ELECTRICAL ENGINEERING DEPARTMENT

Structure and syllabus

Of

M. Tech. (Control Systems)

With effect from July 2017

Program Educational Objectives:

1. To prepare graduates meet the challenges of modern society through viable engineering solutions.
2. To prepare graduates to develop economically viable cutting edge technology for local industry. Need.
3. To prepare graduates to inspire next generation graduates as successful engineer/ entrepreneur, scientist and researcher.

Program Outcomes:

1. Ability to apply knowledge of science, mathematics, and engineering principles for solving problems.
2. Ability to identify, formulate and solve electrical power system problems
3. Ability to understand and use different software tools in the domain of Power electronics, power system and control system simulations.
4. Ability to design and conduct experiments and analyze and interpret data.
5. Ability to coherently work in a multidisciplinary team.
6. Demonstrate sensitivity towards professional and ethical responsibility.
7. Ability to communicate effectively in writing as well as through public speaking.
8. Demonstrate ability to appreciate and engage in lifelong learning.
9. Demonstrated knowledge of contemporary issues.
10. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
11. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.

DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY LONERE

ELECTRICAL ENGINEERING DEPARTMENT

Proposed Teaching and Examination Scheme for
M. Tech. (CONTROL SYSTEMS) w. e. f. July 2017

SEMESTER I

Subject Code	Name of the Subject	Teaching Scheme (Hours/Week)			Credit	Examination Scheme				
						Theory		CA	PR/OR	Total
		L	T	P		TH	Tests			
MTCSC101	Modelling and Dynamic System	03	01	--	04	60	20	20	--	100
MTCS102	System Identification	03	01	--	04	60	20	20	--	100
MTCS103	Modern Control System	03	01	--	04	60	20	20	--	100
MTCS104	Elective-I	03	-	--	03	60	20	20	--	100
MTCS105	Elective-II	03	-	--	03	60	20	20	-	100
MBS106	Communication Skills	02	-	--	02	-	-	25	25	50
MTCS107	PG Lab-I	--	-	03	02			25	25	50
	Total	17	03	03	22	300	100	150	50	600

Elective-I MTCS104

1) Modell Predictive control
2) Optimal Control
3) Robust Control

Elective-II MTCS105

1) Power Electronics and Control
2) Advanced Drives and Control
3) Industrial Automation and Control

SEMESTER II

Subject Code	Name of the Subject	Teaching Scheme (Hours/Week)			Credit	Examination Scheme				
						Theory		CA	PR/OR	Total
		L	T	P		TH	Tests			
MTCS201	Sliding mode Control	03	01	--	04	60	20	20	--	100
MTCS202	Multivariable Control	03	01	--	04	60	20	20	--	100
MTCS203	Elective-III	03	-	--	03	60	20	20	--	100
MTCS204	Elective-IV	03	-	--	03	60	20	20	--	100
MTCS205	Elective-V (Open)	03	-	--	03	60	20	20	-	100
MTCS206	Seminar-I	--	-	04	02	-	-	50	50	50
MTCS107	PG Lab-II or Mini Project	--	-	04	02	-	-	50	50	50
	Total	15	02	08	21	300	100	200	100	700

Elective-III MTCS203

1) Digital Control Systems
2) Fractional Order Modeling and Control
3) Embedded control

Elective-IV MTCS204

1) Nonlinear Dynamic Systems
2) Linear System Theory
3) Control System design and estimation

Elective-V MTCS205

1) Modern Optimization Techniques.
2) Sustainable energy system
3) Energy Management and Auditing.
4) Energy storage system.
5) Research Methodology
6) Finance management
7) Intelligent systems

M. Tech. (CONTROL SYSTEMS)

SEMESTER–III

Subject Code	Name of the Subject	Teaching Scheme (Hours/Week)			Credit	Examination Scheme				
						Theory		CA	PR/OR	Total
		L	T	P		TH	Tests			
MTME301	**Project Management and Intellectual Property Rights** (Self Study)*	--	--	--	02	--	--	50	50	100
MTCS302	**Project work Phase-I**	--	--	--	14	--	--	50	50	100
	Total	**--**	**--**	**--**	**16**	**--**	**--**	**100**	**100**	**200**

