, noise reduction techniques, proper grounding practices, and troubleshooting procedures.
5. Identify the hardware and software components of HMI, SCADA and Distributed Control System and configure a DCS programming.

| Module:1 | Role of Computers in Automation: | 4 hours |
|---|---|---|

Data loggers ; Data Acquisition Systems (DAS) ; Functional block diagram of computer based control system ; Sampling considerations ; Automation: Definition, Benefits, Examples, Evolution of Automation ; Automation Components: Discrete Switches, Analog Sensors, Relays, Actuators, and Automation tools.

| Module:2 | Programmable Logic Controller (PLC) : Architecture and basic Ladder Instructions | 4 hours |
|---|---|---|

Definition ; PLC Architecture: input/output modules, power supplies, and isolators, programming device ; Program Scan ; IEC61131-3 Standard programming languages and their selection ; PLC Basic Instructions ; Input and Output Addressing ; Ladder Diagram for Boolean Gates ; Concept of Latching and Unlatching ; Programming Timers and Counters ; Applications

| Module:3 | Advanced PLC Instructions and Functions | 4 hours |
|---|---|---|

Arithmetic functions ; Comparison functions ; Program control Instructions ; Data transfer Instructions ; Sequencer functions ; Shift register functions ; Analog PLC operation ; PLC-PID functions ; Applications ; Networking of PLC ; Design of interlocks and Alarm annunciator sequence (ISA 18.1 Standard)

| Module:4 | PLC Installation and Troubleshooting | 4 hours |
|---|---|---|

PLC Enclosure; Electrical Noise; Leaky inputs and outputs; Grounding; Voltage Variations and surges; preventive maintenance; Troubleshooting: Processor Module, I/O Malfunctions, PLC program.

| Module:5 | Supervisory Control and Data Acquisition (SCADA) | 4 hours |
|---|---|---|

SCADA Components: Human Machine Interface, Supervisory System, Remote Terminal Unit, Controller, Intelligent Electronic Devices ; Types of SCADA Architectures ; SCADA Communication : IEC61850, Modbus, Distributed Network Protocol (DNP), OPC UA

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|---|---|---|
| IEC62541 Standard | | |
| **Module:6** | **Distributed Control System (DCS)** | **4 hours** |
| Evolution of Distributed Control Systems ; Generalized architecture of DCS: Local Control unit – Data Input and Output Unit, Operator Interface , Engineering interface ; DCS commissioning and Configuration ; Programming a DCS ; Redundancy concept ; Selection of DCS ; Case Studies: Thermal power plant , Water treatment plant | | |
| | | |
| **Module:7** | **Advances in Industrial Automation** | **4 hours** |
| Data communication: HART Protocol ; Field bus Protocol; Industrial Ethernet ; Wireless MAC Standards– IEEE 802.11- IEEE 802.15.4 , Wireless HART ; ISA 100 Wireless Standard for Automation ; 4th Industrial revolution Industry 4.0 ; Building blocks of Industrial IoT. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| | | |
| | **Total Lecture hours:** | **30 hours** |

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|---|---|
| **Text Book(s)** | |
| 1. | Frank D Petruzella, “Programmable Logic Controllers”, McGraw Hill, New York, 2016 |
| 2. | Stuart A Boyer, “SCADA: Supervisory Control and Data Acquisition Systems”, ISA Press, 2010 |
| **Reference Books** | |
| 1. | Lawrence (Larry) M. Thompson and Tim Shaw, “Industrial Data Communications”, 5th Edition, ISA Press, 2015. |
| 2. | John Park, Steve Mackay, Edwin Wright, “Practical Data Communications for Instrumentation and Control”, Elsevier, 2004 |
| 3. | Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things” Kindle Edition, Apress, New York, 2016 |
| **Mode of Evaluation:** CAT / Assignment / Quiz / FAT | |

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|---|---|---|---|
| Recommended by Board of Studies | 09-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA507P | Industrial Automation Lab | 0 | 0 | 2 | 1 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Identify the hardware and software requirements of process and factory automation.
2. Configure and construct both PLC and DCS programs to implement process and factory automation.

**Course Outcomes**

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

1. Develop a ladder program for a given automation application using Timer, counter, and Advanced Function block instructions.
2. Configure DCS and create a Function block diagram for the closed-loop process control and Monitoring application.

**Indicative Experiments**

| | |
|---|---|
| 1. | Create a Ladder program to automate the continuous filling system using basic instructions in PLC. |
| 2 | Create a Ladder program to implement Alarm annunciator sequence (ISA 18.1 Standard) using Timer Instructions |
| 3. | Create a Ladder program to design an Automatic Parking System using Counter instructions in PLC |
| 4. | Construct a Ladder/Function Block program to design an Automatic weighing system |
| 5. | Program a ladder/Function Block program to control traffic in four-way Sequencer Output Instruction in PLC |
| 6. | Interface the Analog /Digital Input /Output devices with Industrial type Standalone PLC.(Temperature Sensor /Limit Switch/ Photo Sensor/ Hooter/Light Indicator/Relay) |
| 7. | HMI Configuration and Programming of Discrete Control Sequence Process |
| 8. | DCS commissioning and hardware configuration (AI, AO, DI and DO Modules). |
| 9. | Construct a DCS functional block programming to design an Interlock system |
| 10. | Interfacing Filed devices with DCS and build PID configuration in DCS |
| 11. | SCADA configuration and programming of Level /Temperature process control and Monitoring |
| 12. | Realization of various closed loop control schemes of Pilot plant (Level/Flow/Temperature/Pressure Process) using DCS |
| 13. | IoT Based Level/Temperature Monitoring System |
| | **Total Laboratory Hours** **30 hours** |

Mode of assessment: Continuous assessment, FAT

**Text Book**


1. Frank D Petruzella, “Programmable Logic Controllers”, McGraw Hill, New York, 2016
2. Popovic Bhatkar and Vijay P. Bhatkar, "Distributed Computer control for Industrial Automation", Imprint- Routledge, New York, 2017, https://doi.org/10.1201/9781315141404.


**Reference Books**


1. Hugh Jack, “Automating Manufacturing Systems with PLCs”, Lulu.com, 2010, eBook, ISBN-13: 978-0557344253

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|---|---|---|---|---|
| 2. | David Bailey and Edwin Wright “Practical SCADA for Industry” IDC Technologies, Newness, Imprint of Elsevier, 2003. | | | |
| Mode of Evaluation: Continuous Assessments and FAT | | | | |
| Recommended by Board of Studies | | 09-07-2022 | | |
| Approved by Academic Council | | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA601L | Building Automation | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives:**

1. To impart knowledge on various systems involved in a building management system.
2. To give exposure on factors influencing controller design for building automation

**Course Outcome:**

On the completion of this course the student will be able to:

1. Demonstrate the importance of building automation and design fire alarm system for building automation
2. Construct the access control system with enhanced security and examine the various components of HVAC
3. Design, implement and evaluate the performance of controllers for BAS to meet various factors.
4. Develop and enhance the efficiency of energy management system.
5. Formulate a building management system for a given problem.

| Module:1 | Introduction: | 4 hours |
|---|---|---|

Concept and application of Building Management System (BMS) and Automation: requirements and design considerations and its effect on functional efficiency of building automation system, architecture and components of BMS

| Module:2 | Fire Alarm System: | 6 hours |
|---|---|---|

Fundamentals: Fire modes, History, Components, and Principles of Operation. FAS Components: Different fire sensors, smoke detectors and their types, Fire control panels, design considerations for the FA system. Field Components, Panel Components, Applications. FAS Architectures: Types of Architectures, Examples. FAS loops: Classification of loops, Examples. Fire Standards: FAS Design procedure in brief, NFPA 72A, BS 5839, IS Concept of IP enabled fire & alarm system, design aspects and components of PA system.

| Module:3 | Access Control System: | 8 hours |
|---|---|---|

**CCTV:** Camera: Operation & types, Camera Selection Criteria, Camera Applications, DVR Based system, DVM, Network design, Storage design. Components of CCTV system like cameras, types of lenses, typical types of cables, controlling system.
**Security Design:** Security system design for verticals. Concept of automation in access control system for safety, Physical security system with components, RFID enabled access control with components, Computer system access control – DAC, MAC, RBAC.

| Module:4 | HVAC system: | 8 hours |
|---|---|---|

**Fundamentals:** Introduction to HVAC, HVAC Fundamentals, Basic Processes (Heating, Cooling etc)
**Basic Science:** Air Properties, Psychometric Chart, Heat Transfer mechanisms, Examples.
**Human Comfort:** Human comfort zones, Effect of Heat, Humidity, Heat loss.
**Processes:** Heating Process & Applications (i.e., Boiler, Heater), Cooling Process & Applications (i.e., Chiller), Ventilation Process & Applications (i.e., Central Fan System, AHU, Exhaust Fans), Unitary Systems (VAV, FCU etc).

| Module:5 | Field Control System and Networking Protocols: | 5 hours |
|---|---|---|

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|---|---|---|
| Instrumentation Basics, Field components & use, DDC, DCS & applications. Control Panel: HVAC Control Panel, MCC Basics, Panel Components Communication: Communication Basics, Networks, BACNet, Modbus, LON | | |
| | | |
| **Module:6** | **Energy Management System:** | **6 hours** |
| ASHRAE Symbols -Energy Management: Energy Savings concept & methods, lighting control, Building Efficiency improvement, Green Building, Concept & Examples. | | |
| | | |
| **Module:7** | **Building Management System:** | **6 hours** |
| BMS (HVAC, Fire & Security) project cycle, Project steps BMS. Verticals: Advantages & Applications of BMS, Examples Integration: IBMS. Architecture, Normal & Emergency operation. Advantages of BMS | | |
| | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| | | |
| | **Total Lecture hours:** | **45 hours** |

