Scheme
of
Master of Technology
in
Electrical Engineering
(Instrumentation & Control)
(Effective from 2018-19)
### M.Tech. in Electrical Engg. (Instrumentation & Control), Semester-I
Choice Based Credit System (effective from Session 2018-19)

#### SEMESTER – I

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Teaching Schedule</th>
<th>Marks</th>
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<th>Total Credits</th>
<th>Duration of Exam (Hours)</th>
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<tr>
<td></td>
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$L=$ Lecture, $T=$ Tutorials, $P=$ Practicals & $C=$ Credits

### List of Programme Electives:

<table>
<thead>
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<th>PE1 S. No.</th>
<th>Course Code</th>
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<tbody>
<tr>
<td>1.</td>
<td>MIC521C</td>
<td>Robotics and Automation</td>
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<td>3.</td>
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### List of AUDIT-I:

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Approved in the 13th meeting of Academic Council held on 18/06/2018.
M.Tech. in Electrical Engg. (Instrumentation & Control)
Choice Based Credit System (effective from Session 2018-19)

SEMESTER – II

<table>
<thead>
<tr>
<th>S. No</th>
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<th>Course Title</th>
<th>Teaching Schedule</th>
<th>Marks</th>
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<th>Duration of Exam (Hrs.)</th>
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L= Lecture, T = Tutorials, P = Practicals & C = Credits

List of Programme Electives:

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<th>Course Code</th>
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<td>MIC526C</td>
<td>Adaptive Learning &amp; Control</td>
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List of AUDIT-II:

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<td>AUD543C</td>
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<td>AUD545C</td>
<td>Personality Development Through Life Enlightenment Skills</td>
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M.Tech. in Electrical Engg. (Instrumentation & Control)
Choice Based Credit System (effective from Session 2018-19)

SEMESTER – III

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<th>Course Title</th>
<th>Teaching Schedule</th>
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<th>Credits</th>
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L= Lecture, T = Tutorials, P = Practicals & C = Credits

List of Programme Electives:

**PE5**

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<td>MIC623C</td>
<td>Stochastic Control</td>
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List of open Electives:

**OE**

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<td>MTOE651C</td>
<td>Business Analytics</td>
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<td>3</td>
<td>MTOE653C</td>
<td>Industrial Safety</td>
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<td>MTOE655C</td>
<td>Operations Research</td>
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<td>5</td>
<td>MTOE657C</td>
<td>Cost Management of Engineering Projects</td>
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<td>6</td>
<td>MTOE659C</td>
<td>Composite Materials</td>
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<td>MTOE661C</td>
<td>Waste to Energy</td>
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Dissertation (Phase-II) being an extension of Dissertation (Phase-I), for progression to Dissertation (Phase-II), it is necessary that the candidate must have passed Dissertation (Phase-I).
M.Tech. in Electrical Engg. (Instrumentation & Control)
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SEMESTER – IV

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*The dissertation shall be the extension of dissertation (Phase-I) carried out in the 3rd semester. Every student will be required to present three seminar talks & the committee constituted by the Chairman of the Department will screen all the presentations so as to award the sessional marks.

EXTERNAL ASSESSMENT:
The Dissertation will be evaluated by the committee consisting of following three persons:

1. **Chairperson of the Department**: Chairperson
2. **Respective Dissertation Supervisor(s)**: Member(s)
3. **External Expert**: To be appointed by the University

**NOTE:** The external expert must be from the respective area of the specialization. The chairperson and M.Tech. (I&C) coordinator with mutual consultation will divide the submitted dissertation into groups depending upon area of specialization and recommend the list of experts for each group separately to the Vice-Chancellor for selecting the examiners with the note that an external expert should be assigned a maximum of four dissertations for the evaluation. The students will be required to submit three copies of dissertation report to the M.Tech.(I&C) Coordinator for record and processing.
Programme Outcomes

At the end of M.Tech. (EE(I&C)) Program, students will have

PO1 an ability to apply knowledge of mathematics, allied sciences, and engineering to the problems related to control system & instrumentation.

PO2 an ability to conduct independent research both of an academic and applied nature in the area of applied control theory & instrumentation.

PO3 an ability to use the techniques, skills, and modern control engineering tools necessary for engineering practice.

PO4 an ability to be conversant with practical control & instrumentation system (Design, operation, control, and testing issues).

PO5 an ability to communicate effectively to convey the ideas acquired through research.

PO6 enhanced knowledge and skill set required in the field of control & instrumentation.

PO7 engineering skills for problem solving so as to arrive at appropriate technological solutions.

PO8 an understanding of professional and ethical responsibility

Programme Objectives

1. To provide an advanced knowledge in the field of control & instrumentation through core subjects and flexible program specific electives.

2. To widen the multidisciplinary skills by open electives.

3. To ensure overall personality development through Audit courses.

4. To introduce fundamental concepts and basic tools for mathematical analysis and applications of nonlinear dynamical systems such as robot control.

5. To introduce the concepts, mathematical modelling and design of analog & digital controllers.

6. To introduce the fundamental & computational aspects of optimal, robust and adaptive control.

7. To introduce the fundamental concepts of stochastic filtering, prediction, control & system identification.

8. To inculcate the research aptitude in the students.

9. To understand the working & design aspects of advanced industrial instrumentation & automation systems.

10. To introduce the fundamental concepts and applications of microcontroller based control & instrumentation.

11. To impart the knowledge of soft computing techniques and their use for engineering applications.
M.Tech. in Electrical Engg. (Instrumentation & Control), Semester-I
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MIC501C MODERN CONTROL SYSTEMS

<table>
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<tr>
<th>L</th>
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<tbody>
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Class-work Marks: 25
Exam Marks: 75
Total Marks: 100
Duration of Exam: 3 Hrs.
Credits: 3

COURSE OBJECTIVES:
1. To give students an understanding of foundational concepts of modern control primarily based on State Space concept, rather than on Transfer Function. To impart a review of operations on matrices, followed by defining Fields & Vector Spaces, ‘State’ & related concepts.
2. To derive State Models of different types for a range of systems such as electrical, mechanical, hydraulic, electro-mechanical systems, etc.
3. To get an insight into solutions of state equations for continuous-time & discrete-time systems.
4. To understand controllability & observability concepts & apply tests thereof. To understand Lyapunov’s stability analysis tool for linear dynamical systems.

DETAILED CONTENTS:

UNIT-I
Linear Spaces & Linear Operators: Review of vectors & matrices, Limitations of classical control theory; Axiomatic treatment of Field, Vector, Vector Space; Linear combination, Linear Independence, The notion of bases; Linear function/map/operator & its matrix representation, Scalar product of vectors; Quadratic functions & definite, semi-definite matrices, Gram determinant; vector & matrix norms; Rank & Nullity of a matrix; Eigenvalues, Eigenvectors & Canonical form representation of linear operators; Generalized Eigen vectors.

UNIT-II
State Variable Descriptions: The concept of State: initial state, definition of state, state vector, trajectory, Consistency conditions, State Transition Relation or State Equation; State equations for dynamic discrete-time system; Time invariance; Linearity; State model for linear systems, Non-uniqueness of State model; State diagrams for linear time-invariant continuous-time & discrete-time systems.

Physical System & State Assignment: Linear continuous time models of electrical, mechanical, hydraulic, electromechanical systems (illustrative problems). State variable representation using Phase variables, Observable Phase variable form, Controllable phase variable form, State space representation using Canonical variable or Normal form.

UNIT-III
Solution Of State Equations: Derivation of T.F. from State model; Diagonalization, Determination of diagonalized matrix, J and diagonalizing or Modal matrix, M; State equations for continuous time LTI system, Properties of STM (State Transition System) for LTI system; Computation of STM by...
Infinite series expansion, by Resolvent matrix method (Inverse Laplace Transform), by Similarity or Canonical transformation & by technique based on Cayley-Hamilton Theorem; Solution of state equations for discrete-time systems; Evaluation of STM, φ(k), for Discrete Time System; System Modes. (12 hours)

UNIT-IV

Controllability, Observability & Stability: Concept of controllability, Definition of controllability; General concept of observability, Definition of observability; Kalman tests for controllability & observability for Continuous-time system; Gilberts tests (Physical interpretation of Gilberts Tests) for controllability & observability; Lyapunov’s stability theory for linear dynamical systems. (10 hours)

TEXT BOOK:

REFERENCE BOOKS:

COURSE OUTCOMES:
After going through this course, the student shall be able to:
1. Have an understanding of State & related concepts, & carry out operations on matrices, & appreciate the axioms of Fields & Vector Spaces.
2. Derive State Models of different types of systems such as electrical, mechanical, hydraulic, electro-mechanical systems, etc.
3. Solve state equations for continuous-time & discrete-time systems.
4. Apply controllability & observability tests to different system models & to apply Lyapunov’s stability analysis tool for linear dynamical systems.