SEMESTER–IV

Subject Code	Name of the Subject	Teaching Scheme (Hours/Week)			Credit	Examination Scheme				
						Theory		CA	PR/OR	Total
		L	T	P		TH	Tests			
MTCS401	**Project work Phase-II**	--	--	--	28	--	--	100	100	200
	Total	**--**	**--**	**--**	**28**	**--**	**--**	**100**	**100**	**200**

SEMESTER I

MTCS101: MODELLING AND DYNAMIC SYSTEM

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTCS101	MODELLING AND DYNAMIC SYSTEM	core	3-0-1	42

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

Course Outcomes:

CO1	To Develop mathematical models of various engineering and physical systems using classical and energy approach.
CO2	To Demonstrate linearization techniques
CO3	To Analyze the model from control perspective

Course Content

Unit-1. Modeling by first principle approach of simple mechanical, electrical, thermal, chemical systems.

Unit-2. Modeling by energy approach using Lagrangian and Hamiltonian

Unit-3. Linearization of nonlinear models,

Unit-4. State space approach for analyzing the dynamic models.

Unit-5 Modeling and analysis of some typical systems such medical disease and treatment, rocket launcher, resource management etc.,

Unit-6 .Numerical models using impulse response, step response

References:

1. K. Ogata, ”System Dynamics”, Pearson Prentice-Hall, 4th Edition, 2004.

2. M. Gopal, ”Modern Control Systems Theory”, 2nd Edition, John Wiley, 1993

3. E.O. Doeblin, ”System Modeling and Response”, John Wiley and Sons, 1980.

4. Desai and Lalwani, ”Identification Techniques”, Tata McGraw Hill, 1977.

5. Goldstain ,”Classical Mechanics**”.**

MTCS102: SYSTEM IDENTIFICATION

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS102	**SYSTEM IDENTIFICATION**	**core**	**3-0-1**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

Course Outcomes:

CO1	Understand correlation analysis
CO2	Identify linear nonparametric models.
CO3	Identify parametric models.

Course Content

Unit-1.Review of probability theory and random variables. Transformation (function) of random variables, conditional expectation

Unit-2. Development of first principle models and liberalization. State estimation for linear perturbation models (Luenberger observer),

Unit-3. Development of grey box models, discrete time series models: FIR and ARX models

Unit-4 development of ARX models by least square estimation unmeasured disturbance modeling: ARMAX, OE, Box-Jenkins's models,

Unit-5. Parameter estimation using prediction error method and instrumental variable method, maximum likelihood estimation

Unit-6, distribution of bias and variance errors, input signals, recursive approaches to identification, controller design.

References:

1. Papoulis, "Probability, Random Variables and stochastic processes", 2nd Ed., McGraw Hill, 1983.

2. George E.P.Box, Gwilym M.Jenkin,George C. Reinsel, "Time series analysis,forcasting and Control".

3. L. Ljung, "System Identification Theory for the user", Prentice-Hall, 1999.

4. Rik Pintelon, John Schouleens, "System Identification", IEEE Press.

5. Young, Peter, "Recursive Estimation and Time Series Analysis", Springer Verlag Berlin, 1984.

6. Soderstrom and Stoica, "System Identification", Prentice Hall, 1989.

SEMESTER I

MTCS103-1: MODERN CONTROL SYSTEM

COURSE OUTCOMES:

1) Analyze dynamics of a linear system by State Space Representation.
2) Determine the stability of a linear system using pole-placement technique.
3) Design state observers.
4) Analyze basics of Non-linear control system.
5) Determine the stability of Non-linear systems.
6) Formulate and solve deterministic optimal control problems in terms of performance indices.
7) Realize the structure of a discrete time system and model its action mathematically.

COURSE CONTENTS:

UNIT I: STATE SPACE ANALYSIS (09 Hours)

The Concept of State and State Models, State Diagram, State Space and State Trajectory, State Space Representation using Phase Variable and Canonical Variables, Solution of State Equation, State Transition Matrix and its Properties, Eigen Values, Eigen Vectors, Model Matrix, Diagolization, Generalized Eigen vectors, Computation of State Transition Matrix using Laplace Transformation, Power Series Method, Cayley-Hamilton Method, Similarity Transformation Method. Controllability and Observability Tests: Kalman's test, Gilbert's Test, Controllability and Observability Canonical Forms.