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| **Textbook(s)** | |
| 1. | Gerardus Blokdyk, “Building Management Systems a Complete Guide”, Emereo Pty Limited, 2020 |
| 2. | Jim Sinopoli, Butterworth-Heinemann, “Smart Buildings”, imprint of Elsevier, 2nd ed., 2010. |
| 3. | Albert Ting-Pat So, WaiLok Cha, “Intelligent Building Systems”, Kluwer Academic publisher,3rd ed., 2012. |
| **Reference Books** | |
| 1. | Robert Gagnon, “Design of Special Hazards and Fire Alarm Systems”, Jones & Bartlett Learning, 2016. |
| 2. | Ronnie J. Auvil, “HVAC Control Systems”, American Technical Publishers, 2017 |

| | | | |
|---|---|---|---|
| Mode of Evaluation**:** CAT / Assignment / Quiz / FAT | | | |
| Recommended by Board of Studies | 09-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA602L | Industrial Robotics | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. To understand the importance of robotics in scientific and industrial domains.
2. To introduce mathematical aspects of robotics such as spatial transformations. Kinematics and dynamics of the manipulator.
3. To develop a controller for tracking a desire trajectory and path planning by a robot.

**Course Outcome**

At the end of the course, the students will be able to

1. Understand the concept of forward and inverse kinematic of robot manipulators.
2. Develop the dynamics of the robotic manipulator using Euler Lagrangian approach.
3. Demonstrate an ability to generate joint trajectories for motion planning.
4. Implement the PD and PID controller for independent joint control.
5. Formulate solutions to solve problems related to robotics.

| | | |
|---|---|---|
| **Module:1** | **Introduction to Robotics** | **5 hours** |
| Basic definitions- Fundamentals about robot technology-Degree of freedom- Serials parallel manipulator, work space, classification of robots- Industrial Robots-actuator and gripper. | | |
| **Module:2** | **Kinematics** | **8 hours** |
| Position and orientation of links-Coordinate transformation-d-h parameters-Joint variable and position of end effectors-Inverse kinematic analysis. | | |
| **Module:3** | **Velocity and static force analysis** | **9 hours** |
| Translational and rotational velocities-Velocity transformations –Jacobian- Inverse kinematics of velocity-Static force/torque transformations-Recursive equations of motion and static force/torque relationships. | | |
| **Module:4** | **Trajectory generation** | **5 hours** |
| Point -to-point vs Continuous motion- Cubic and Quintic Polynomials- Linear functions with parabolic blends-Via points-Cartesian paths- Kinematic control. | | |
| **Module:5** | **Manipulator Dynamics** | **9 hours** |
| Newton Euler formulation of robot dynamics- Actuator dynamics- Computational considerations. | | |
| **Module:6** | **Robot Positional Control** | **5 hours** |
| Independent joint control-Feed forward control based on PD and PID compensators-Computed Torque control-Linear and Nonlinear controller design of robot. | | |
| **Module:7** | **Application of Robotics** | **2 hours** |
| Applications of robotics in active perception, medical robotics- autonomous vehicle and other acres. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| | | |
| | | |
| | **Total Lecture hours:** | **45 hours** |

**Text Book(s)**

1. John J. Craig, Introduction to Robotics: Mechanics and Control, 4th Edition, 2022, ISBN-13: 9780137848744, Pearson Internationals.
2. Mark W. Spong, Seth Hutchinson, M. Vidyasagar, Robot Modeling and Control, 2020, 2nd edition, ISBN 9781119524045, Wiley.

**Reference Books**

1. M.P. Groover, et.al., Industrial Robots: Technology, Programming and applications,

| | | | | |
|---|---|---|---|---|
| | McGraw Hill, 2nd Indian edition, 2017. | | | |
| 2. | M O Tokhi, A K M Azad, Flexible robot manipulator :modelling, simulation and control 2nd Edition, 2017. | | | |
| 3. | Ashitava Ghosal. Robotic fundamental Concept and Analysis, Oxford University Press 11th Impression 2015. | | | |
| | | | | |
| Mode of Evaluation: Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test | | | | |
| Recommended by Board of Studies | 09-07-2022 | | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 | |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA603L | Control of Electric Drives | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives:**

1. To provide the concepts and basic operation of electric drive system
2. To Analyse the solid state control of dc, induction and synchronous machine drives
3. To provide the design techniques of drive system

**Course Outcome:**

On the completion of this course the student will be able to:

1. Identify the need of various, electrical machines, power converters and control systems.
2. Design the phase controlled and chopper controlled DC motor drives.
3. Develop the dynamic model and control of IM Drives.
4. Analyse the performance of permanent magnet machines Drives.
5. Apply intelligent control algorithms/ techniques for control of electric drives.

| Module:1 | Introduction to Electric Drives | 6 hours |
|---|---|---|

Review of electric drive system, electrical machines, power converters and control, Different types of loads encountered in drive applications, Dynamics of drive systems, starting, braking, and speed-control.

| Module:2 | Phase Controlled DC motor drives: | 5 hours |
|---|---|---|

Single quadrant, Two –quadrant and four quadrant rectifier fed dc separately excited d.c. motor - Closed loop operation of rectifier fed drive, design of controller

| Module:3 | Chopper Controlled DC motor drives: | 5 hours |
|---|---|---|

Single quadrant, Two –quadrant and four quadrant chopper fed dc separately excited motor – Closed loop operation of chopper fed drive, design of controller

| Module:4 | Dynamic Modelling of Induction Machines | 8 hours |
|---|---|---|

Model of a Two phase induction machine, Three phase to two phase transformation- Power Equivalence Generalised Model in Arbitrary reference Frames, Electromagnetic Torque , stator Reference Frames Model , Rotor Reference Frames Model , Synchronously rotating Reference Frames Model

| Module:5 | Control of Induction Motor Drive: | 8 hours |
|---|---|---|

Stator- Voltage Control, Slip· Energy Recovery Scheme , Voltage-Source Induction Motor Drives , Current Source Induction Motor Drives , V/f control, need for vector control, direct and indirect vector control of induction motor drives.

| Module:6 | Permanent-Magnet Synchronous and Brushless DC Motor Drives | 5 hours |
|---|---|---|

Permanent Magnets and Characteristics, Permanent synchronous motor drive, Sensor less control of Permanent synchronous motor drive, Permanent Magnet Brushless DC motor, Sensor less control of PMBLDCM Drive.

| Module:7 | Intelligent Control of Electric Drives: | 6 hours |
|---|---|---|

Fuzzy Logic Control of ac and dc Drives, Artificial Neural Network control of ac and dc

| | | |
|---|---|---|
| Drives, Hybrid Fuzzy/PI Control of ac and dc Drives, | | |
| | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| | **Total Lecture hours:** | **45 Hours** |

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|---|---|
| **Text Book(s)** | |
| 1. | Krishnan, Electric Motor Drives: Modelling, Analysis and Control, **Pearson Education , 2015** |
| **Reference Books** | |
| 1 | Bimal K. Bose, “Modern Power Electronics and AC Drives”, Pearson Education, 2015. |
| 2 | Muhammad H. Rashid **,** Power Electronics: Circuits, Devices and Applications**,** Pearson Education , 2014 |
| 3 | Orłowska-Kowalska, Teresa, Blaabjerg, Frede, Rodríguez, José ,"Advanced and Intelligent Control in Power Electronics and Drives", Springer, 2014 |
| 4 | Ned Mohan, “Electrical Machines and Drives: A First course”, Wiley Publications, 2011. |
| 5 | Tze-Fun Chan, Keli Shi, "Applied Intelligent Control of Induction Motor Drives", Wiley, 2011 |
| 6 | G’K.DUBEY , Fundamentals of Electric drives , Narosa publications, second edition , 2010 |

| | | | |
|---|---|---|---|
| Mode of Evaluation**:** CAT / Assignment / Quiz / FAT / Project / Seminar | | | |
| Recommended by Board of Studies | 09-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA604L | Machine Learning | 2 | 0 | 0 | 2 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives:**

1. To provide the student with a broad understanding of machine learning algorithms and their applications.
2. To Understand and Interpret machine learning concepts, such as to robotic control, data mining, autonomous navigation, bioinformatics, speech recognition, and text and web data processing to the real world applications.