NOTES:
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.
M.Tech. in Electrical Engg. (Instrumentation & Control), Semester-I 
Choice Based Credit System (effective from Session 2018-19)

MIC503C MICROCONTROLLER BASED CONTROL & INSTRUMENTATION

L T P Class-work Marks: 25
3 - - Exam Marks: 75
   Total Marks: 100
Duration of Exam: 3 Hrs.
   Credits: 3

COURSE OBJECTIVES:
1. To give students an understanding of architecture of advanced microcontrollers.
2. To understand the applications of these controllers.
3. To get an insight into interfacing aspects of microcontrollers with various devices.
4. To apply microcontrollers in control and instrumentation systems.

DETAILED CONTENTS:

UNIT-I
Microcontrollers (8051) and Arduino: Classification of microcontrollers, Concept of embedded systems, Review of 8051Microcontrollers, Architecture, Pin Diagram, Timers, Addressing Modes & Power management features of 8051 microcontrollers. Serial Port operation & interrupts of 8051 microcontroller, Programming applications based on 8051 microcontrollers. Introduction to Arduino, classification of Arduino. (12 hours)

UNIT-II
Interfacing and Applications of 8051/Arduino: Basic issues of interfacing, Interfacing applications of 8051microcontrollers, interfacing of 8051 with External memory, 8255, keyboards, DACs/ADCs, LCD,LED, control of DC Motors, Stepper motor, servomotor etc., Interfacing of Arduino with keypad, LED, LCD, DC motor etc. (12 hours)

UNIT-III
PIC Microcontrollers: Introduction, different types, Salient features of PIC microcontrollers, PIC microcontroller families, The PIC16F877 MC, Features of the PIC16F877, The PIC16F877 architecture, Program memory, Data memory, Ports, I/O devices, serial I/O and data communication, Clock source options, the timer/counter module, Low power operation and the sleep, instructions, The watchdog timer, special function registers. (12 hours)

UNIT-IV
AVR Microcontrollers: Important features, Pins & Signals, Internal architecture, Watchdog Timer. MCS-96 Microcontrollers: Salient features, architecture, Instruction set & addressing modes. ARM Microcontrollers: ARM core architecture, versions of ARM, Important features, intelligent energy manager. Applications of different Microcontrollers in various controls and instrumentation systems. (10 hours)
TEXT BOOKS:

REFERENCE BOOKS:
2. Myke Predko, “Programming and Customizing the PIC Microcontroller”, TMH.
4. Dhananjay V. Gadre, “Programming and Customizing the AVR Microcontroller”, TMH.
6. Microchip Datasheets for PIC16F877

COURSE OUTCOMES:
After going through this course, the students shall be able to:
1. Learn how to program a processor in assembly language and develop an advanced processor based system.
2. Learn configuring and using different peripherals in digital systems.
3. Compile and debug a program for control systems.
4. Generate an executable file and use it for control applications in instrumentation systems.

NOTES:
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.

Approved in the 13th meeting of Academic Council held on 18/06/2018.
MIC505C RESEARCH METHODOLOGY AND IPR

COURSE OBJECTIVES:
1. To introduce the systematic approach to identify/formulate a good research problem.
2. To introduce various approaches for solving a research problem.
3. Inculcating the skills for good report/technical research paper/project writing.
4. Introduction to Research ethics.
5. Introduction to the process of patenting & new developments in IPR.

DETAILED CONTENTS:

UNIT-I

UNIT-II
Literature Study, Research Ethics & Report Writing: Effective literature studies approaches, Plagiarism, Research ethics, Effective technical writing, how to write a report/ research paper, Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee (12 hours)

UNIT-III

UNIT-IV

TEXT BOOKS:

REFERENCE BOOKS:

COURSE OUTCOMES:
At the end of this course, students will be able to
1. Understand research problem formulation.
2. Analyze research related information.
3. Follow research ethics.
4. Understand that today’s world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
5. Understand the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
6. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

NOTES:
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.
M.Tech. in Electrical Engg. (Instrumentation & Control), Semester-I
Choice Based Credit System (effective from Session 2018-19)

MIC507C MODELLING & SIMULATION LAB

L T P Class-work Marks: 25
- - 4 Exam Marks: 75
                                      Total Marks: 100
                                      Duration of Exam: 3 Hrs.
                                      Credits: 2

LIST OF EXPERIMENTS:
1. To design PI, PD & PID controllers for temperature control of an oven
   /water level control using MATLAB/PSPICE.
2. To implement Fuzzy controller for temperature control of an oven & for
   water level control of a single & two tank coupled systems.
3. To observe the effects of parametric disturbances on the performance of
   PI, PD, PID & Fuzzy controllers.
4. To observe the effects of load disturbances on the performance of PI, PD,
   PID & Fuzzy controllers.
5. To observe the effects of nonlinearities (such as saturation, backlash etc.)
   on performance of PI, PD&PID controllers used for a second order system.
6. Design and simulation of Linearized models using MATLAB/PSPICE.
7. Simulation and analysis of State space models for continuous time and
   discrete time systems using MATLAB/PSPICE
8. Simulation and analysis of Digital Control System using MATLAB/PSPICE.
9. To control speed of dc motor using choppers (MATLAB- Simulink model)
10. Implementation of speed control of a stepper motor.
11. Simulation and Stability analysis of control system with common non-
    linearities using MATLAB/PSPICE
12. Familiarization and use of MATLAB commands associated with Robust
    Control Systems.
13. Familiarization and use of PSIM software.
14. Familiarization and use of LabVIEW.
15. Identification and control of a non-linear plant using artificial neural
    networks.

NOTES:
1. At least 10 experiments are to be performed by students in the
   semester.
2. At least 8 experiments should be performed from the above list; remaining
   two experiments may either be performed from the above
   list or designed and set by the Department as per the scope of the
   syllabus and Infrastructure available in the Institute.
3. However, few experiments may be designed & included in this list
   depending upon the scope of the syllabus and infrastructure available in
   the institute.
MIC509C  CONTROL & INSTRUMENTATION LAB

L  T  P
-  -  4

Class-work Marks: 25
Exam Marks: 75
Total Marks: 100
Duration of Exam: 3 Hrs.
Credits: 2

LIST OF EXPERIMENTS:
1. Designing of Ladder logic for various practical applications.
2. Execution of the Ladders using PLC's.
4. Experiment on Position Control System.
5. Experiment on Velocity Control System.
6. Experiment on Adaptive Control System.
7. To study the position control of DC servomotor with P, PI control actions.
8. Determination of Magnetic Amplifier Characteristics with different possible connections.
9. Characteristics of Synchros: (a) Synchro transmitter characteristics (b) Implementation of error detector using synchro pair.
10. To study the compensation of the second order process by using: (a) Lead Compensator (b) Lag Compensator (c) Lead- Lag Compensator.

NOTES:
1. At least 10 experiments are to be performed by students in the semester.
2. At least 8 experiments should be performed from the above list; remaining two experiments may either be performed from the above list or designed and set by the Department as per the scope of the syllabus and Infrastructure available in the Institute.
**COURSE OBJECTIVES:**
1. To study the various parts of robots and fields of robotics.
2. To study the various kinematics and inverse kinematics of robots.
3. To study the trajectory planning for robot.
4. To study the control of robots for some specific applications.