UNIT II: POLE PLACEMENT TECHNIQUES (07 Hours)

Controller Design by State Feedback, Necessary and Sufficient Condition for Arbitrary Pole Placement-State Regulator Problem and State Regulator Design, Evaluation of State Feedback Gain Matrix K, Selection of Location of Desired Closed Loop Poles, State Observer Design, Full Order/Reduced Order Observer Design, Observer Based State Feedback Control, Separation Principle.

UNIT III: NONLINEAR CONTROL SYSTEM (10Hours)

Introduction, Properties of Nonlinear System, Behavior of Non-Linear System, Classification of Nonlinearities, Common Physical Nonlinearities: Saturation, Friction, Backlash, Dead-Zone, Relay, On-Off Nonlinearity, Nonlinear Spring, Limit cycle, Jump resonance. Phase-Plane Method, Singular points, Stability of Nonlinear System, Construction of Phase Trajectories, Describing Functions Method, Stability Analysis by Describing Function Method. Lyapunov's Stability Analysis, Lyapunov's

Stability Criterion, Direct Method of Lyapunov and the Linear Systems, Method of Construction of Lyapunov Functions for Nonlinear Systems.

UNIT IV: OPTIMAL CONTROL **(08 Hours)**

Introduction to Optimal Control, Parameter Optimization: Servomechanism, Optimal Control Problem: Transfer Function and State Variable Approach, State Regulator Problem, Infinite Time Regulator Problem, Output Regulator and the Tracking Problem, Parameter Optimization: Regulators.

UNIT V: DIGITAL CONTROL SYSTEMS **(08 Hours)**

Introduction to Discrete Time Systems, Necessary for Digital Control System, Spectrum Analysis of Sampling Process, Signal Reconstruction, Difference Equations, Z transforms, and the Inverse Z transform, Pulse Transfer Function, Time Response of Sampled Data Systems, Stability using Jury Criterion, Bilinear Transformation.

REFERENCES:

1) Katsuhiko Ogata, Modern Control Engineering Prentice-Hall of India, New Delhi.
2) I. J. Nagarath and M. Gopal, Control system Engineering, New Age International (P) Ltd.
3) Katsuhiko Ogata, State Space Analysis of Control Systems, Prentice Hall Inc, New Jersey.
4) Benjamin C. Kuo and Farid Golnaraghi, Automatic Control Systems, 8th Edition, John Wiley & Sons.
5) H. Khalil, Nonlinear Control systems, Prentice Hall Inc, New Jersey.
6) Brogan W. L., Modern Control theory, Prentice Hall International, New Jersey.
7) Jean-Jacques E, Slotine, Weiping Li, Applied Nonlinear Control, Prentice Hall Inc., New Jersey.
8) Donald Kirk, Optimal Control Theory, an Introduction, Prentice Hall, Inc, Englewood Cliffs, New Jersey.
9) Brain D., Anderson and J. B. Moore, Optimal Control, Prentice Hall.
10) Andrew P., Sage, Optimum Systems Control, Prentice Hall.
11) M. Gopal , Digital Control & State Variable Methods, TMH.
12) A. Nagoor Kani, Control System, RBA Publications.

MTCS104-1. MODELL PREDICTIVE CONTROL

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours

MTCS104-1	**MODELL PREDICTIVE CONTROL**	**elective**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessmen	Total	Credits
60	20	20	100	4

Course Outcomes:

CO1	**Describe concept of MPC**
CO2	**Design and analyze MPC**

Course Content

Unit-1. Review of single input single output (SISO) control; model based control;

Unit-2. Multivariable control strategies, model forms for model predictive control, model forms for model predictive control;

Unit-3. Predictive control strategy, prediction model, constraint handling prediction equations, unconstrained optimization, and infinite horizon cost incorporating constraints, quadratic programming,

Unit-4. Closed-loop properties of model predictive control, incorporating constraints, quadratic programming, interior point QP algorithms, closed loop properties of model predictive control, coping with uncertainty, MPC with integral action, robustness to constant disturbances, robust constraint satisfaction.

Unit-5. Pre-stabilized predictions, analysis of dynamic matrix control (DMC) and generalized predictive control (GPC) schemes,

Unit-6. Controller tuning and robustness issues; extensions to constrained and multivariable cases.