**Course Outcome:**

At the end of the course, the student will be able to:

1. Apply gradient descent approach for regression problems and Instant based learning for Classification problems.
2. Analyze and interpret the data using multiple classes and text classification problems.
3. Analyze the data using SVM, LDA and PCA
4. Apply Reinforcement learning by formulating MDP and computing optimal policy for continuous variables or higher dimension.
5. Conduct experiments to design a component or a product applying all the relevant standards with realistic constraints.

| Module:1 | Introduction, Regression Problem and Gradient Descent | 4 hours |
|---|---|---|

Introduction: Prediction, Classification, Forecasting, Filtering, Regression, Clustering. Review of Linear Algebra, Probability and Statistics. Data Exploration and Pre-processing: Data Objects and Attributes; Statistical Measures, Visualization, Data Cleaning and Integration, Linear Regression; Gradient Descent, Batch Gradient Descent, Stochastic Gradient Descent, The Concept of Under fitting and Overfitting.

| Module:2 | Classification Problem and Instance Based Learning | 4 hours |
|---|---|---|

The Concept of Parametric Algorithms and Non-parametric Algorithms: Locally Weighted Regression, The motivation of Logistic Regression, Logistic Regression and Perceptron Learning Algorithm.

| Module:3 | Multiple Classes and Text Classification | 4 hours |
|---|---|---|

Softmax Regression Discriminative Algorithms, Generative Algorithms, Gaussian Discriminant Analysis (GDA) and Naive Bayes algorithm.

| Module:4 | Support Vector Machine Algorithm | 4 hours |
|---|---|---|

Intuitions about Support Vector Machine (SVM): Notation for SVM, Functional and Geometric Margins.

| Module:5 | Dimensionality Reduction | 4 hours |
|---|---|---|

Linear Discriminant Analysis (LDA); Principal Component Analysis (PCA); Transform Domain and Statistical Feature Extraction and Reduction.

| Module:6 | Markov Decision Process and Reinforcement Learning | 4 hours |
|---|---|---|

Applications of Reinforcement Learning: Markov Decision Process (MDP); Defining Value & Policy Functions, Value Function and Optimal Value Function.

| Module:7 | Computing an Optimal Policy | 4 hours |
|---|---|---|

Value Iteration: Policy Iteration; Generalization to Continuous States; Discretization & Curse of Dimensionality and Fitted Value Iteration algorithm.

| | | | | |
|---|---|---|---|---|
| **Module:8** | **Contemporary Issues** | | | **2 hours** |
| | | | | |
| | **Total Lecture hours:** | | | **30 hours** |
| **Text Book(s)** | | | | |
| 1. | Tom Mitchell, “Machine Learning”, McGraw-Hill Education, 2010. | | | |
| 2. | Daume, H. III, “A Course in Machine Learning”, 2015; http://ciml.info/ | | | |
| **Reference Books** | | | | |
| 1. | Christopher Bishop, “Pattern Recognition and Machine Learning”, Springer, 2013. | | | |
| 2. | Balas K Natarajan, “Machine Learning”, Elsevier Science, 2014. | | | |
| Mode of Evaluation**:** CAT / Assignment / Quiz / FAT / Lab / Seminar | | | | |
| Recommended by Board of Studies | | 09-07-2022 | | |
| Approved by Academic Council | | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA604P | Machine Learning Lab | 0 | 0 | 2 | 1 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Understand the implementation procedures for the machine learning algorithms using Matlab /R/Python, Weka.
2. Understand modern notions in data analysis-oriented computing and conduct experiments to design a component or a product applying all the relevant standards with realistic constraints.

**Course Outcomes**

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

1. Apply appropriate data sets to the Machine Learning algorithms.
2. Identify and apply Machine Learning algorithms to solve real world problems

**Indicative Experiments**

| | | |
|---|---|---|
| 1. | Implement the non-parametric Locally Weighted Regression algorithm in order to fit data points. Select appropriate data set for your experiment and draw graphs. | |
| 2. | Implement linear regression using python. Select appropriate data set for your experiment and plot the graphs. | |
| 3. | Write a program to construct a Bayesian network considering medical data. Use this model to demonstrate the diagnosis of heart patients using standard Heart Disease Data Set. You can use Java/Python ML library classes. | |
| 4. | Write a program to implement k-Nearest Neighbour algorithm to classify the iris data set. Print both correct and wrong predictions. Java/Python ML library classes can be used for this problem. | |
| 5. | Implement k-means clustering for classification. | |
| 6. | Implement an algorithm to demonstrate the significance of genetic algorithm | |
| 7. | Write a program to demonstrate the working of the decision tree based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample. | |
| 8. | Implement PCA, LDA for dimensionality reduction using MATLAB. Use this model to demonstrate the diagnosis of Epilepsy patients using standard EEG Data Set. | |
| 9. | Implement SVM tool for the detection of the Epilepsy patients using standard EEG Data Set. Also use standard Heart Disease Data Set to detect the heart disease. | |
| 10. | Implementation of popular architectures related to CNN, RNN, LSTM and Auto-encoder | |
| 11. | Implementation of Time Series Clustering and alignment algorithms | |
| 12. | Implementation of Reinforcement Learning algorithms. | |
| | **Total Laboratory Hours** | **30 hours** |

**Text Books**

| | |
|---|---|
| 1. | Tom Mitchell, “Machine Learning”, McGraw-Hill Education, 2010. |
| 2. | Daume, H. III, “A Course in Machine Learning”, 2015 |

**Reference Books**

| | |
|---|---|
| 1. | Christopher Bishop, “Pattern Recognition and Machine Learning”, Springer, 2013. |
| 2. | Balas K Natarajan, “Machine Learning”, Elsevier Science, 2014. |

Mode of Evaluation: Assignment, FAT

| | | | |
|---|---|---|---|
| Recommended by Board of Studies | 09-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA605L | Advanced Python programming | 1 | 0 | 0 | 1 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives:**

1. Design and apply programming constructs in Python to solve engineering problems.
2. Apply embedded programming features in Python

**Course Outcomes:**

1. Acquire programming skills in python
2. Perform coding using loops and conditional execution.
3. Ability to create and use different data structures.
4. Create functions, modules and packages to facilitate reusability of the code.
5. Developing python constructs for control engineering applications

| Module:1 | Fundamentals of Python Programming | 2 hours |
|---|---|---|
| History of python- Python shell- Programming using IDE- Indentation-Comments, Variables-Data types- conversion- Operators-Different forms of Assignment-Reserved words- Built in functions | | |
| **Module:2** | **Flow controls** | **2 hours** |
| Conditional blocks using If, else, elif-For loop-For loop using in range-while loop- Loop manipulation using pass, break ,continue and else. | | |
| **Module:3** | **Data structures** | **2 hours** |
| Lists-Tuples-Sets-Dictionaries-Various operations on data structures-user defined data structures | | |
| **Module:4** | **Functions and Files** | **2 hours** |
| Defining a function-calling a function- local and global scope of variables-lambda function-Files-create, read, write, append, close | | |
| **Module:5** | **String handling** | **2 hours** |
| Strings -various operations on strings- Regular expressions-Matching, replace, patterns | | |
| **Module:6** | **Modules and packages** | **2 hours** |
| Creating module-Importing module-in built modules-user defined modules-Overview of numpy, matplotlib, control packages | | |
| **Module:7** | **Control Engineering using Python** | **3 hours** |
| Time response analysis-Stability analysis-Root locus-Bode plot-PID controller-State space analysis-state feedback, observer design | | |
| **Mode of evaluation:** No separate evaluation for theory | | |
| | **Total Lecture hours:** | **15 hours** |

**Text Book(s)**


1. Smith, E. (2020). Python, the Fundamentals. In *Introduction to the Tools of Scientific Computing* (pp. 19-50). Springer, Cham.
2. Lynch, S. (2018). *Dynamical systems with applications using python*. Switzerland: Springer International Publishing.
3. Ramalho, L. (2022). *Fluent python*. " O'Reilly Media, Inc.".


**Reference Books**


1. Padmanabhan, T. R. (2016). *Programming with python* (Vol. 349). Springer.
2. McGrath, M. (2018). *Python in easy steps: Covers Python 3.7*. In Easy Steps.

| | | | | |
|---|---|---|---|---|
| 3 | Gowrishankar, S., & Veena, A. (2018). *Introduction to python programming*. CRC Press. | | | |
| 4 | Sharma, V. K., Kumar, V., Sharma, S., & Pathak, S. (2021). *Python Programming: A Practical Approach*. Chapman and Hall/CRC. | | | |
| **Mode of Evaluation :** No separate evaluation for theory class | | | | |
| Recommended by Board of Studies | | 09-07-2022 | | |
| Approved by Academic Council | | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA605P | Advanced Python Programming Lab | 0 | 0 | 4 | 2 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Apply embedded programming features in Python to solve engineering problems.

**Course Outcomes**

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

1. Acquire programming skills in python
2. Design and analysis of control theory applications using python

**Indicative Experiments**

| | |
|---|---|
| 1. | Write a program to perform various athematic operation on two numbers |
| 2 | Write a program to find simple and compound interest |
| 3. | Write a program to find the prime numbers in a given range |
| 4. | Write a program to calculate distance between two cartesian coordinates by taking inputs from user |
| 5. | Write a program to find whether the given number is even or odd |
| 6. | Write a program to generate Fibonacci series |
| 7. | Write a program to count number of characters/words in a file |
| 8. | Write a program to find the factorial of a number |
| 9. | Write a function two find roots of a quadratic equation |
| 10 | Create a function to compute gcd and lcm |
| 11 | Write a program to detect and remove repetitive words in a list |
| 12 | Write a program to find union and intersection of two lists |
| 13 | Write a program to separate positive and negative numbers from a list |
| 14 | Write a program to map lists into a dictionary |
| 15 | Write a program to capitalize a specific word in a list/file |
| 16 | Write a program to find a value in list using linear search/binary search |
| 17 | Write a program to sort a list using selection sort/insertion sort/merge sort |
| 18 | Write a program to check whether the given string is palindrome |
| 19 | Write a program to detect substrings in a given strings |
| 20 | Time response analysis of first order systems |
| 21 | Stability analysis using root locus |
| 22 | Stability analysis using bode plot |
| 23 | Design full state feedback controller |
| | **Total Laboratory Hours** **60 hours** |

Mode of assessment: Continuous assessment, FAT

**Text Book**


1. Smith, E. (2020). Python, the Fundamentals. In *Introduction to the Tools of Scientific Computing* (pp. 19-50). Springer, Cham.
2. Lynch, S. (2018). *Dynamical systems with applications using python*. Switzerland: Springer International Publishing.