**DETAILED CONTENTS:**

**UNIT-I**

**Introduction to Automation & Automated Inspection:** Reasons for automation, Automation strategies, automated inspection: Principles & methods, Sensor technologies for automated inspection, Coordinate measuring machine, other contact inspection methods, machine vision, optical inspection methods, non-contact inspection methods. (11 hours)

**UNIT-II**

**Basic Concepts of Robotics & Power Sources:** Definition and origin of robotics, different types of robots, various generations of robots, Asimov’s laws of robotics, Dynamic stabilization of robots. Hydraulic, pneumatic and electric drives, Determination of HP of motor and gearing ratio, variable speed arrangements, path determination. (11 hours)

**UNIT-III**

**Sensors, Manipulators, Actuators & Grippers:** Micro machines in robotics, machine vision, ranging, Laser, acoustic, magnetic, fibre optic and tactile sensors. Construction of manipulators – manipulator dynamics and force control, electronic & pneumatic manipulator control circuits, end effectors, various types of grippers, Design considerations. (12 hours)

**UNIT-IV**

**Kinematics & Path Planning:** Solution of inverse kinematics problem, multiple solution, Jacobian work envelop, hill climbing techniques, robot programming languages, robots in manufacturing & non-manufacturing applications, selection of robot. (12 hours)

**TEXT BOOKS:**

REFERENCE BOOKS:

COURSE OUTCOMES:
Students will be able to
1. Obtain forward, reverse kinematics and dynamics model of the industrial robot arm.
2. Propose and synthesize control law for a given application.
3. Classify robots and decide specifications depending on the applications.

NOTES:
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.
MIC513C  INDUSTRIAL INSTRUMENTATION

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COURSE OBJECTIVES:
1. To give students an understanding of foundational concepts of industrial instrumentation and automation with introduction to smart sensors, Compensation methods, smart sensors and related issues.
2. To introduce Interfacing Instruments & Computers with details of Sensor Networks and Communication.
3. To get an insight into signal conditioning circuits used in industrial instrumentation, measurement and automation.
4. To understand basic structure of programmable logic controllers and introduce programming of PLCs.

DETAILED CONTENTS:

UNIT-I

Transducers: Strain gauge, derivation of gauge factor, Link type load cell, beam type load cell, ring type load cell and their sensitivities, Frequency response of link type load cell, Torque cell and its data transmission (slip ring and radio telemetry).

Specific Transducers: Pressure transducer [Bourdon gauge, diaphragm gauge (metal and semiconductor) etc], all vacuum gauges, photo electric transducer and its application, Liquid in glass thermometer, venturimeter, Orifice meter, pitot tube, Rotameter, Weir, electromagnetic flowmeter, Hot wire anemometer, Variable reluctance displacement sensor, tachogenerator, turbine flowmeter. Measurement of viscosity, conductivity and pH of a liquid. Flapper nozzle system and Control Valves. (11 hours)

UNIT-II

Smart Sensors: Primary sensors; Excitation; Compensation (Nonlinearity: look up table method, polygon interpolation, polynomial interpolation, cubic spline interpolation, Approximation & Regression; Noise & interference; Response time; Drift; Cross-sensitivity); information Coding/processing; Data communication; Standards for smart sensor interface. (11 hours)

UNIT-III

Interfacing Instruments & Computers: Basic issues of interfacing; Address decoding; data transfer control; A/D converter; D/A converter; Sample & hold circuit; other interface considerations.

UNIT-IV

Signal Conditioning: Integrated circuit operational amplifiers, Inverting and non-inverting amplifiers. Amplifiers to perform: logarithms, sum, subtraction, differentiation, integration, voltage level detection, voltage to frequency and frequency to voltage conversion. Schmitt trigger, comparator, oscillators. (11 hours)

TEXT-BOOKS:
3. Electronic Devices and Circuits By David A. Bell, Oxford university Press.
4. Programmable Logic Control, NIIT book published by PHI.

REFERENCE BOOKS:

COURSE OUTCOMES:
After going through this course, the student shall be able to:
1. Have an understanding of smart sensors, compensation and smart sensor interface.
2. Understand the smart sensor networking and communication schemes.
3. Know about details of different signal conditioning circuits.
4. Learn about basics of programmable logic controllers and their programming issues.

NOTES:
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.
M.Tech. in Electrical Engg. (Instrumentation & Control), Semester-I
Choice Based Credit System (effective from Session 2018-19)

MIC515C  SYSTEMS BIOLOGY

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COURSE OBJECTIVES:
1. Introduction to Mathematical Model and Frame Work.
2. Learning of core – Process, Pulses and Oscillations.
3. Introduction to Feed Forward Loops, Fundamental trade offs.

DETAILED CONTENTS:

UNIT-I
Mathematical models and frameworks: Law of mass action, Master Equation, Deterministic vs stochastic, Spatial aspects. Examples of core processes: Gene expression, Protein degradation, Phosphorylation Equilibrium solutions & their Bifurcations Switches & Bistability. (11 hours)

UNIT-II
Pulses and Oscillations, Circadian Rhythms and Clocks Spatial patterns, Morphogenesis and Development. (11 hours)

UNIT-III
Robustness to Perturbations, Integral Feedback Control, Homeostasis and Perfect Adaptation Feed-forward Loops. (12 hours)

UNIT-IV
Fold Change Detection, Fundamental Tradeoffs, Internal Model Principle. (12 hours)

TEXT BOOKS:

COURSE OUTCOMES:
Students will be able to
1. Understand and apply mathematical models to design a particular system.
2. Apply feed-forward loops to design a biological control system.
NOTES:
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.
M.Tech. in Electrical Engg. (Instrumentation & Control), Semester-I
Choice Based Credit System (effective from Session 2018-19)

MIC517C SCADA SYSTEM AND PLC

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Class-work Marks: 25
Exam Marks: 75
Total Marks: 100
Duration of Exam: 3 Hrs.
Credits: 3

COURSE OBJECTIVES:
1. To understand what is meant by SCADA and its functions.
2. To know SCADA communication.
3. To get an insight into its application.
4. To know the basics of PLC and Ladder diagram programming.

DETAILED CONTENTS:

UNIT-I
Basics of SCADA:- Introduction to SCADA, Data acquisition systems, Evolution of SCADA, Communication technologies, Monitoring and supervisory functions, SCADA applications in Utility Automation.

(10 hours)

UNIT-II
Components of SCADA:- Industrial SCADA System Components, Schemes- Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED), Programmable Logic Controller (PLC), Communication Network, SCADA Server, SCADA/HMI Systems.

(11 hours)

UNIT-III
SCADA Architecture and Communication Technology:- SCADA Architecture, Various SCADA architectures, advantages and disadvantages of each System single unified standard architecture -IEC 61 50. SCADA Communication, various industrial communication technologies, wired and wireless methods and fiber optics, Open standard communication protocols.

(12 hours)

UNIT-IV
SCADA Applications and PLC:- Utility applications, Transmission and Distribution sector operations, monitoring, analysis and improvement, Introduction of PLC, Architecture, discrete I/O Systems, Analog I/O systems, definition of discrete state process control, discrete state variables, event sequence description, Ladder diagram: Background, ladder diagram elements, ladder diagram symbols, development of ladder diagrams, Programming, Advanced features and study of at least one industrial PLC.

(12 hours)
TEXT BOOKS:

REFERENCE BOOKS:

COURSE OUTCOMES:
After going through this course, the student shall be able to:
1. Describe the basic tasks of Supervisory Control Systems (SCADA) as well as their typical applications.
2. Acquire knowledge about SCADA architecture, various advantages and disadvantages of each system.
4. To learn about SCADA system components: remote terminal units, PLCs, intelligent electronic devices, HMI systems, SCADA server.
5. Learn and understand about SCADA applications in transmission and distribution sector, industries etc.

NOTES:
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.
**M.Tech. in Electrical Engg. (Instrumentation & Control), Semester-I**
**Choice Based Credit System (effective from Session 2018-19)**

**MIC519C  DESIGN ASPECTS IN CONTROL**

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**COURSE OBJECTIVES:**
1. The student is introduced to the tools and techniques of control system design.
2. Introduction to various aspects of controller design philosophy.
3. Learning PID Controller.

**DETAILED CONTENTS:**

**UNIT-I**

**System Modelling:** System Modelling, review of concepts, First – Order – Plus – Dead – Time (FOPDT) and Second – Order – Plus – Dead - Time (SOPDT) systems and identification, Smith Predictor and its variations.

(12 hours)

**UNIT-II**

**Classical Control System Design:** Introduction, Steady state error behaviour, Proportional, Integral, Derivative Controllers and PID Controllers, review PID Tuning – Ziegler Nichols, Cohen-Coon techniques.