References:

1. L. Ljung, ”System Identification - Theory for the User”, Prentice Hall, 1987.

2. E. Camacho and C. Bordons, ”Model Predictive Control in the Process Industry”, 1995.

3. Rawlings, J.B. and Mayne, ”Model Predictive Control: Theory and Design”, Nob Hill Publishing, 2009.

4. Maciejowski J.M., ”Predictive control with constraints”, Prentice Hall, 2002.

5. Rossiter, J.A., ”Predictive Control: a practical approach”, CRC Press, 2003

6. Soderstrom and Stoica, ”System Identification”, Prentice Hall, 1989

MTCS104-2 OPTIMAL CONTROL

Teaching Scheme:

Course code	Course name	Course	Teaching	Total teaching

			(L-P-T)	hours
MTCS104-2	OPTIMAL CONTROL	elective	3-0-0	42

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

Course Outcomes:

CO1	Solve problems on Calculus of Variation
CO2	Demonstrate concept of LQR Design and Dynamic programming techniques.
CO3	Demonstrate certain examples in MATLAB

Course Content

Unit-1. Introduction, static and dynamic optimization, parameter optimization,

Unit-2. Calculus of variations: problems of Lagrange, Mayer and Bolza, Euler-Language equation and transversality conditions,

Unit-3. Lagrange multipliers, Pontryagins maximum principle; theory; application to minimum time, energy and control effort problems, and terminal control problem,

Unit-4. Dynamic programming: Bellman's principle of optimality, multistage decision processes, application to optimal control,

Unit-5. Linear regulator problem: matrix Riccati equation and its solution, tracking problem, computational methods in optimal control,

Unit-6 Application of mathematical programming, singular perturbations, practical examples.

References:

1. Enid R. Pinch, "Optimal Control and Calculus of variation", Oxford University Press.

2. D.E.Kirk, "Optimal Control Theory", Prentice-Hall, 1970.

3. A.P.Sage and C.C.White II, "Optimum Systems Control", 2nd Ed., Prentice-Hall, 1977.

4. D.Tabak and B.C.Kuo, "Optimal Control by Mathematical Programming", Prentice Hall, 1971.

5. B.D.O. Anderson and J.B.Moore, "Linear Optimal Control", Prentice-Hall, 1971.

6. F.L. Lewis , V.L. Symmos, "Optimal Control", Second Edition, John Wiley, 1995.

MTCS104-3.ROBUST CONTROL

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTCS104-3	ROBUST CONTROL	elective	3-0-0	42

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

Course Outcomes:

CO1	Solve problems on Calculus of Variation
CO2	Demonstrate concept of LQR Design and Dynamic programming techniques.
CO3	Demonstrate certain examples in MATLAB

Course Content

UNIT I: Review of classical feedback control Review of classical feedback control: The control problem, Transfer functions, Deriving linear models, Frequency response, Feedback control, Closed loop stability, Evaluating closed - loop performance, Controller design, Loop shaping, Shaping closed loop transfer functions. Introduction to Multivariable Control Transfer functions for MIMO systems, Multivariable frequency response analysis, Control of multivariable plants, Introduction to robustness, General control problem formulation.

UNIT II: Elements of Linear System Theory Internal stability of feedback systems, Stabilizing controllers, System norms, Input - Output Controllability, perfect control and plant inversion, Constraints on S and T.

UNIT III: Limitations on Performance in SISO Systems Limitations imposed by RHP - zeros, Limitations imposed by RHP - poles, Performance requirements imposed by disturbances and commands, Limitations imposed by input constraints, Limitations imposed by uncertainty. Limitations on Performance in MIMO Systems Constraints on S and T, Functional Controllability, Limitations imposed by RHP - zeros, Limitations imposed by RHP - poles, Performance requirements imposed by disturbances, Limitations imposed by input constraints, Limitations imposed by uncertainty.

UNIT IV: Uncertainty and Robustness for SISO Systems Introduction to robustness, Representing uncertainty, parametric uncertainty, Representing uncertainty in the frequency

UNIT V: Robust Stability and Performance Analysis General control formulation with uncertainty, Representing uncertainty, Obtaining P, N and M, Definition of robust stability and performance, Robust stability of the MΔ - structure, RS for complex unstructured uncertainty, RS with structured uncertainty: Motivation, The structured singular value and RS, Properties and computation of μ, Robust performance, Application: RP with input uncertainty, μ - synthesis and DK - iteration, Further remarks on μ.