**Reference Books**


1. Sharma, V. K., Kumar, V., Sharma, S., & Pathak, S. (2021). *Python Programming: A Practical Approach*. Chapman and Hall/CRC.
2. Gowrishankar, S., & Veena, A. (2018). *Introduction to python programming*. CRC Press.


Mode of Evaluation: Assignment, FAT

| | | | |
|---|---|---|---|
| Recommended by Board of Studies | 09-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA606L | Optimal Control Systems | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

The course is designed to enable the students to

1. Understand the optimal control theory fundamentals and apply the dynamic programming method for finding the optimal control law
2. Use the variational approach for solving the constrained optimal problem and
3. Compare the different iterative methods used for solving the optimal control problems

**Course Outcome**

At the end of the course, the student will be able to

1. Formulate the optimal control problem and find an optimal solution for the functionals with boundary conditions.
2. Determine an optimal control law using dynamic programming technique for a practical dynamic system.
3. Solve the optimal control problems using variational approach and determine a control law for optimal tracking and regulatory problems.
4. Design a controller for achieving the desired output in minimum time and with optimal control effort.
5. Determine an optimal control using different numerical techniques with MATLAB tool.

| Module:1 | Introduction | 6 hours |
|---|---|---|

Optimal Problem formulation: Mathematical model, Physical constraints, Performance measure – Form of optimal control – Performance measures for optimal control problem – Selecting a performance measure.

| Module:2 | Calculus of Variations | 8 hours |
|---|---|---|

Basic concepts: Function and functionals, Increment, Differential and variation – Functionals of a single function – Functionals involving several independent functions – Piecewise–smooth extremals – Constrained extrema: Direct method, Lagrange multiplier method.

| Module:3 | Dynamic Programming | 7 hours |
|---|---|---|

Optimal control law – Principle of optimality – Dynamic programming: Computational procedure, Interpolation – Recurrence relation of dynamic programming –- Characteristics of dynamic programming solution.

| Module:4 | Variational Approach | 5 hours |
|---|---|---|

Hamilton–Jacobi–Bellman equation – Continuous linear regulator problems – Variational approach to optimal control problems: Necessary conditions for optimal control.

| Module:5 | Linear Quadratic Optimal Control Systems | 6 hours |
|---|---|---|

Finite time linear regulator problems – Finite time Linear tracking problems – Solution of general continuous time optimal control problem – Continuous time Linear Quadratic Regulator design – Riccati equation – Pontryagin's minimum principle – state inequality constraints.

| Module:6 | Constrained Optimal Control Systems | 5 hours |
|---|---|---|

Time optimal control of LTI system – Fuel optimal control systems – Energy optimal control systems – Singular intervals in optimal control problems.

| Module:7 | Iterative Numerical Techniques | 6 hours |
|---|---|---|

Two point boundary–value problems – Method of steepest decent – variation of extremals – Quasilinearization – Gradient projection algorithm – Case studies.

| Module:8 | Contemporary Topics | 2 hours |
|---|---|---|

| | | |
|---|---|---|
| | **Total Lecture hours:** | **45 hours** |

| | |
|---|---|
| **Text Book(s)** | |
| 1. | Donald E. Kirk (2004). Optimal Control Theory: An Introduction, Dover Publications. |
| 2. | Desineni Subbaram Naidu (2009). Optimal Control Systems , CRC Press. |
| **Reference Books** | |
| 1. | Frank Lewis, Draguna L. Vrabie, Vassilis L. Syrmos (2012). Optimal Control, 3rd edition, John Wiley & Sons, Inc., Hoboken, New Jersey. |
| 2. | Leonid T Aschepkov, Dmitriy V Dolgy, Taekyun Kim and Ravi P Agarwal (2016). Optimal Control, Springer. |
| 3. | Suresh P. Sethi (2019). Optimal Control Theory: Applications to Management Science and Economics, 3rd Edition, Springer Cham. |

| | | | |
|---|---|---|---|
| Mode of Evaluation **:** Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test | | | |
| Recommended by Board of Studies | 09-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA607L | Adaptive and Robust Control | 3 | 0 | 0 | 3 |
| Pre-requisite | MCOA502L, MCOA502P | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives:**

1. Expose to techniques of system identifications for time varying systems
2. Design of Adaptive Control Systems
3. Analyze uncertain systems and design robust control systems.

**Course Outcome:**

On the completion of this course the student will be able to:

1. Estimate system parameters and design self-tuning regulators
2. Apply Lyapunov theory and MIT rule to design Model-Reference Adaptive Control schemes
3. Utilize vector fields to analyze variable structured systems and design sliding mode control law
4. Analyze the stability of systems with unstructured uncertainty and design robust control loops satisfying system norms
5. Utilize simulation tools to design, implement and test adaptive and robust control strategies

| Module:1 | Adaptive Control Approach | 6 hours |
|---|---|---|

Background: Linear feedback, Effects of process variations, Adaptive control schemes; Estimation: Parameter estimation, Least squares and Regression models; Estimating Parameters in Dynamical Systems; Recursive least squares (RLS) estimate

| Module:2 | Self-Tuning Regulators (STR) | 6 hours |
|---|---|---|

Controller design: Minimum degree pole placement (MDPP) design; Direct and Indirect self-tuning regulators; Continuous-time self-tuners; Stochastic self-tuning regulators; Minimum variance controller design, Minimum average controller design; Linear Quadratic STR, Adaptive Predictive Control

| Module:3 | Model-Reference Adaptive Control (MRAC) | 6 hours |
|---|---|---|

Series and Parallel MRAC schemes; The MIT Rule, Determination of adaptation gain; Lyapunov Theory: Design of MRAC Using Lyapunov Theory; Bounded-Input Bounded- Output Stability; Applications to Adaptive Control, MRAC via Output Feedback; Relations between MRAS and STR.

| Module:4 | Gain Scheduling Control | 7 hours |
|---|---|---|

Principle; Design approach: Linearization of nonlinear actuators, Measurement of auxiliary variable, Time scaling based on production rate, Nonlinear transformation of the system dynamics; Application of gain scheduling controllers; Case studies: Industrial adaptive controllers, ship steering

| Module:5 | Sliding Mode Control | 6 hours |
|---|---|---|

Variable structure systems, Vector field; Sliding surfaces; Continuous approximations of switching control laws; Modeling and Performance Trade-Offs; Relay control for multi-input systems

| Module:6 | Model Uncertainty | 6 hours |
|---|---|---|

Unstructured uncertainty and system model; Stability under unstructured uncertainties; Robust stability criteria; Robust performance analysis: Small gain theorem, μ- Analysis and Synthesis, Lyapunov approach

| | | |
|---|---|---|
| **Module:7** | **$H_2$ and $H_\infty$ Control** | **6 hours** |
| Norms: Computation of $H_2$ and $H_\infty$ norms; Standard LQR, LQG control problem; Robust Control Problem as $H_2$ and $H_\infty$ Control; $H_2$ and $H_\infty$ control synthesis; LQG as special $H_2$ controller; Case study on aircraft hovering | | |
| | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| | **Total Lecture hours:** | **45 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | Astrom, K. J., & Wittenmark, B. (2013). Adaptive control. Courier Corporation. |
| 2. | Liu, K. Z., & Yao, Y. (2016). Robust control: theory and applications. John Wiley & Sons. |

Reference Books

| | |
|---|---|
| 1. | Sastry, S. & Bodson, M., & Bartram, J. F. (2011). Adaptive control: stability, convergence, and robustness. Dover Publications, New York |
| 2. | Petros A Ioannou and Jing Sun. (2013). *Robust adaptive control*. Dover Publications. |
| 3. | Mackenroth, U. (2013). Robust control systems: theory and case studies. Springer Science & Business Media. |

**Mode of Evaluation:** CAT, Assignment, Quiz, FAT

| | | | |
|---|---|---|---|
| Recommended by Board of Studies | 09-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA608L | Discrete Control Systems | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives:**

1. To impart the in-depth knowledge of control theory, design of different controllers, analysis of discrete systems by state space analysis.
2. To analyze the concepts of realizing discrete systems.