(10 hours)

**UNIT-III**

**State Space Design:** State feedback review – pole placement, Eigen structure assignment, Eigen structure – time response relation, Controller gain selection, controller robustness, disturbance rejection.

(12 hours)

**UNIT-IV**

**Frequency Domain Design:** Frequency Domain Loop Shaping, Lag, Lead and Lag-lead compensators, Zero dynamics in servo control, Unstable zero dynamics – control design, Observer – concept and design, Case studies – Applications.

(12 hours)

**TEXT BOOKS:**

**REFERENCE BOOK:**

**COURSE OUTCOMES:**
After going through this course, the student shall be able to:
1. Model a control system given its parameters.
2. Decide gains of the controllers like PI,PID in a given control system.
NOTES:
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.
COURSE OBJECTIVES:
1. To give students an understanding of foundational concepts of instrumentation systems used in health care systems.
2. To introduce Biomedical Instruments & Equipments Technology with basic concepts.
3. To get an insight into monitoring systems used in health care industry.
4. To understand basics of Telemetry in Medical Applications and health care systems.

DETAILED CONTENTS:

UNIT-I
Introduction to Biomedical Instrumentation: Overview, role of technology in modern healthcare, role of biomedical engineer, man-instrument system, origin of Biosignals, classification of biomedical instruments, performance parameters of instruments, physiological systems. (10 hours)

UNIT-II
Biomedical Instruments & Equipments Technology: Bio-potential electrodes, amplifiers and measurements Systems, Bio-Potential electrodes-Electrode-Electrode interface, Half-cells and their potentials, Silver-Silver chloride electrodes, biomedical Recording electrodes, circuit model of electrode. Bioelectric amplifiers-carrier amplifiers, chopper amplifiers, phase sensitive or lock-in amplifiers, isolation amplifiers, instrumentation amplifiers. (11 hours)

UNIT-III
Monitoring Systems: Sensory and behavioral measurements & patient monitoring systems. audiometer, galvanic skin Response (GSR), biofeedback instrumentation. Computer-assisted patient monitoring system: Bedside monitors, central monitors, measurement of heart rate, measurement of blood pressure, measurement of respiratory rate, impedance pneumography, apnea detectors, Intelligent patient monitoring: Intelligent monitoring system architecture. (12 hours)

UNIT-IV
Telemetry in Medical Applications: Telemedicine & Medical Informatics. Telemedicine and its applications: Teleradiology, telecardiology, telepsychiatry, teledermatology, telesurgery, advantages and disadvantages of telemedicine. Hospital Information systems, Computer Networks in healthcare. (11 hours)
TEXT BOOKS:
1. R.S. Khandpur, “Handbook of Biomedical Instrumentation,” TMH.

REFERENCE BOOKS:

COURSE OUTCOMES:
After going through this course, the student shall be able to:
1. Have an understanding of instrumentation system used in health care industry.
2. Understand the Biomedical Instruments & Equipments Technology details.
3. To understand details of monitoring systems in health care industry.
4. Details of Telemetry in Medical Applications and related issues.

NOTES:
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.
M.Tech. in Electrical Engg. (Instrumentation & Control), Semester-II Choice Based Credit System (effective from Session 2018-19)

MIC502C  OPTIMAL CONTROL THEORY

L  T  P  Class-work Marks: 25
3  -  -  Exam Marks: 75
               Total Marks: 100
               Duration of Exam: 3 Hrs.
               Credits: 3

COURSE OBJECTIVES:
1. To introduce the basic and fundamental concepts of optimal control theory, controller design
2. Introduction to computational aspects of optimal control.
3. To get the students acquainted with the matrix Riccati equation and Pontryagin’s minimum principle.
4. To discuss the Dynamic programming and its applications in solving optimal control problems.
5. To explain the numerical techniques for obtaining the optimal trajectories.

DETAILED CONTENTS:

UNIT-I
Calculus of Variations in Optimal Control:- Review of matrix computations, fundamentals of calculus of variations and optimal control, definition of an optimal control problem, concept of functionals, increment and variations of a functional, performance measures for optimal control problems, selecting a performance measure, maximization/minimization of functionals of a single and several functions using calculus of variations, constrained extremals, Euler-Lagrange Equation. (12 hours)

UNIT-II
Pontryagin’s Minimum Principle:- Necessary conditions for optimal control, Pontryagin’s minimum principle and state inequality constraints, minimum time problems, minimum control effort problems, linear quadratic regulator problems, Riccati Equation, Singular intervals in optimal control problems. (12 hours)

UNIT-III
Dynamic Programming:- The optimal control law, principle of optimality, Application of The principle of optimality to decision making, Dynamic programming applied to routing problems, solving optimal control problems using dynamic programming, a recurrence relation of dynamic programming, Discrete linear regulator problems, Hamilton-Jacobi-Bellman Equation. (12 hours)
UNIT-IV
Determination of Optimal Trajectories:-- Two point boundary value problems, Numerical techniques to determine optimal trajectories, Numerical aspects of optimization, the method of steepest descent for minimization of functionals, variation of extremals, quasi-linearization, gradient projection method. (10 hours)

TEXT BOOKS:

REFERENCE BOOKS:

COURSE OUTCOMES:
After going through this course, the students shall be able to:
1. Combine the mathematical methods used in optimal control to derive the solution to variations of the problems studied in the course.
2. Use the standard algorithms for numerical solution of optimal control problems and use Matlab to solve fairly simple but realistic problems.
3. Integrate the tools learnt during the course and apply them to more complex problems.
4. Apply Dynamic programming and Pontryagin’s Minimum principle to different optimal system models.

NOTES:
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.
M.Tech. in Electrical Engg. (Instrumentation & Control), Semester-II

Choice Based Credit System (effective from Session 2018-19)

MIC504C STOCHASTIC FILTERING AND IDENTIFICATION

L T P Class-work Marks: 25
3 - - Exam Marks: 75
Total Marks: 100
Duration of Exam: 3 Hrs.
Credits: 3

COURSE OBJECTIVES:
1. To introduce fundamental concepts of random variables and their distribution.
2. To give understanding of functions of single and two random variables.
3. To get insight into stochastic filtering and Kalman filtering.
4. To introduce parameter estimation for static and dynamic non-linear systems.

DETAILED CONTENTS:

Unit I


Random Variable: Concept of Random Variable, Distribution function, Properties of Distribution function, Probability density function, Normal Distribution, Exponential distribution, Uniform Distribution, Conditional Distributions, Total Probability and Bayes’ theorem using condition distribution.

Unit II

Function of Random Variable: Random variable, Distribution of Random variable, fundamental theorem for random theorem, mean, variance, Characteristic functions, Moment theorem, Moment generating functions.


Unit III

Filtering: System, Noise filtering, Smoothing, Prediction; Gauss-Markov discrete-time model description, noise description, initial state description, Gaussian and Markov properties of the system state, propagation of means and co-variances, dropping the Gaussian assumption, minimum variance estimate, minimum variance estimator property, unbiased estimates and estimator properties, other estimation criteria, main points of the section.
Kalman Filter: Filtering problem, discrete-time Kalman filtering problem, solution of the Kalman filter problem, first-principles derivation of the Kalman filter equations, obvious properties of the filter, a generalization, main points of the section, Best linear estimator property of Kalman filter. Identification as a Kalman filtering problem, application of Kalman filters, Kalman filter properties, Solution procedure for the Wiener filtering problem, rapprochement with Kalman filtering. (12 hours)

Unit IV


TEXT BOOKS:

REFERENCE BOOKS:

COURSE OUTCOMES:
Students will be able to
1. Develop skills in analyzing and interpreting the concept of random variables and functions of random variables.
3. Formulate and solve problems which involve designing the filtering process and Kalman filters.

NOTES:
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.
MIC580C

MINI PROJECT

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- - 4

Class-work Marks: 25
Exam Marks: 75
Total Marks: 100
Duration of Exam: 3 Hrs.
Credits: 2

The objective of mini project is to develop in students the professional quality of synthesis employing technical knowledge obtained in the field of Engineering & Technology through a project work involving design, analysis augmented with creativity, innovation and ingenuity.