UNIT VI: Control System Design Trade - offs in MIMO feedback design, LQG control, 2 H and H_∞ control, H_∞ loop - shaping design.

References:

1. Sigurd Skogestad and Ian Postlethwaite, Multivariable Feedback Control Analysis and Design - John Wiley & Sons Ltd., 2nd Edition, 2005.

2. D. W. Gu, P. Hr. Petkov and M. M. Konstantinov “Robust Control Design with MATLAB” Spring - Verlag London Ltd., 2005.

3. Kennin Zhou, “Robust and Optimal Control”, Prentice Hall, Engle wood Cliffs, New Jersy.

MTCS105-1. POWER ELECTRONICS AND CONTROL

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTCS105-1	**POWER ELECTRONICS AND CONTROL**	**elective**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

<u>Course Outcomes:</u>

CO1	Analyze and model the behavior of converters.
CO2	. Design and control for the desired performance

Course Content

Unit-1. Analysis of Switched and averaged models;

Unit-2. Analysis of Small/large-signal models;

Unit-3. Analysis of time/frequency models.

Unit-4 Linear control approaches associated with power converters;

Unit-5. Linear control approaches associated with resonant controllers

Unit-6. Nonlinear control methods including feedback linearization, stabilizing, passivity-based, and variable-structure control.

References:

1. Seddik Bacha , Iulian Munteanu , Antoneta Iuliana Bratcu " Power Electronics Converters Modeling & Control " Springer.

2. Keng C. Wu," Switched Mode Power Converters: design and analysis", Elseware academic press

3. K. Kit Sum," Switch Mode Power Conversion: Basic Theory and Design

MTCS105-2 ADVANCED DRIVES AND CONTROL

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours

MTCS105-2	**ADVANCED DRIVES AND CONTROL**	**elective**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

Course Outcomes:

CO1	To develop modelling of AC and DC drives
CO2	To understand and analyze speed control techniques of AC and DC drives

Course Contents:

Unit I: Introduction to motor drives: Classification, comparison of AC and DC drives, Basic elements, torque equations, component of load torque, multi-quadrant operation, equivalent drive parameters, components of power electronic drives, criteria for selection of drive components match between the motor and the load, calculation of time and energy in transient conditions, characteristics of mechanical systems, stability consideration, thermal consideration, thermal model of motor for heating and cooling, match between the motor and power electronics converter, closed loop control of drives. (7Hrs)

Unit II: DC drives System model, motor rating, motor mechanism dynamics, drive transfer function, effect of armature current waveform, torque pulsations, adjustable speed drives, chopper fed and 1 phase converter fed drives, effect of field weakening. (5 Hrs)

Unit III: A.C. Drives Basic Principle of operation of 3 Phase motor, equivalent circuit, MMF space harmonics due to fundamental current, fundamental spatial MMF distributions due to time harmonics simulation, effect of time and space harmonics, speed control by varying stator frequency and voltage, impact of nonsinusoidal excitation on induction motors, variable square wave VSI drives, variable frequency CSI drives, line frequency variable voltage drives. (6 Hrs)

Unit IV: Induction Motor drives: Review of induction motor equivalent circuit, effect of voltage, frequency and stator current on performance of the m/c, effect of harmonics, slip power recovery schemes-static Kramer drive and dynamic d.q. model, small signal model, voltage and current fed scalar control, direct and indirect vector control, sensor less vector control, direct torque and flux control. (6 Hrs)

Unit V: Synchronous motor drives: Review of synchronous motor fundamental, equivalent circuit, dynamic d-q model, synchronous reluctance, sinusoidal and trapezoidal back emf permanent magnet motors, sinusoidal SPM machine drives, trapezoidal SPM machines drives, wound field machine drives, switched reluctance motor drives. (6 Hrs)

Unit VI: Closed loop control technique: Motor transfer function-P, PI and PID controllers, current control-Design procedure, phase locked loop (PLL) control-microcomputer control. Industrial applications and modern trends in drive, effect of RMS voltage variation on drive behavior. (6 Hrs)

Rerferences:

1. B. K. Bose, "Modern Power Electronics and AC drives", Pearson Education, Asia, 2003.
2. M. H. Rashid, "Power Electronics", Third Edition, PHI
3. G. K. Dubey, "Fundamentals of Electrical Drives", Narosa Publishing house.
4. V. Subrahmanyam, "Electric Drives-Concepts and Applications", TMH
5. G. K. Dubey, "Power Semiconductor controlled drives", PH 1989.
6. R. Krishnan, "Electric Motor Drives: Modeling, Analysis and Control", PH, 1998.
7. P. Vas, "Sensor less vector and direct torque control", Oxford Press, 1998.
8. W. Leonard, "Control of Electric Drives", Springer Verlag, 1985.