**Course Outcomes:**

On the completion of this course the student will be able to:

1. Analyze discrete-time systems by using the z-transform.
2. Propose the model and analyze the response and stability of systems in discrete domain.
3. Design and realize digital controllers.
4. Design and analysis of discrete systems using state space approach
5. Analyze the Practical implementation of discrete systems and associated constraints

| Module:1 | Introduction to Discrete Control System: | 6 hours |
|---|---|---|

Introduction- continuous versus digital control- sampling process- effect of sampling rate-Discrete time system representation-Z-transform-Mapping of s-plane to z-plane.

| Module:2 | Discrete Time System Modelling and Response: | 6 hours |
|---|---|---|

Pulse transfer function-Signal flow graph-Stability analysis-Jury Stability-Bilinear transformation-Time Response-Transient and steady state response of second order system

| Module:3 | Design of Digital Controller: | 8 hours |
|---|---|---|

Discretization of continuous transfer functions-Controller design using transformation techniques-Z- plane specifications-Design in the w domain- Digital PID controller-dead-beat controller-Dahlin's controller- Root Locus design.

| Module:4 | Discrete state space model: | 7 hours |
|---|---|---|

Introduction to state space-state equation-solutions-conversion of state space to transfer function-state space modeling-solution to discrete state equation.

| Module:5 | Design via State space: | 8 hours |
|---|---|---|

Controllability-Observability- stability-Pole placement by state feedback-Full order observer design- Reduced order observer design.

| Module:6 | Quantization effects: | 4 hours |
|---|---|---|

Quantization effects-Truncation and Rounding off error – SNR- Limit cycles and dither-Sample rate reduction.

| Module:7 | Realization of discrete controllers | 4 hours |
|---|---|---|

Mechanization of control algorithms- Iterative computation via parallel, direct, canonical, cascade realization- Effects of computing time- Systems with time delay-Case studies.

| Module:8 | Contemporary Issues | 2 hours |
|---|---|---|
| | Total Lecture hours: | 45 hours |

| | | | | |
|---|---|---|---|---|
| **Text Book(s)** | | | | |
| 1. | Jacquot, R.G., 2019. *Modern digital control systems*. Routledge. | | | |
| 2 | Nise, N. S. (2020). *Control systems engineering*. John Wiley & Sons. | | | |
| **Reference Books** | | | | |
| 1. | Rabbath, C. A., & Léchevin, N. (2013). *Discrete-time control system design with applications*. Springer Science & Business Media. | | | |
| 2. | Gopal, M. (2012). *Digital cont & state var met*. Tata McGraw-Hill Education. | | | |
| **Mode of Evaluation :** Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test | | | | |
| Recommended by Board of Studies | | 09-07-2022 | | |
| Approved by Academic Council | | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA609L | Multivariable Control System | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. To describe the fundamentals of multivariable control design.
2. To demonstrate the performance of state feedback and output feedback control techniques
3. To analyze the effects of decentralized control and decoupling schemes.

**Course Outcome**

At the end of the course, the student will be able to

1. Develop mathematical models of a multivariable process
2. Analyze multivariable systems and multi-loop control schemes
3. Apply decentralized control to MIMO systems
4. Analyze MIMO systems using state space analysis
5. Design controllers for MIMO systems using optimization techniques

| | | |
|---|---|---|
| **Module:1** | **Introduction to Multivariable Control:** | **6 hours** |
| Multivariable systems – Transfer function for MIMO systems – Fundamental limitations on sensitivity – Limitations imposed by time delays, RHP-zeros and input constraints | | |
| **Module:2** | **Linear System Analysis:** | **7 hours** |
| Linear system time response – stability conditions – gain – frequency response - system internal structure – Block system structure - model reduction – Solutions to the control problem: variable selection – control structures – two degree of freedom controller - hierarchical control. | | |
| **Module:3** | **Decentralized Control:** | **6 hours** |
| Introduction – Plant decomposition, grouping of variables – Multi-loop control and paring selection: relative gain array(RGA) , integrity, diagonal dominance – RGA properties and application. | | |
| **Module:4** | **Decoupled Control:** | **6 hours** |
| Decoupling schemes: Feedforward, feedback, SVD - Enhancing SISO loops with MIMO techniques: cascade control- Sequential-Hierarchical design and tuning. | | |
| **Module:5** | **Centralised Closed-loop Control:** | **6 hours** |
| State feedback – output feedback – rejection of deterministic unmeasurable disturbances – case study. | | |
| **Module:6** | **Optimisation based control:** | **6 hours** |
| Optimal state feedback – optimal output feedback – predictive control – Generalised optimal disturbance rejection problem – case study. | | |
| **Module:7** | **Designing for Robustness and implementation:** | **6 hours** |
| Uncertainty and feedback – trade-offs and design guidelines – robustness analysis methodologies – controller synthesis – control implementation – implementation technologies - Control Schemes for Distillation Column, CSTR and Four-tank system | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| | | |
| | **Total Lecture hours:** | **45 hours** |

**Text Book(s)**


1. Albertos, Pedro, Antonio Sala, “Multivariable Control Systems: An Engineering Approach”, Springer, 2010.
2. Sigurd Skogestad, Ian Postlethwaite,” Multivariable Feedback Control: Analysis and Design”, Wiley, 2014.

| Reference Books | | | | |
|---|---|---|---|---|
| 1. | Bhattacharyya, Shankar P., and Lee H. Keel. Linear Multivariable Control Systems. Cambridge University Press, 2022. | | | |
| 2. | Gu, Da-Wei, Petko Petkov, and Mihail M. Konstantinov. Robust control design with MATLAB, 2nd Edition, Springer, 2013. | | | |
| 3. | W.M. Wonham, "Linear Multivariable Control: A Geometric Approach", Springer, 2013 | | | |
| | | | | |
| Mode of Evaluation **:** Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test | | | | |
| Recommended by Board of Studies | | 09-07-2022 | | |
| Approved by Academic Council | | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA610L | Industrial Data Networks | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. To describe the different network topologies and protocols
2. To identify the requirements of data communications including encoding, synchronization and protocols.
3. To analyze the features and operations of Modbus, HART and ProfiBus.

**Course Outcome**

At the end of this course, the student will be able to:

1. Describe the rudiments of how industrial devices communicate.
2. Infer the standards in network design and ensure the best practice followed in installing and commissioning data networks
3. Analyze Industrial Ethernet protocol for interfacing higher layer devices in automation pyramid.
4. Explain master-slave functioning of Modbus and implement for networking devices like smart meters.
5. Interpret HART handheld controller for calibration of field devices and interface field level devices using Fieldbus protocol.

| | | |
|---|---|---|
| **Module:1** | **Introduction to Networks:** | **6 hours** |
| Network topology -Classification of networks: LANs, MANs, WANs, GANs- OSI Model- Foundations of OSI Model. Protocol – Standards. | | |
| **Module:2** | **Physical Interface Standards:** | **5 hours** |
| EIA 232 overview, EIA 485 overview, EIA 484 Installation, noise problems, current loop & EIA converters | | |
| **Module:3** | **Industrial Ethernet:** | **7 hours** |
| Introduction-IEEE Standards-Ethernet MAC layer-IEEE 802.2 and Ethernet SNAP- OSI and IEEE 802.3 standard. Ethernet transceivers, Ethernet types, switches & switching hubs, 10 Mbps Ethernet, 100 Mbps Ethernet, Gigabit Ethernet. TCP / IP Overview- Internet Layer Protocols- Host-to-Host layer | | |
| **Module:4** | **Modbus:** | **7 hours** |
| Overview-Protocol Structure-Example Function codes. Modbus Plus protocol- Overview, Networking Modbus plus. Data Highway Plus/DH485 Overview, AS – interface Overview- Layers- Operating Characteristics. | | |
| **Module:5** | **HART Overview:** | **5 hours** |
| Introduction to HART and smart instrumentation, HART Protocol, Physical layer, Data link layer, and application layer, Application in SCADA | | |
| **Module:6** | **ProfiBus overview:** | **6 hours** |
| Introduction, ProfiBus protocol stack, ProfiBus communication model, communication objects, performance, system operation, ProfiBus in Automation | | |
| **Module:7** | **Foundation Fieldbus overview:** | **7 hours** |
| Introduction to Foundation Fieldbus- Architecture- physical layer and wiring rules, data link layer, application layer and user layer. | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| | | |
| | **Total Lecture hours:** | **45 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | Behrouz A. Forouzan, “Data Communications and Networking”, Tata McGraw-Hill, 5th edition, 2017. |

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|---|---|---|---|---|
| 2. | Sen, Sunit Kumar. Fieldbus and Networking in Process Automation. CRC Press, 2nd Edition, 2021. | | | |
| **Reference Books** | | | | |
| 1. | Steve Mackay, Edwin Wright, Deon Reynders, John Park, Practical Industrial Data Networks, Design, Installation and Troubleshooting, Newnes, Elsevier, 2004. | | | |
| 2. | Bela G. Liptak, “Instrument Engineers' Handbook: Process Software and Digital Networks”, Third Volume, 4th Edition, CRC Press, 2011. | | | |
| 3. | Theodore S. Rappaport, “Wireless Communications: Principles and Practice”, 2nd edition, Pearson, 2009. | | | |
| 4. | Axelsson, Björn, and Geoff Easton, eds. Industrial networks: a new view of reality. Routledge, 2016. | | | |
| | | | | |
| Mode of Evaluation **:** Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test | | | | |
| Recommended by Board of Studies | | 09-07-2022 | | |
| Approved by Academic Council | | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA611L | Data Acquisition and Hardware Interfaces | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives:**

1. To impart an in-depth knowledge in data acquisition, and analysis.
2. To provide a comprehensive coverage of data acquisition methods and hardware interface cards available commercially
3. To provides knowledge of different data acquisition systems used in industry.