This course is meant to enable the students to take up investigative study in the broad relevant field of engineering, either hardware or software or involving both hardware and software to be assigned by the department on an individual basis, under the guidance of a supervisor from the department. This is expected to provide a good initiation for the student(s) in R&D work.

The activities under mini project may normally include:
1. Literature survey on the assigned topic.
2. Working out a preliminary approach to the problem relating to the assigned topic.
4. Compilation of the project work and presenting it in two seminar talks in a semester, before a committee having M. Tech. coordinator and supervisor(s).
5. Submit a written spiral bound report on the work conducted to the M.Tech. Coordinator.

The internal evaluation of the Mini project will be done at the end of the semester through a seminar by the committee consisting of the following:

1. Chairperson/Head of Department/Nominee: Chairperson
2. M. Tech. Coordinator: Member Secretary
3. Respective Project Supervisor(s): Member(s)

Final exam will be conducted by the internal examiner (M.Tech. Coordinator/faculty nominated by Chairperson) and external examiner to be appointed by the Controller of Examinations from the panel of examiners submitted by the Dept.

M. Tech. coordinator will be assigned a load of 1 hour per week excluding his/her own guiding load & project supervisor(s) (guiding teacher) will be assigned the load of 1 hour per week per student subject to a maximum load of 2 hours.
MIC508C    ADVANCED CONTROL & INSTRUMENTATION LAB

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Class-work Marks: 25
Exam Marks: 75
Total Marks: 100
Duration of Exam: 3 Hrs.
Credits: 2

LIST OF EXPERIMENTS:

1. Determine State Space Model of a given transfer function and determine its controllability and observability in MATLAB.
2. Software programming for determination of STM.
3. Verify State feedback control using pole placement.
4. Design State observer and validate it by software.
5. To analyse design of digital Kalman filter and discrete systems.
6. Convert a continuous time system into digital control system and check response using MATLAB.
7. Study of saturation and dead zone non-linearity using describing function technique of a relay control system.
8. To draw phase trajectory of a given non-linear system.
9. To determine AC servomotor Characteristics.
10. To design controller using root locus in MATLAB.

NOTES:
1. At least 10 experiments are to be performed by students in the semester.
2. At least 8 experiments should be performed from the above list; remaining two experiments may either be performed from the above list or designed and set by the Department as per the scope of the syllabus and Infrastructure available in the Institute.
LIST OF EXPERIMENTS:

1. Write an assembly language program in 8051 for generating a triangular waveform.
2. Write a program in 8051 to find the largest from a set of ten numbers and display it using LEDs.
3. Write a program in 8051 for displaying the decimal numbers in 7 Segment display.
4. Write a program in 8051 to read the DIP switches for displaying the reading using 7-Segment display.
5. Write a program in 8051 to rotate the given motor in clockwise and anticlockwise direction.
6. Write a program in 8051 to display a message in LCD display.
7. To interface PIC microcontroller with servomotor.
8. To interface PIC microcontroller with DC motor.
9. Write an ALP to control mouse using 68HC11.
10. Write an ALP to generate PWM using 8096 microcontroller.
11. Minor project on Microcontroller based interfacing of stepper motor.
12. Minor project on Microcontroller based temperature controller.
13. Write an ALP to switch ON alarm when MC receives interrupt.
14. Write an ALP to interface one MC with another using serial/parallel communication.
15. Write an ALP using 8051 & interface traffic light.
16. Write an ALP using 8051 & interface LED display.
17. Write a program to interface 7 segments Display/Keypad Interface using Arduino.
18. Write a program using Arduino to generate square wave of different frequency with different duty cycles.
19. Write a program to control the speed of DC motor using Arduino.
20. Write a program to interface 8x8 LED matrix using Arduino.
21. Interfacing of Arduino with MATLAB.

NOTE:

1. At least 10 experiments are to be performed by students in the semester.
2. At least 8 experiments should be performed from the above list; remaining two experiments may either be performed from the above list or designed and set by the Department as per the scope of the syllabus and Infrastructure available in the Institute.
COURSE OBJECTIVES:
1. To introduce the concept of model reduction of large scale dynamics models from various engineering disciplines.
2. Introduction to model reduction in control.

DETAILED CONTENTS:

UNIT-I
Introduction to Model Reduction: Model reduction problem, Importance of model order reduction, Sources of Large Models: Circuits, Electromagnetic Systems, Mechanical Systems, Modal analysis approach for modal order reduction & Control of large scale systems. (11 hours)

UNIT-II
Frequency Domain Methods For Model Order Reduction: Moment matching, Padé approximation methods; Padé approximation for SISO systems & multivariable systems in frequency domain, Time domain Modal-Pade method, Routh Approximation techniques; Routh approximation using $\alpha - \beta$ and $\gamma - \delta$ parameters respectively, Continued fraction method. (11 hours)

UNIT-III
Modern Methods For Model Reduction: SVD based methods; Singular Value Decomposition, Empirical (Grammian), Balanced truncation, Hankel approximation, Proper Orthogonal Decomposition (POD) Methods, Krylov based methods; Realization, Interpolation, Lanczos&Arnoldi processes, SVD-Krylov based methods. (12 hours)

UNIT-IV
Model Reduction in Control: Control Design on Reduced Models – Sub- optimal control; Review of continuous time & discrete sliding mode control (SMC), Design aspects of sliding mode control, Sliding Mode Control as model reducing control - First Order SM, Higher Order Sliding Mode. (12 hours)

TEXT BOOKS:

**REFERENCE BOOKS:**

**COURSE OUTCOMES:**
After going through this course, the students shall be able to:
1. Apply model reduction techniques for a given control design problem.
2. Design control loops for all techniques.
3. Know modern methods of control.

**NOTES:**
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.
MIC514C DIGITAL CONTROL SYSTEMS

L T P Class-work Marks: 25
3 - - Exam Marks: 75
   Total Marks: 100
   Duration of Exam: 3 Hrs.
   Credits: 3

COURSE OBJECTIVES:
1. To familiarize the student with the concept of discretization.
2. Introduction to discrete-time system representations and digital control.
3. Learn to design controller for digital systems.

DETAILED CONTENTS:

UNIT-I
Introduction: Block diagram of a digital control system, importance of Sampling in control systems. Mathematical analysis of the sampling process, ideal sampler, evaluation of starred transform function and their properties, Shannon's sampling theorem. (12 hours)

UNIT-II
Reconstruction of Sampled Signals & Z-Transform: Data reconstruction by polynomial extrapolation, zero order hold, first order hold, fractional order hold, definition & evaluation of the z-transform, mapping of the s-plane into the z-plane, inverse z-transform, theorems of the z transform, Pulse transfer function, limitations of the z-transform method, response of open loop sampled data systems between sampling instants, theorems of the modified z-transforms. (11 hours)

UNIT-III
Block Diagram, Signal Flow Graph and Matrix Representation of Sampled Data systems: Block diagram analysis and transfer functions of closed loop sampled data systems, signal flow graphs of sampled data systems, transmission matrix of sampled data systems, the state variable approach, system characteristic equation, time response, steady state accuracy, stability techniques, Bi-linear transformation, Routh-Hurwitz criterion, Jury stability test & Root locus. (11 hours)

UNIT-IV
Frequency Response & Digital Controller Design: Nyquist criterion, Bode diagram, interpretation of frequency response, closed loop frequency response. Introduction to controller design, need for compensation, phase lag compensator, phase lead compensator, phase lead design procedure, lag lead compensator, PID controllers, analysis and design of digital control systems using root locus and transform techniques. (11 hours)
TEXT BOOKS:

REFERENCE BOOKS:
1. K. Ogata, “Discrete Time Control System,” PHI.

COURSE OUTCOMES:
At the end of this course, students will be able to
1. Model digital filters and systems.
2. Analyse digital systems in time domain and frequency domain.
4. Design controllers for digital systems in state space representation.

NOTES:
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.
MIC516C  ROBUST CONTROL
L  T  P  Class-work Marks: 25
3 - -  Exam Marks: 75
3  -  -  Total Marks: 100
Duration of Exam: 3 Hrs.
Credits: 3

COURSE OBJECTIVES:
1. To appreciate the role of robustness in control system design.
2. Be familiar with uncertainty models including additive, multiplicative & parameter uncertainty. Introduction to parameter variations, presence of disturbances & noise.
3. To get an insight into different norms & their interpretations.
4. To understand design issues of robust control systems.
5. To attempt $H_2$ and $H_\infty$ optimization with LQG methodology & Ricatti equation, etc.