MTCS105-3. INDUSTRIAL AUTOMATION AND CONTROL

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTCS105-3	**INDUSTRIAL AUTOMATION AND CONTROL**	**elective**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

Course Outcomes:

CO1	To understand architecture of industrial automation system
CO2	To understand industrial measurement system
CO3	To understand PID control technique
CO4	To understand and apply PLC technique
CO5	To understand various hydraulic control components and functions
CO6	To understand AC and DC drives specifications and control functions

Course Contents:

Unit I: Introduction Architecture industrial automation system, development trends in industrial automation, classification of existing systems, and functionality of industrial automation system. Relay and contactor logic, AC and DC relays and their role for load control. Power and Auxiliary contactors and their usage for load control. [8Hrs]

Unit II: Industrial Measurement System Characteristics Sensors and control logic, control using potential free output sensors Control using PO, PC, NO, NC type output sensor, 2W(2wire), 3W(3 wire), 4W(4wire) and 4WC sensors, Linear potentiometer Timer hardware architecture, Controlling industrial system using timers Controlling industrial system using counters .Temperature

Measurement, Pressure, Force and Torque Sensors, Motion Sensing, Flow Measurement, Signal Conditioning, Data Acquisition Systems. [8Hrs]

Unit III: Automatic Control Introduction, P-I-D Control, manual and auto PID Control Tuning, Feed forward Control Ratio Control, Time Delay Systems and Inverse Response Systems, Special Control Structures. Temperature controller hardware architecture. [8Hrs]

Unit IV: PLC Introduction to Sequence Control, PLC, RLL (Relay Ladder Logic), Sequence Control. Scan Cycle, Simple RLL Programs, Sequence Control. More RLL Elements, RLL Syntax, A Structured Design Approach to Sequence, PLC Hardware Environment, Introduction To CNC Machines, Contour generation and Motion Control, Allen Bradley PLC and SIEMEN PLC. [8Hrs]

Unit V: Industrial Control Basics of hydraulics, Hydraulic components their functions and symbols Hydraulic actuators, Pumps and its operation, pump control, Hydraulic valves (Direction control, pressure and flow control), special valves, pressure gauges and switches, hydraulic logic circuits, Hydraulic Control System, Multiple pressure and speed operations, Industrial Hydraulic Circuit, Pneumatic systems and components Pneumatic Control Systems, compressor operation and control, air treatment. [8Hrs]

Unit VI: Industrial Drives AC Drive basics, Electrical specifications and hardware architecture .AC drive and AC motor specification matching. AC drive power wiring and Interfacing input and output signals. Operation and control of AC motor in scalar mode. Operation and control of AC drive in vector. control mode. Performance verifications of special features of AC drive. Requirement and specifications of input and output chokes, braking applications, methodology and specifications of braking resistors. Selection of power, motor and signal cables for AC drive application. Wiring and lay outing guidelines of AC drive .Energy Savings with Variable Speed Drives, DC Motor Drives, DC and BLDC Servo Drives. [8Hrs]

References:

1. Lingefeng Wang, Kay Chen Tan,"Modern Industrial Automation and Software Design" John Wiley & Sons Inc.

2. K. L.S. Sharma, “ Overview of Industrial Process Automation”, Elsevier

3. Kok Kiong “Drives and Control for Industrial Automation”, Springer

MTCS201 SLIDING MODE CONTROL

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTCS201	**SLIDING MODE CONTROL**	**core**	**3-0-1**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

Course Outcomes:

CO1	Design and analyze sliding mode controller for uncertain systems.
CO2	Demonstrate capability to design estimators for state and uncertainty estimations
CO3	Design and analyze discrete sliding mode controller

Course Content

Unit-1. Notion of variable structure systems and sliding mode control,

Unit-2.Design continuous sliding mode control, chattering issue,

Unit-3. Discrete sliding mode control, sliding mode observer, uncertainty estimation using sliding mode,

Unit-4. Discrete output feedback SMC using multirate sampling.