**Course Outcome:**

On the completion of this course the student will be able to:

1. Interpret the elements of data acquisition techniques.
2. Comprehend the function of signal conditioning for various sensor and grounding for data acquisition system
3. Design and simulate Virtual Instrumentation using Lab view and different NI DAQ card
4. Comprehend the functioning of different communication interface for data acquisition system
5. Design Hardware in loop using Lab view and MATLAB DSPACE

| Module:1 | Fundamentals of Data acquisition: | 6 hours |
|---|---|---|

Generalized instrumentation system, PC-Based instrumentation system, Principles of data acquisition, Generalized data acquisition system, S/H circuits, and Multi-channel data acquisition systems.

| Module:2 | Signal conditioners for Data acquisition: | 6 hours |
|---|---|---|

Signal conditioners- voltage conditioners-integrated signal conditioners for temperature sensors, strain gages, piezoelectric sensors and linear position sensors. Signal conditioning modules for plug-in board, two-wire transmitter, and high speed digital transmitter. Field wiring and signal measurement-grounded and floated signal source-single ended and differential ended measurements. Ground loop and system isolation-noise and interference-shielding.

| Module:3 | Basic Virtual Instrumentation: | 7 hours |
|---|---|---|

LabVIEW - Graphical user interfaces - Controls and Indicators - 'G' programming - Data type, Format, Precision and representation - Data flow programming - Debugging and Running Virtual instrument - Functions and Libraries. FOR loops, WHILE loops, CASE structure, formula nodes –Math script -Sequence structures, , Real-Time System, VISA Field Point I/O, Compact RIO I/O and Intelligent Real-Time Embedded Controller. PCI or PXI R Series device,

| Module:4 | Common interface standards for data acquisition systems: | 6 hours |
|---|---|---|

RS232C, RS485, GPIB standard IEEE488.2, Distributed and standalone data loggers-storage and retrieval- USB, HART Protocol, Foundation Fieldbus, Device net, Profibus, Control net, and Industrial , Ethernet , Sigsbee , Bluetooth & Internal Calibration

| Module:5 | NI DAQ cards for Data acquisition systems : | 6 hours |
|---|---|---|

Data acquisition systems using USB DAQ card, MiRIO , PCI or PXI R Series device, CDAQ, MyRIO , CRIO, NI ELVIS.

| Module:6 | Real Time Hardware interface implementation using | 6 hours |
|---|---|---|

| | | |
|---|---|---|
| | **Lab VIEW and NI DAQ Card:** | |
| Real Time Hardware Interface using LabVIEW. Hardware in the loop (HIL) for temperature measurement, DC motor speed control, Induction motor control, MPPT based solar PV based system , Electric vehicle. System, Robotics control | | |
| | | |
| **Module:7** | **Real Time Hardware interface implementation using MATLAB/SIMULINK and DSPACE DAQ CARD:** | **6 hours** |
| Real Time Hardware Interface using MATLAB /SIMULINK, Hardware in the loop (HIL) for temperature measurement, DC motor speed control, Induction motor control, MPPT based solar PV based system , Electric vehicle. System, Robotics control | | |
| **Module:8** | **Contemporary Issues** | **2 hours** |
| | **Total Lecture hours:** | **45 hours** |

**Text Book(s)**

| | |
|---|---|
| 1. | Maurizio Di Paolo Emilio, “Data Acquisition systems- from fundamentals to Applied Design”, Springer, 2013. |

**Reference Books**

| | |
|---|---|
| 4. | Robert H King, “Introduction to Data Acquisition with LabVIEW”, McGraw Hill, 2nd edition, 2012. |
| 5. | Robert H. Bishop, National Instruments, Inc., “LabVIEW Student Edition”, Prentice Hall, 2014. |
| 6. | Karel Perutka, MATLAB for Engineers - Applications in Control, Electrical Engineering, IT and Robotics, 2011, EBOOK (PDF) ISBN978-953-51-5591-1 , Intech publshers |

Mode of Evaluation **:** Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test

| | | | |
|---|---|---|---|
| Recommended by Board of Studies | 09-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA696J | Study Oriented Project | | | | 02 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives:**

1. The student will be able to analyse and interpret published literature for information pertaining to niche areas.
2. Scrutinize technical literature and arrive at conclusions.
3. Use insight and creativity for a better understanding of the domain of interest.

**Course Outcome:**

1. Retrieve, analyse, and interpret published literature/books providing information related to niche areas/focused domains.
2. Examine technical literature, resolve ambiguity, and develop conclusions.
3. Synthesize knowledge and use insight and creativity to better understand the domain of interest.
4. Publish the findings in the peer reviewed journals / National / International Conferences.

| Module Content | (Project duration: One semester) |
|---|---|

This is oriented towards reading published literature or books related to niche areas or focussed domains under the guidance of a faculty.

**Mode of Evaluation:** Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Report to be submitted, presentation and project reviews – Presentation in the National / International Conference on Science, Engineering Technology.

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| Recommended by Board of Studies | 09-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA697J | Design Project | | | | 02 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives:**

1. Students will be able to design a prototype or process or experiments.
2. Describe and demonstrate the techniques and skills necessary for the project.
3. Acquire knowledge and better understanding of design systems.

**Course Outcome:**

1. Develop new skills and demonstrate the ability to upgrade a prototype to a design prototype or working model or process or experiments.
2. Utilize the techniques, skills, and modern tools necessary for the project.
3. Synthesize knowledge and use insight and creativity to better understand and improve design systems.
4. Publish the findings in the peer reviewed journals / National / International Conferences.

**Module Content** **(Project duration: One semester)**

Students are expected to develop new skills and demonstrate the ability to develop prototypes to design prototype or working models related to an engineering product or a process.

**Mode of Evaluation:** Evaluation involves periodic reviews by the faculty with whom the student has registered. Assessment on the project – Report to be submitted, presentation and project reviews – Presentation in the National / International Conference on Science, Engineering Technology.

| | | | |
|---|---|---|---|
| Recommended by Board of Studies | 09-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA698J | Internship I/ Dissertation I | | | | 10 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives:**

To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field and also to give research orientation.

**Course Outcome:**

1. Considerably more in-depth knowledge of the major subject/field of study, including deeper insight into current research and development work.
2. The capability to use a holistic view to critically, independently and creatively identify, formulate and deal with complex issues.
3. A consciousness of the ethical aspects of research and development work.
4. Publications in the peer reviewed journals / International Conferences will be an added advantage.

| Module Content | (Project duration: one semester) |
|---|---|

1. Dissertation may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.
2. Dissertation should be individual work.
3. Carried out inside or outside the university, in any relevant industry or research institution.
4. Publications in the peer reviewed journals / International Conferences will be an added advantage.

**Mode of Evaluation:** Assessment on the project - Dissertation report to be submitted, presentation, project reviews and Final Oral Viva Examination.

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| Recommended by Board of Studies | 09-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MCOA699J | Internship II/ Dissertation II | | | | 12 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives:**

To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field.

**Course Outcome:**

Upon successful completion of this course students will be able to

1. Formulate specific problem statements for ill-defined real life problems with reasonable assumptions and constraints.
2. Perform literature search and / or patent search in the area of interest.
3. Conduct experiments / Design and Analysis / solution iterations and document the results.
4. Perform error analysis / benchmarking / costing.
5. Synthesize the results and arrive at scientific conclusions / products / solution.
6. Document the results in the form of technical report / presentation.

**Module Content** **(Project duration: one semester)**

1. Dissertation may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.
2. Dissertation should be individual work.
3. Carried out inside or outside the university, in any relevant industry or research institution.
4. Publications in the peer reviewed journals / International Conferences will be an added advantage.

**Mode of Evaluation:** Assessment on the project - Dissertation report to be submitted, presentation, project reviews and Final Oral Viva Examination.

| | | | |
|---|---|---|---|
| Recommended by Board of Studies | 09-07-2022 | | |
| Approved by Academic Council | No. 67 | Date | 08-08-2022 |

| Course code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MGER501L | Deutsch für Anfänger | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Demonstrate competency in reading, writing and speaking in Basic German.
2. Achieve proficiency in German culture oriented view point.
3. Develop basic vocabulary in the technical field.

**Course Outcome**

At the end of the course, the student will be able to

1. Communicate in German language in their daily life communicative situations.
2. Apply the German language skill in writing corresponding letters, E-Mailsetc.
3. Create the talent of translating passages from English-German and vice versa and to
   frame simple **dialogues** based on given situations.
4. Understand and demonstrate the comprehension of some particular new range of unseen
   written materials.
5. Develop a general understanding of German culture and society.

| Module:1 | Die erste Begegnung | 6 hours |
|---|---|---|

Einleitung, Begrüssungs formen, Länder und Sprachen, Alphabet, Buchstabieren, Personalpronomen, Zahlen (1-100), Telefonnummer und E-Mail Addressenennen W-fragen, Aussagesätze, Nomen – Singular und Plural und Artikel

**Lernziel:**

Verständnisvon Deutsch, Genus- Artikelwörter

| Module:2 | Hobbys und Berufe | 6 hours |
|---|---|---|

Über Hobbyssprechen, Wochentage, Jahreszeiten, und Monatenennen, Uhrzeitensagen, über Arbeit, Berufe und Arbeitszeitensprechen, Zahlen (Hundertbiseine Million) Aritel (bestimmter, unbestimmter), Plural der Substantive, Konjugation der Verben (regelmässig /unregelmässig), Ja-/Nein- Frage, Imperativmit Sie.