DETAILED CONTENTS:

UNIT-I
Introduction: Definition & rationale of robust control; Elements of robust control theory; Inaccuracies & uncertainties in models of physical systems; Modelling of uncertain systems; Adaptive & Multiplicative perturbations; Plant-Controller configuration; Sensitivity function; Analysis of robustness, systems with uncertain parameters, Design objectives (stability, performance, robustness); Translating design objectives into mathematical relationships: Tracking error, Disturbance rejection, Insensitivity to noise, Model uncertainty (low frequency), model uncertainty (high frequency); Shaping the loop gain.  (12 hours)

UNIT-II
Signals, Systems, Norms: Signals and their norms; Physical interpretation/significance of Norms; Signal spaces, Signals in frequency domain; The $L_2$-norm; The $L_\infty$ norm; $H_2$ norm; $H_\infty$ norm; All pass systems.  (10 hours)

UNIT-III
Design of Robust Control Systems: Design objectives; Determining the structure of the controller; Adjusting the parameters of the controller; Robust Stability criterion; Systems with uncertain parameters; Stability of uncertain system; Sensitivity & compensation; Internal model principle; Design of robust PID-controlled systems; Determination of pre-filter; Coprime factorization of controller; Stabilizing controller.  (11 hours)

UNIT-IV
$H_2$ and $H_\infty$ Optimization: Linear Quadratic Regulator (LQR); Linear Quadratic Gaussian (LQG) problems; Ricatti equations; Ricatti equation solution; H-infinity control;
Linear matrix inequalities for robust control; Pseudo-quantitative feedback system. (12 hours)

**TEXT BOOKS:**

**REFERENCE BOOKS:**
1. L. Fortuna, M. Frasca (Eds.), “Optimal and Robust Control”, CRC Press.

**COURSE OUTCOMES:**
Upon going through this course, the students will be able to:
1. Have an understanding of robustness in control system design.
2. Deal with uncertainty models, parameter variations, presence of disturbances and noise.
3. Appreciate different norms.
4. Understand design issues of robust control systems.
5. Carry out $H_2$ and $H_{\infty}$ optimization.

**NOTES:**
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.
M.Tech. in Electrical Engg. (Instrumentation & Control), Semester-II
Choice Based Credit System (effective from Session 2018-19)

MIC518C ADAPTIVE LEARNING AND CONTROL

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Class-work Marks: 25
Exam Marks: 75
Total Marks: 100
Duration of Exam: 3 Hrs.
Credits: 3

COURSE OBJECTIVES:
1. To impart the knowledge of neural network based learning for adaptive control.
2. To understand adaptive control techniques for uncertain dynamical systems.
3. To learn about stability analysis of adaptive controllers.
4. To introduce robustness to disturbances in adaptive controllers.

DETAILED CONTENTS:

UNIT-I

Single Layer Classifiers: Classification model, features & decision regions; discriminant functions; linear machine and minimum distance classification; training and classification using discrete perceptron algorithm, single layer continuous perceptron networks for linearly separable classification, multicategory single layer perceptron networks, linearly inseparable pattern classification.

UNIT-II
Multilayer Perceptron Classifiers: Delta learning rule for multilayer perceptron, generalized delta learning rules; error back-propagation training, learning factors.
Adaptive Control: Introduction, approaches to adaptive control, Direct and Indirect adaptive control schemes, parameter perturbation, Sensitivity method, gain scheduling, Model reference adaptive control (MRAC), Direct MRAC, Indirect MRAC, Self tuning regulators, stochastic control approach.

UNIT-III
Persistence Excitation: Persistence excitation in adaptive systems, properties of persistently exciting functions, Application of persistence excitation to adaptive systems, relation between persistence excitation and uniform asymptotic stability parameter convergence using averaging techniques, applications of parameter convergence to adaptive control.

UNIT-IV

Adaptive Control of Nonlinear Systems: Introduction, linearizing control for nonlinear systems: minimum phase nonlinear systems, model reference control for nonlinear systems; adaptive control of linearizable minimum phase systems.

Robust adaptive Control: Introduction, adaptive observers in the presence of disturbances, adaptive control of a first-order plant in the presence of bounded disturbances, adaptive control of n\textsuperscript{th} order plant, robustness without persistent excitation, robustness with persistent excitation.

TEXT BOOKS:

REFERENCE BOOKS:

COURSE OUTCOMES:
After going through this course, the students shall be able to:
1. Understand detailed knowledge of neural network based learning and the development and properties of various neural networks.
2. Understand knowledge of adaptive control systems and their development and properties.
3. Understand knowledge of methods and tools for stability analysis of adaptive systems.
4. Understand detailed knowledge of robustness in adaptive control.

NOTES:
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.
COURSE OBJECTIVES:

1. To give students an understanding of foundational concepts of fuzzy control primarily based on fuzzy set theory. To know operations on fuzzy sets, fuzzy relations.
2. To understand basic building blocks of Mamdani & Sugeno Fuzzy Logic Controllers (FLCs).
3. To get an insight into Fuzzification, Fuzzy Inferencing, Defuzzification.
4. To understand the nonlinearity of different blocks of FLC.
5. To analyze adaptive issues in FLC & the stability issues of FLCs.

DETAILED CONTENTS:

UNIT-I
Introduction: Fuzzy control from an industrial perspective; Knowledge-Based Controllers (KBCs); Knowledge representation in KBCs; Precision v/s Significance; The all-pervasive uncertainty; Core control algorithms & surrounding heuristic logic;

The Mathematics of Fuzzy Control: Vagueness; Fuzzy logic versus probability theory; Fuzzy set definition. (Function method, List/ Enumeration method); Properties of & operations on fuzzy sets, Shapes of Membership Functions & their Elicitation methods; Fuzzy relations & operations on fuzzy relations; The Extension Principle, Fuzzy propositions; N-valued Logic & Fuzzy logic; Classical inference rules; Classical & Fuzzy implications.

UNIT-II
FKBC Structure & Design Parameters: The architecture of Mamdani Type FKBC; Choice of variables; Content & Derivation of rules; Choice of membership functions; Rationale for Normalization; Choice of scaling factors; Rationale for Denormalization; Choice of fuzzification procedure; Fuzzy or Approximate Reasoning (Inferencing); Composition of crisp relations; Composition of fuzzy relations; The Compositional Rule of Inference, Individual Rule-based Inferencing; Choice of defuzzification procedure; Comparison and evaluation of defuzzification methods.
UNIT-III

**Nonlinear Fuzzy Control:** Linear & nonlinear fuzzy rules & FLCs; The FKBC as a Non-Linear Transfer Element; Mathematical proofs of each element's linearity / non-linearity; Types of FKBC such as Fuzzy PID controller and Fuzzy Controller of PID Type; Takagi-Sugeno-Kang (TSK or TS) FKBC structure, TSK rules; Distinctions between TSK type & Mamdani type FLCs. (11 hours)

UNIT-IV

**Adaptive Fuzzy Control:** Rationale; Extra components & Tunable parameters in adaptive FKBC; Design & Performance Evaluation; The Process Monitor; Performance Measures; Parameter Estimators; The adaptation mechanism: Altering scaling factors, altering fuzzy set definitions, altering rules; Approaches to Design such as membership function tuning using gradient descent, membership function tuning using performance criteria; The self-organizing fuzzy controller, model based controller. (11 hours)

**TEXT BOOK:**

**REFERENCE BOOKS:**
2. Timothy Ross, “Fuzzy Logic with Engineering Applications”, TMH.

**COURSE OUTCOMES:**
After going through this course, the students shall be able to:
1. Understand the nuances of the fuzzy set, distinct from crisp set.
2. Understand the operations on fuzzy sets.
3. Understand the concepts of fuzzy inferencing.
4. Apply the learnt concepts to further decipher the non-linearities in FLCs.
5. Appreciate the advanced concepts such as adaptive FLCs.