Unit-5. Introduction to higher order sliding mode control, twisting and super twisting algorithms**.**

References:

1. Spurgeaon and Edwards, ”Sliding Mode Control Theory and Applications”.

2. B. Bandyopadhyay and S. Janardhanan , ”Discrete-time Sliding Mode Control : A Multirate-Output Feedback Approach”, Ser. Lecture Notes in Control and Information Sciences, Vol. 323, Springer-Verlag, Oct. 2005.

3. Yuri Shtessel , Christopher Edwards, Leonid Fridman ,Arie Levant “Sliding Mode Control and Observation “Birkhauser

4. S. Kurode, B. Bandyopadhyay and P.S. Gandhi, ”Output feedback Control for Slosh free Motion using Sliding modes”, Lambert Publications 2012

MTCS202 MULTIVARIABLE CONTROL

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTCS202	**MULTIVARIABLE CONTROL**	**core**	**3-0-1**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

Course Outcomes:

CO1	Understand types of MIMO systems and models, their mathematical properties, analyze the system to relate these properties to the physical properties of the system.
CO2	Demonstrate the control design strategies and understand the purpose for specific strategy to be applied.
CO3	Design the control algorithms for MIMO systems for desired performance and stability
CO4	Implement the control algorithms for MIMO systems on MATLAB-SIMULINK platform and compute the performance

Course Content

Unit-1.Examples of multivariable control systems, state space, polynomial and stable fraction models, polynomial matrices, transmission zero,

Unit-2.Solution of state equations, controllability, observability and computations involved in their analysis. •

Unit-3. Realization theory of multivariable systems and algorithms, stability and stabilizability.

Unit-4. Pole placement, observer design and stabilization theory, minimal realization, frequency domain design, decoupling,

Unit-5 Model matching, spectral factorizations of systems, solution of the Ricatti equation, balanced realizations and their computations

References:

1. Y.S.Apte, ”Linear multivariable control system”.

2. W.M.Wonham, ”Multivariable control systems”.

3. C.T.Chen, ”Linear system theory and design”, 3rd edition, Oxford 1999.

4. John Bay,”Fundamentals of linear state space systems”, McGraw Hill, 1998.

5. Wilson Rugh, ”Linear system theory”, 2nd edition, Prentice Hall, 1996. H.H.Rosenbrock, ”Computer aided control system design.

MTCS203-1. DIGITAL CONTROL SYSTEM

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTCS203-1	**DIGITAL CONTROL SYSTEM**	**elective**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

Course Outcomes:

CO1	Obtain discrete representation of LTI systems
CO2	Analyze stability of open loop and closed loop discrete system
CO3	Design and analyze Discrete Controller
CO4	Design state feedback controller and estimators

Course Content

Unit-1. Discrete time systems , discretization, sampling, aliasing, choice of sampling frequency, ZOH equivalent,

Unit-2. State space models of discrete systems.

Unit-3. Z-Transform for analyzing discrete time systems, transfer function,

Unit-4. Internal stability,

Unit-5. design of discrete time control using conventional methods,

Unit-6 Stability of discrete time systems, state space analysis, pole placement and observer

References:

1. K. Ogata,”Discrete Time Control Systems”, Prentice hall, 1995.

2. Kannan M. Moudgalya,”Digital Control”, John Wiley and Sons, 2004.

3. Kuo, Benjamin C, ”Digital Control Systems”, New York : Holt, Rinehart and Winston, 1980. 4. M. Gopal, ”Digital Control”, MacGraw Hill.

5. G. F. Franklin, J. D. Powell, M.L. Workman, Digital Control of Dynamic Systems, Addison-Wesley, Reading, MA, 1998

MTCS203-2. FRACTIONAL ORDER MODELING AND CONTROL

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTCS203-2	FRACTIONAL ORDER MODELING AND CONTROL	elective	3-0-0	42

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

Course Outcomes:

CO1	To illustrate concept of fractional calculus
CO2	To develop fractional order models.
CO3	To describe fractional control analysis in time domain and frequency domain
CO4	To design and analyze fractional control strategies

Course Content

Unit-1 Review of basic definitions of integer-order (IO) derivatives and integrals and their geometric and physical interpretations, Definition of Riemann-Liouville (RL) integration, Definitions of RL, Caputo and Grunwald-Letnikov (GL) fractional derivatives (FDs), Various geometrical and physical interpretations of these FDs, Computation of these FDs for some basic functions like constant, ramp, exponential, sine, cosine, etc., Laplace and Fourier transforms of FDs.