**Lernziel :**

Sätzeschreiben, überHobbyserzählen, über Berufesprechenusw.

| Module:3 | Alltag und Familie | 7 hours |
|---|---|---|

Über die Familiesprechen, eineWohnungbeschreiben, Tagesablaufschreiben, Mahlzeiten, Lebensmittel, Getränke Possessivpronomen, Negation, Kasus- Akkusatitv und Dativ (bestimmter, unbestimmterArtikel), trennnbareverben, Modalverben, Adjektive, Präpositionen

**Lernziel :**

Sätzemit Modalverben, Verwendung von Artikel, über Familiesprechen, eine Wohnungbeschreiben.

| Module:4 | Situations gespräche | 6 hours |
|---|---|---|

**Dialoge:**

a) Gespräche mit Familienmitgliedern, am Bahnhof,
b) Gespräche beim Einkaufen, in einem Supermarkt, in einer Buchhandlung
c) Gespräche in einem Hotel/ in einem Restaurant, Treffen im Cáfe, Termin beim Arzt.

| Module:5 | Korrespondenz | 6 hours |
|---|---|---|

Leseverständnis, Mindmapmachen, Korrespondenz- Briefe, Postkarten, E-Mail

**Lernziel :**

Wortschatzbildung und aktiverSprachgebrauch

| Module:6 | Aufsatzschreiben | 6 hours |
|---|---|---|

**Aufsätze :**

Meine Universität, Das Essen, mein Freund odermeine Freundin, meine Familie, einFest in Deutschlandusw.

| Module:7 | Übersetzungen | 6 hours |
|---|---|---|

Übersetzungen : (Deutsch – Englisch / Englisch –Deutsch)

**Lernziel :**

| | | | | |
|---|---|---|---|---|
| Grammatik – Wortschatz – Übung | | | | |
| **Module:8** | **Trainierung den Sprachfähigkeiten** | | | **2 hours** |
| | | | | |
| | **Total Lecture hours:** | | | **45 hours** |
| **Text Book(s)** | | | | |
| 1. | Netzwerk A1, Stefanie Dengler, Paul Rusch, Helen Schmitz, Tanja Sieber, Ernst Klett Sprachen GmbH, Stuttgart, 2017 | | | |
| **Reference Books** | | | | |
| 1. | Studio d A1 Deutsch als Fremdsprache, Hermann Funk, Christina Kuhn, Silke Demme: Heuber Verlag, Muenchen, 2012. | | | |
| 2. | Lagune ,Hartmut Aufderstrasse, Jutta Müller, Thomas Storz,. Muenchen, 2012 | | | |
| 3. | Deutsche SprachlehrefürAusländer, Heinz Griesbach, Dora Schulz, 2011, Berlin | | | |
| 4. | Themen Aktuell 1, Hartmurt Aufderstrasse, Heiko Bock, MechthildGerdes, Jutta Müller und Helmut Müller, 2010, Muenchen. | | | |
| | www.goethe.de<br>wirtschaftsdeutsch.de<br>hueber.de, klett-sprachen.de<br>www.deutschtraning.org | | | |
| Mode of Evaluation **:** Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test | | | | |
| Recommended by Board of Studies | | 19-05-2022 | | |
| Approved by Academic Council | | No.66 | Date | 16-06-2022 |

| Course code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MFRE501L | Français Fonctionnel | 3 | 0 | 0 | 3 |
| Pre-requisite | NIL | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. Demonstrate competence in reading, writing, and speaking basic French, including knowledge of vocabulary (related to profession, emotions, food, workplace, sports/hobbies, classroom and family).
2. Achieve proficiency in French culture oriented view point.

**Course Outcome**

At the end of the course, the student will be able to

1. Remember the daily life communicative situations via personal pronouns, emphatic pronouns, salutations, negations, interrogations etc.
2. Create communicative skill effectively in French language via regular / irregular verbs.
3. Demonstrate comprehension of the spoken / written language in translating simple sentences.
4. Understand and demonstrate the comprehension of some particular new range of unseen written materials.
5. Demonstrate a clear understanding of the French culture through the language studied.

| | | |
|---|---|---|
| **Module:1** | **Saluer, Se présenter, Etablir des contacts. Compétences en lecture - consulter un dictionnaire, appliquer des stratégies de lecture, lire pour comprendre.** | **9 hours** |

Les nombres cardinaux- Les 7 jours de la semaine-Les 12 mois de l'année- La date-Les saisons-Les Pronoms personnels sujets-Les Pronoms Toniques- La conjugaison des verbes réguliers- er / - ir /-re verbes (Le présent)- La conjugaison des verbes irréguliers- avoir /être / aller / venir / faire /vouloir /pouvoir etc.

*Savoir-faire pour:* saluer, et se présenter – épeler en français – communiquer en classe – utiliser des stratégies pour comprendre un texte en français.

| | | |
|---|---|---|
| **Module:2** | **Présenter quelqu'un, Chercher un(e) correspondant(e), Demander des nouvelles d'une personne.** | **7 hours** |

La conjugaison des verbes Pronominaux (s'appeler/ s'amuser/ se promener)- La Négation- L'interrogation avec 'Est-ce que ou sans Est-ce que'- Répondez négativement.

| | | |
|---|---|---|
| **Module:3** | **Situer un objet ou un lieu, Poser des questions** | **6 hours** |

Les articles (défini/ indéfini)- Les prépositions (à/en/au/aux/sur/dans/avec etc.)- L'article contracté- L'heure- La Nationalité du Pays- Les professions- L'adjectif (La Couleur, l'adjectif possessif, l'adjectif démonstratif, l'adjectif interrogatif (quel/quelle/quels/quelles)- L'interrogation avec Comment/ Combien / Où etc., Pronoms relatifs simples (qui/que/dont/où).

| | | |
|---|---|---|
| **Module:4** | **Comprendre et traduire un texte court, Demander et indiquer le chemin.** | **5 hours** |

La traduction simple d'un texte/ dialogue :(français-anglais / anglais –français)

| | | |
|---|---|---|
| **Module:5** | **Trouver les questions, Répondre aux questions générales en français, Écouter des vidéos (site internet, YouTube) qui aident à améliorer leur prononciation/ vocabulaire et leurs compétences orales** | **6 hours** |

L'article Partitif (du/ de la / de l'/ des) -Faites une phrase avec les mots donnés- Mettez les phrases en ordre, masculin/féminin ; singulier/pluriel- Associez les phrases- les adverbes de temps (ensuite/hier/puis….)

| | | |
|---|---|---|
| **Module:6** | **Comment écrire un passage - développer des ompétences rédactionnelles. Discussion de groupe (donnez un sujet et demandez aux élèves de partager** | **5 hours** |

| | | |
|---|---|---|
| | **leurs idées)** | |
| Décrivez La Famille -La Maison -L'université -Les Loisirs-La Vie quotidienne- La ville natale-Un personnage célèbre | | |
| **Module:7** | **Comment écrire un dialogue** | **5 hours** |
| Dialogue<br>a) Réserver un billet de train<br>b) Entre deux amis qui se rencontrent au café<br>c) Parmi les membres de la famille<br>d) Entre le patient et le médecin<br>e) Entre le professeur et l'étudiant(e) | | |
| **Module:8** | **Contemporary Topics** | **2 hours** |
| | | |
| | **Total Lecture hours:** | **45 hours** |

| | |
|---|---|
| **Text Book(s)** | |
| 1. | Adomania 1, Méthode de français, CelineHimber, Corina Brillant, Sophie Erlich. Publisher HACHETTE, February 2016. |
| 2. | Enchanté 1 !, Méthode de français, Rachana Sagar Private Limited, Jan 2017. |
| **Reference Books** | |
| 1. | Le français pour vous 1, Méthode de français, VinodSikri, Anna Gabriel Koshy, Prozopublishing, Jan 2019. |
| 2. | Accueil 1, Méthode de français, Rachana Sagar Private Limited, January 2016 |
| 3. | Apprenons le français 1 Méthode de français, Mahitha Ranjit & Monica Singh, Jan 2019 |
| Modeof Evaluation **:** Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test | |

| | | | |
|---|---|---|---|
| Recommended by Board of Studies | 19-05-2022 | | |
| Approved by Academic Council | No. 66 | Date | 16-06-2022 |

| Course code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MENG501P | Technical Report Writing | 0 | 0 | 4 | 2 |
| Pre-requisite | Nil | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives**

1. To develop writing skills for preparing technical reports.
2. To analyze and evaluate general and complex technical information.
3. To enable proficiency in drafting and presenting reports.

**Course Outcome**

At the end of the course, the student will be able to

1. Construct error free sentences using appropriate grammar, vocabulary and style.
2. Apply the advanced rules of grammar for proofreading reports.
3. Interpret information and concepts in preparing reports.
4. Demonstrate the structure and function of technical reports.
5. Improve the ability of presenting technical reports.

| Indicative Experiments | |
|---|---|
| 1. | **Basics of Technical Communication**<br>General and Technical communication,<br>Process of communication, Levels of communication |
| 2. | **Vocabulary& Editing**<br>Word usage: confusing words, Phrasal verbs<br>Punctuation and Proof reading |
| 3. | **Advanced Grammar**<br>Shifts: Voice, Tense, Person, Number<br>Clarity: Pronoun reference, Misplace and unclear modifiers |
| 4. | **Elements of Technical writing**<br>Developing paragraphs, Eliminating unnecessary words, Avoiding clichés and slang<br>Sentence clarity and combining |
| 5. | **The Art of condensation**<br>Steps to effective precis writing,<br>Paraphrasing and summarizing |
| 6. | **Technical Reports:** Meaning, Objectives, Characteristics and Categories |
| 7. | **Formats of reports and Prewriting**: purpose, audience, sources of information, organizing the material |
| 8. | **Data Visualization**<br>Interpreting Data - Graphs - Tables – Charts - Imagery - Info graphics |
| 9. | **Systematization of Information:** Preparing Questionnaire<br>Techniques to Converge Objective-Oriented data in Diverse Technical Reports |
| 10. | **Research and Analyses:** Writing introduction and literature review, Reference styles, Synchronize Technical Details from Magazines, Articles and e-content |
| 11.. | **Structure of Reports**<br>Title – Preface – Acknowledgement - Abstract/Summary – Introduction - Materials and Methods – Results – Discussion - Conclusion - Suggestions/Recommendations |
| 12. | **Writing the Report:** First draft, Revising,<br>Thesis statement, Developing unity and coherence |
| 13. | **Writing scientific abstracts:** Parts of the abstract, Revising the abstract<br>Avoiding Plagiarism, Best practices for writers |
| 14. | **Supplementary Texts**<br>Appendix – Index – Glossary – References – Bibliography - Notes |
| 15 | **Presentation** |