**NOTES:**
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.
MIC522C  GENETIC ALGORITHMS & APPLICATIONS

**COURSE OBJECTIVES:**

1. To give students an understanding of foundational concepts of Genetic Algorithms (GAs). To impart a distinction of basic concepts of classical & stochastic optimization.
2. To understand the terminology & elements of Genetic Algorithm (GA).
3. To get an insight into Fundamental Theorem of GAs.
4. To understand applications of GAs.

**DETAILED CONTENTS:**

**UNIT-I**

*Traditional & Modern Optimization:* Review of traditional search & optimization methods: Calculus based, Enumerative search, Random search; Evolution; Early developments in Genetic Algorithms (GAs); Distinction of GAs from Evolution Programs; Definition of GAs; Distinction of GAs from traditional computer programs; Distinction between GAs and traditional optimization / search methods; Uni-modality v/s multimodality; Comparison of GAs terms with those of natural biology. (10 hours)

**UNIT-II**

*Elements of Canonical Gas and Schema Theorem:* Random initialization of population; Selection; Crossover; Mutation; Algorithms for three operators: algorithm for Roulette Wheel selection, Algorithm for single point crossover, Algorithm for mutation; Genesis of GA’s processing power: implicit parallelism; Similarity templates (schemas); Schema order and Defining length; The fundamental theorem of GAs (Schema Theorem): Individual effects of selection, crossover and mutation on schemata and their combined effect; Derivation of schema growth equation, Building blocks hypothesis. (12 hours)

**UNIT-III**

*Operators Variants and Implementation Issues:* Problems / limitations of Roulette wheel selection and ways to overcome limitations: Stochastic universal sampling, Sigma scaling, Boltzmann selection, Rank selection, Steady state selection; Problems with single point crossover: Positional bias, Spurious correlation, End point effects; Two point crossover; Parametrized Uniform crossover; Evolving crossover hotspots; Inversion. (12 hours)
UNIT-IV

Applications of GAs: Evolving computer programs, Evolving Lisp programs, Koza’s algorithm; Data analysis and prediction; Predicting dynamical systems, GAs for predicting chaotic time series; Evolving neural networks; Evolvable aspects of NNs, Evolving weights in a fixed network. PID tuning by GAs. (11 hours)

TEXT BOOKS:

REFERENCE BOOKS:

COURSE OUTCOMES:
After going through this course, the student shall be able to:
1. Have an understanding of evolution & Genetic Algorithms.
3. Develop algorithms for operators of GAs.
4. Dig into implicit parallelism of GAs.
5. Apply GAs to practical problems.

NOTES:
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.
M.Tech. in Electrical Engg. (Instrumentation & Control), Semester-II
Choice Based Credit System (effective from Session 2018-19)

MIC524C ADVANCED VIRTUAL INSTRUMENTATION

L T P Class-work Marks: 25
3 - - Exam Marks: 75
     Total Marks: 100
     Duration of Exam: 3 Hrs.
     Credits: 3

COURSE OBJECTIVES:
1. To give students an understanding of foundational concepts of Basics of LabVIEW and Modular programming.
2. To understand strings and input-output file handling along with instrument control.
3. To get an insight into data acquisition and Cluster of instruments in VI system.
4. To understand Graphical Programming Environment in Virtual Instruments.

DETAILED CONTENTS:

UNIT-I
Introduction to LabVIEW: Software environment, front panel, block diagram, palettes, loops, structures and tunnels, arrays, clusters, plotting data.
Modular Programming: Modular programming in LabVIEW, creating an icon, building a connector pane, displaying sub VIs and express VIs as icons or expandable nodes, creating sub VIs from sections of VIs, opening and editing sub VIs, placing sub VIs on block diagrams, creating stand alone applications. (12 hours)

UNIT-II
Strings and File I/O: Creating string controls and indicators, string functions, editing, formatting & parsing strings, configuring string controls and indicators, basics of file input/output, file I/O VIs.
Instrument Control: GPIB communication, hardware and software architecture and specifications, instrument I/O assistant, VISA, Instrument Drivers, Serial Port communications. (12 hours)

UNIT-III
Data Acquisition: Transducers, signal conditioning, DAQ hardware configuration, DAQ hardware, Analogy I/O, counters, digital I/O, DAQ assistant, selecting & configuring a data acquisition device.

UNIT-IV
Graphical Programming Environment in VI: Concepts of graphical programming - Lab-view software - Concept of VIs and sub VI - Display types - Digital - Analog - Chart - Oscilloscopic types - Loops - Case and sequence structures - Types of data - Arrays - Formulae nodes - Local and global variables - String and file I/O. (12 hours)
TEXT BOOKS:
2. Jovitha Jerome, Virtual Instrumentation using LabVIEW”, PHI.

REFERENCE BOOKS:

COURSE OUTCOMES:
After going through this course, the student shall be able to:
1. Have an understanding of Basics concepts in LabVIEW and programming.
2. Get the knowledge of input-output file handling along with instrument control.
3. Have good insight into data acquisition and Cluster of instruments in VI system.

NOTES:
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.
The objective of this course is to develop in students the capacity for analysis and judgment and the ability to carry out independent investigation in design/development through a dissertation work involving creativity, innovation and ingenuity. The work should start with comprehensive literature search and critical appreciation thereof so as to select research problem and finalize the topic of dissertation.

Each student will carry out an independent dissertation under the supervision of supervisor(s). In no case, more than two supervisors may be associated with one dissertation work. The first supervisor must be from the department and the second supervisor may be from the other department of the university/ outside university/industry depending upon the interdisciplinary nature of the research work, however, consent of the second supervisor with justification thereof needs to be submitted to the dissertation coordinator.

The dissertation (phase-I) involving literature survey and problem formulation along with data collection (if required) which commences in the 3rd semester will be completed as dissertation in 4th semester. Every student will be required to present three seminar talks, first at the beginning of the dissertation (phase-I) to present the scope of the work and to finalize the topic, second in the middle of the semester involving literature survey and fine-tuning of work, and third towards the end of the semester, presenting the progress report containing the partial results if any of the work carried out by him/her in the semester. The student will be required to submit one copy of progress report (spiral bound) to the M.Tech. coordinator for record of department. The internal evaluation of the dissertation (phase-I) will be done by following committee:

1. Chairperson of the Department/Nominee : Chairperson
2. M.Tech. Coordinator/Senior Faculty: Member Secretary
3. Respective Dissertation Supervisor(s): Member(s)

Final exam will be conducted by the internal examiner (M.Tech. Coordinator/ faculty nominated by Chairperson) and the external examiner to be appointed by the controller of examinations from the panel of examiner submitted by the department.

For this course, M. Tech. coordinator will be assigned a load of 1 hour per week excluding his/her own guiding load and dissertation supervisor (guiding teacher) will be assigned a load of 2 hours per week for the first student and additional 1 hour per week (for their own department only) for the subsequent student/students subject to a maximum load of 3 hours. Work load allocated for the joint supervision within the department will be treated as half for each supervisor.
MIC603C MODELING AND CONTROL OF DISTRIBUTED PARAMETER SYSTEMS

L T P  Class-work Marks: 25
3 - -  Exam Marks: 75

Total Marks: 100
Duration of Exam: 3 Hrs.
Credits: 3

COURSE OBJECTIVES:
1. Introduction to modelling, analysis and control of distributed parameter systems.
2. Introduction to finite discretization.

DETAILED CONTENTS:

UNIT-I
Overview & Modelling: Overview: Motivation and examples (wave propagation, fluid flow, network traffic, electromagnetism), Modelling of Distributed Parameter Systems: Parabolic and Hyperbolic Partial Differential Equations (PDEs), Analytic and Numerical Solution of Partial Differential Equations (12 hours)

UNIT-II
Stability & Design of DPS: Lyapunov stability analysis of Distributed Parameter System (DPS), Boundary control and Observer Design of DPS (10 hours)

UNIT-III
Discretization: Finite Difference discretization of Distributed Parameter System, Finite Element discretization of DPS, Boundary Elements discretization of DPS, Reduction of discretized models (12 hours)

UNIT-IV
Applications: Applications: Control of systems with time delays, control of fluid flow, network control. (12 hours)

TEXT BOOKS:

REFERENCE BOOK:

COURSE OUTCOMES:
After going through this course, the student shall be able to:
1. Mathematically model a distributed parameter system.
2. Obtain numerical solutions for distributed parameter system.
3. Reduce the complexity of discretized models.
NOTES:
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.
MIC605C  STOCHASTIC CONTROL

L T P  Class-work Marks: 25
3 - -  Exam Marks: 75

Total Marks: 100
Duration of Exam: 3 Hrs.
Credits: 3

COURSE OBJECTIVES:
1. To understand dynamics of stochastic systems and their control strategies
2. To introduce about different stochastic state models and its calculus.
3. To introduce about linear stochastic control theory, prediction and filtering theory of
   stochastic processes.