| | | | | |
|---|---|---|---|---|
| | Presenting Technical Reports<br>Planning, creating anddigital presentation of reports | | | |
| | | | **Total Laboratory hours :** | **60 hours** |
| **Text Book(s)** | | | | |
| 1. | Raman, Meenakshi and Sangeeta Sharma, (2015).Technical Communication: Principles and Practice, Third edition, Oxford University Press, New Delhi. | | | |
| **Reference Books** | | | | |
| 1. | Aruna, Koneru, (2020). English Language Skills for Engineers. McGraw Hill Education, Noida. | | | |
| 2. | Rizvi,M. Ashraf (2018)Effective Technical Communication Second Edition. McGraw Hill Education, Chennai. | | | |
| 3. | Kumar, Sanjay and Pushpalatha, (2018). English Language and Communication Skills for Engineers, Oxford University Press. | | | |
| 4. | Elizabeth Tebeaux and Sam Dragga, (2020).The Essentials of Technical Communication, Fifth Edition, Oxford University Press. | | | |
| Mode of Evaluation **:** Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test | | | | |
| Recommended by Board of Studies | 19-05-2022 | | | |
| Approved by Academic Council | No. 66 | Date | 16-06-2022 | |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MSTS501P | Qualitative Skills Practice | 0 | 0 | 3 | 1.5 |
| Pre-requisite | Nil | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives:**

1. To develop the quantitative ability for solving basic level problems.
2. To improve the verbal and professional communication skills.

**Course Outcome:**

At the end of the course, the student will be able to

1. Execute appropriate analytical skills.
2. Solve problems pertaining to quantitative and reasoning ability.
3. Learn better vocabulary for workplace communication.
4. Demonstrate appropriate behavior in an organized environment.

| | | |
|---|---|---|
| **Module:1** | **Business Etiquette: Social and Cultural Etiquette; Writing Company Blogs; Internal Communications and Planning: Writing press release and meeting notes** | **9 hours** |

Value, Manners- Netiquette, Customs, Language, Tradition, Building a blog, Developing brand message, FAQs', Assessing Competition, Open and objective Communication, Two way dialogue, Understanding the audience, Identifying, Gathering Information,. Analysis, Determining, Selecting plan, Progress check, Types of planning, Write a short, catchy headline, Get to the Point –summarize your subject in the first paragraph., Body– Make it relevant to your audience.

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| **Module:2** | **Time management skills** | **3 hours** |

Prioritization, Procrastination, Scheduling, Multitasking, Monitoring, Working under pressure and adhering to deadlines

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| **Module:3** | **Presentation skills – Preparing presentation; Organizing materials; Maintaining and preparing visual aids; Dealing with questions** | **7 hours** |

10 Tips to prepare PowerPoint presentation, Outlining the content, Passing the Elevator Test, Blue sky thinking, Introduction , body and conclusion, Use of Font, Use of Color, Strategic presentation, Importance and types of visual aids, Animation to captivate your audience, Design of posters, Setting out the ground rules, Dealing with interruptions,
Staying in control of the questions, Handling difficult questions.

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| **Module:4** | **QuantitativeAbility-L1–Numberproperties; Averages; Progressions; Percentages; Ratios** | **11 hours** |

Number of factors, Factorials, Remainder Theorem, Unit digit position, Tens digit position, Averages, Weighted Average, Arithmetic Progression, Geometric Progression, Harmonic Progression, increase and Decrease or Successive increase, Types of ratios and proportions.

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| **Module:5** | **Reasoning Ability - L1 – Analytical Reasoning** | **8 hours** |

Data Arrangement (Linear and circular & Cross Variable Relationship), Blood Relations, Ordering / ranking / grouping, Puzzle test, Selection Decision table.

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| **Module:6** | **Verbal Ability -L1 – Vocabulary Building** | **7 hours** |

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| Synonyms & Antonyms, One word substitutes, Word Pairs, Spellings, Idioms, Sentence completion, Analogies. | | |
| | | |
| | **Total Lecture hours:** | **45 hours** |
| **Reference Books** | | |
| 1. | Kerry Patterson, Joseph Grenny, Ron McMillan and Al Switzler, (2017).2nd Edition, Crucial Conversations: Tools for Talking when Stakesare High .McGraw-Hill Contemporary, Bangalore. | |
| 2. | Dale Carnegie,(2016).How to Win Friends and Influence People. Gallery Books, New York. | |
| 3. | Scott Peck. M, (2003). Road Less Travelled. Bantam Press, New York City. | |
| 4. | SMART, (2018). Place Mentor, 1st edition. Oxford University Press, Chennai. | |
| 5. | FACE, (2016). Aptipedia Aptitude Encyclopedia. Wiley publications, Delhi. | |
| 6. | ETHNUS, (2013). Aptimithra. McGraw – Hill Education Pvt .Ltd, Bangalore. | |
| **Websites:** | | |
| 1. | **www.chalkstreet.com** | |
| 2. | **www.skillsyouneed.com** | |
| 3. | **www.mindtools.com** | |
| 4. | **www.thebalance.com** | |
| 5. | **www.eguru.ooo** | |
| Mode of Evaluation: Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test | | |
| Recommended by Board of Studies | 19-05-2022 | |
| Approved by Academic Council | No.66 | Date 16-06-2022 |

| Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| MSTS502P | Quantitative Skills Practice | 0 | 0 | 3 | 1.5 |
| Pre-requisite | Nil | Syllabus version | | | |
| | | 1.0 | | | |

**Course Objectives:**

1. To develop the students' advanced problem solving skills.
2. To enhance critical thinking and innovative skills.

**Course Outcome:**

At the end of the course, the student will be able to

1. Create positive impression during official conversations and interviews.
2. Demonstrate comprehending skills of various texts.
3. Improve advanced level thinking ability in general aptitude.
4. Develop emotional stability to tackle difficult circumstances.

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| **Module:1** | **Resume skills – Resume Template; Use of power verbs; Types of resume; Customizing resume** | **2 hours** |

Structure of a standard resume, Content, color, font, Introduction to Power verbs and Write up, Quiz on types of resume, Frequent mistakes in customizing resume, Layout-Understanding different company's requirement, Digitizing career portfolio.

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| **Module:2** | **Interview skills – Types of interview; Techniques to face remote interviews and Mock Interview** | **3 hours** |

Structured and unstructured interview orientation, Closed questions and hypothetical questions, Interviewers' perspective, Questions to ask/not ask during an interview, Video interview, Recorded feedback, Phone interview preparation, Tips to customize preparation for personal interview, Practice rounds.

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| **Module:3** | **Emotional Intelligence - L1 – Transactional Analysis; Brain storming; Psychometric Analysis; SWOT analysis** | **12 hours** |

Introduction, Contracting, ego states, Life positions, Individual Brainstorming, Group Brainstorming, Stepladder Technique, Brain writing, Crawford's Slip writing approach, Reverse brainstorming, Star bursting, Charlette procedure ,Round robin brainstorming, Skill Test, Personality Test, More than one answer, Unique ways, SWOT analysis.

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| **Module:4** | **Quantitative Ability - L3–Permutation - Combinations; Probability; Geometry and menstruation; Trigonometry; Logarithms; Functions; Quadratic Equations; Set Theory** | **14 hours** |

Counting, Grouping, Linear Arrangement, Circular Arrangements, Conditional Probability, Independent and Dependent Events, Properties of Polygon, 2D & 3D Figures, Area & Volumes, Heights and distances, Simple trigonometric functions, Introduction to logarithms, Basic rules of logarithms, Introduction to functions, Basic rules of functions, Understanding Quadratic Equations, Rules & probabilities of Quadratic Equations, Basic concepts of Venn Diagram.

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| **Module:5** | **Reasoning ability - L3 – Logical reasoning; Data Analysis and Interpretation** | **7 hours** |

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| Syllogisms, Binary logic, Sequential output tracing, Crypto arithmetic, Data Sufficiency, Data Interpretation-Advanced, Interpretation tables, pie charts & bar chats. | | |
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| **Module:6** | **Verbal Ability - L3 – Comprehension and Critical reasoning** | **7 hours** |
| Reading comprehension, Para Jumbles, Critical Reasoning (a) Premise and Conclusion, (b) Assumption & Inference, (c) Strengthening & Weakening an Argument. | | |
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| | **Total Lecture hours:** | **45 hours** |

**Reference Books**


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| 1. | Michael Farra and JIST Editors,(2011).Quick Resume & Cover Letter Book: Write and Use an Effective Resume in Just One Day. Jist Works, Saint Paul, Minnesota. |
| 2. | Flage Daniel E, (2003).The Art of Questioning: An Introduction to Critical Thinking. Pearson, London. |
| 3. | David Allen, (2015).Getting Things done: The Art of Stress-Free productivity. Penguin Books, New York City. |
| 4. | SMART, (2018). Place Mentor 1st edition. Oxford University Press, Chennai. |
| 5. | FACE, (2016).Aptipedia Aptitude Encyclopedia. Wileypublications, Delhi. |
| 6. | ETHNUS, (2013).Aptimithra. McGraw-Hill Education Pvt Ltd, Bangalore. |


**Websites:**

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| Mode of Evaluation: Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test | | | |
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