DETAILED CONTENTS:

UNIT I
Stochastic Process: Stochastic control theory, concept of stochastic process.
Special stochastic process: Stationary processes, Normal Process, Markov
   Processes, Processes of second order, processes with Independent Increments,
   Wiener process, Singular or Purely Deterministic processes, Covariance Function,
   Spectral Density, Decomposition of Stationary Processes, White noise, Discrete time
   white noise, Continuous time white noise, Analysis of stochastic processes, choice of
   Convergence concept, Properties of mean square convergence, Continuity,
   Differentiability, Integrability.  (10 hours)

UNIT II
Stochastic State Models: Discrete time systems, solution of stochastic difference
   equations, Linear equations, Mean value function, Covariance function, Continuous time
   systems, Stochastic Integrals, Integrals of a deterministic function, Integrals of
   Stochastic Processes, Integration by Parts, comparison with formal Integration, Linear
   stochastic differential equations, Nonlinear stochastic differential equations, Stochastic
   Calculus- Stochastic Differentiation rule, Evaluation of Loss function, Modelling of
   Physical Process by stochastic differential equations, Sampling a stochastic differential
   equations, Application.  (12 hours)

UNIT III
Analysis of Dynamical Systems: Analysis of Dynamical systems whose inputs are
   stochastic processes, Discrete time systems, stationary process, Spectral factorization
   of Discrete time processes, Analysis of continuous time systems whose inputs are
   stochastic processes, Spectral factorization of Continuous time processes.
Parametric Optimization: Introduction, Evaluation of loss function for discrete time
   systems, Notations and Preliminaries, Computational Aspects, Evaluation of loss
   function for Continuous time systems, Reconstruction of State variables for discrete
   time systems, Parametric optimization problem, Reconstruction of State variables for
   continuous time systems.  (11 hours)
UNIT IV


Linear Stochastic Control Theory: Formulation, Preliminaries, A static Optimization problem, complete state Information, Incomplete state information, Mean value of a quadratic form of Normal Stochastic Variables, Complete state information, A functional equation, Solution of the Bellman equation, incomplete state information, Continuous time problems, properties of the closed loop system. (12 hours)

TEXT BOOKS:

REFERENCE BOOKS:

COURSE OUTCOMES:
Students will be able to
1. Design stochastic models for a given system.
2. Understand different stochastic processes and stochastic calculus.
3. Apply control techniques to stochastic processes.
4. Understand about prediction and filtering process in stochastic systems.

NOTES:
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.
MIC607C NONLINEAR SYSTEMS & CONTROL

L T P  Class-work Marks: 25
3  -  -  Exam Marks: 75

Exam Marks: 75
Total Marks: 100
Duration of Exam: 3 Hrs.
Credits: 3

COURSE OBJECTIVES:
1. To introduce fundamental concepts of nonlinear dynamical systems.
2. Understanding of basic tools for mathematical analysis as well as applications.
3. To get an insight into phase plane analysis and describing function analysis for nonlinear systems.
4. To understand controllability & observability concepts & apply tests thereof. To understand Lyapunov’s stability analysis tool for nonlinear systems.

DETAILED CONTENTS:

UNIT-I

UNIT-II
Describing Function: Definition of describing function, derivation of describing function, Describing function method and applications to various nonlinear components such as backlash, relay with dead-zone and hysteresis, saturation with dead-zone, combined coulomb with viscous friction, square nonlinearity, cubic nonlinearity, etc., stability analysis of nonlinear systems using describing function analysis, Circle criterion. (12 hours)

UNIT-III

UNIT-IV
Non-Linear Systems Analysis: Lie algebra, Basic results on Lie algebra, Concepts of Controllability and Observability of nonlinear systems, Analysis of nonlinear systems based on controllability and observability, Various techniques to test the controllability and observability of nonlinear systems, phenomena of Bifurcations, Chaos, and Synchronization in nonlinear systems. (10 hours)
TEXT BOOKS:

REFERENCE BOOKS:

COURSE OUTCOMES:
After going through this course, the students shall be able to:
1. Explore tools for stability analysis and response evaluation of control problems with significant nonlinearities.
2. Identify the design problems and distinguish between the controls strategies.
3. Correlate between design parameters and the system performance.
4. Apply controllability & observability tests to different system models & to apply Lyapunov’s stability analysis tool for nonlinear systems.

NOTES:
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.
MTOE609C INDUSTRIAL INTERNET OF THINGS

L T P
3 - - Class-work Marks: 25

COURSE OBJECTIVES:
1. To introduce the Internet of things (IoT) and its vision.
2. To introduce the IoT market perspective.
3. Introduction to Data and Knowledge Management and use of Devices in IoT Technology.
4. To introduce the real World IoT Design Constraints, Industrial Automation and Commercial Building Automation in IoT.

DETAILED CONTENTS:

UNIT-I

UNIT-II
M2M to IoT- A Basic Perspective: Introduction, M2M Value Chains, IoT Value Chains, An emerging industrial structure for IoT, The international driven global value chain and global information monopolies, M2M to IoT-An Architectural Overview: Building architecture, Main design, principles and needed capabilities, An IoT architecture outline, standards considerations. (10 hours)

UNIT-III

UNIT-IV
TEXT BOOKS:

REFERENCE BOOKS:

COURSE OUTCOMES:
After learning the course, the student will:
1. Get the vision of IoT from a global context.
2. Learn about the applications & market perspective of IoT.
3. Know about the use of Devices, Gateways and Data Management in IoT.
4. Be able to build state of the art architecture in IoT.
5. Learn about Application of IoT in Industrial and Commercial Building Automation and Real World Design Constraints.

NOTES:
1. The paper setter will set two questions (with/without parts) from each unit, and a ninth compulsory question comprising of 6 to 10 sub-parts (short questions) covering the entire syllabus. The examinee will attempt five questions in all, along with the compulsory question (with all its sub-parts); selecting one question from each unit. All questions carry equal marks.
2. The use of electronic devices such as programmable calculators, phones, etc. & sharing of any materials during the examination are not allowed.
The dissertation (phase-II) shall be the extension of dissertation (phase-I) carried out in the 3rd semester. Every student will be required to present three seminar talks, first at the beginning of the dissertation to present the progress made during the winter break, second in the middle of the semester involving partial results obtained and comparative analysis and third towards the end of the semester, presenting the dissertation report of the work carried out by him/her. The students will be required to submit two copies of dissertation report to M.Tech. Coordinator for record and processing. The committee constituted by the Chairperson of the department will screen all the presentations so as to award the sessional marks.

INTERNAL ASSESSMENT:
The internal assessment (Class-work evaluation) will be effected through presentation and discussion thereon by the following committee:

1. **Chairperson/Head of the Department:** Chairperson
2. **M.Tech. Coordinator/Senior Faculty:** Member Secretary
3. **Respective Dissertation Supervisor(s):** Member(s)

EXTERNAL ASSESSMENT:
Dissertation will be evaluated by the following committee:

1. **Chairperson/Head of the Department:** Chairperson
2. **Respective Dissertation Supervisor(s):** Member(s)
3. **External Expert:** To be appointed by the University

For this course, supervisor(s) will be assigned a load of 3 hours per week for the first student and additional 1 hour per week for the subsequent student(s) subject to a maximum load of 4 hours. Work load allocated for the joint supervision within the department will be treated as half for each supervisor.

**NOTE:** There is a mandatory requirement of one publication in a UGC listed journals/unpaid journals. The external expert must be from the respective area of the specialization. The chairperson and M.Tech. Coordinator with mutual consultation will divide the submitted dissertation into groups depending upon area of specialization and recommend the list of experts for each group separately to the Vice-Chancellor for selecting the examiners (*one examiner for not more than four students*)

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Approved in the 13th meeting of Academic Council held on 18/06/2018.