Unit-2. Study of basic functions like Gamma function, Mittag-Leffler function, Dawson's function, Hypergeometric function, etc, Analysis of linear fractional-order differential equations (FDEs): formulation, Solution with different FDs, Initial conditions, Problem of initialization and the remedies.

Unit-3. Concepts of 'memory' and 'non-locality' in real-world and engineering systems, non-exponential relaxation, 'Mittag-Leffler' type decay and rise, Detailed analysis of fractional-order (FO) modeling of: electrical circuit elements like inductor, capacitor, electrical machines like transformer, induction motor and transmission lines, FO modeling of viscoelastic materials, concept of fractional damping, Models of basic circuits and mechanical systems using FO elements, Concept of anomalous diffusion, non-Gaussian probability density function and the development of corresponding FO model, FO models of heat transfer, A brief overview of FO models of biological systems.

Unit-4. Review of basic concepts of complex analysis, Concepts of multivalued functions, branch points, branch cuts, Riemann surface and sheets, Fractional-order transfer function (FOTF) representation, Concepts like commensurate and noncommensurate TFs, stability, impulse, step and ramp response, Frequency response, non-minimum phase systems, Root locus, FO pseudo state-space (PSS) representation and the associated concepts like solution of PSS model, controllability, observability, etc.

Unit-5. Detailed discussion and analysis of superiority of FO control over the conventional IO control in terms of closed-loop performance, robustness, stability, etc., FO leadlag compensators, FO PID control, design of FO state-feedback, Realization and implementation issues for FO controllers, survey of various realization methods and the comparative study. **Unit-6** Primer on MATLAB and Mathematica, Computation of FDs using MATLAB, Analytical expressions for FDs using Mathematica, Use of Mittag-Leffler functions and various special functions in MATLAB, Analysis of system of non-linear FDEs using these softwares, Use of simulink in analysis of FO systems and control

References:

1. K. B. Oldham and J. Spanier,. The Fractional Calculus. Dover Publications, USA, 2006.

2. Kilbas, H. M. Srivastava, and J. J. Trujillo. Theory and Applications of Fractional Differential Equations. Elsevier, Netherlands, 2006.

3. Podlubny. Fractional Differential Equations. Academic Press, USA, 1999.

4. A. Monje, Y. Q. Chen, B. M. Vinagre, D. Xue, and V. Feliu. Fractional-order Systems and Control: Fundamentals and Applications. Springer-Verlag London Limited, UK, 2010.

5. R. L. Magin. Fractional Calculus in Bioengineering. Begell House Publishers, USA, 2006.

6. R. Caponetto, G. Dongola, L. Fortuna, and I. Petras. Fractional Order Systems: Modeling and Control Applications. World Scientific, Singapore, 2010.

7. K. S. Miller and B. Ross. An Introduction to the Fractional Calculus and Fractional Differential Equations. John Wiley & Sons, USA, 1993.

8. S. Das. Functional Fractional Calculus for System Identification and Controls. Springer, Germany, 2011.

9. . Ortigueira. Fractional Calculus for Scientists and Engineers. Springer, Germany, 2011.

10. Petras. Fractional-Order Nonlinear Systems: Modeling, Analysis and Simulation. Springer, USA, 2011.

11. W. R. LePage. Complex Variables and the Laplace Transform for Engineers. Dover Publications, USA, 2010.

12. H. Ruskeepaa. Mathematica Navigator: Mathematics, Statistics and Graphics. Academic Press, USA, 2009

MTCS203-3. EMBEDDED CONTROL

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTCS203-3	EMBEDDED CONTROL	elective	3-0-0	42

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

Course Outcomes:

CO1	To Define and explain embedded systems and the different embedded system design technologies explain the various metrics or challenges in designing an embedded system
CO2	To Become aware of the architecture of the ARM processor and its programming aspects (assembly Level
CO3	To Foster ability to understand the internal architecture Processor LPC 2148
CO4	To Understand key concepts of embedded systems like IO, timers, interrupts, interaction with peripheral devices
CO5	To Design real time embedded systems using the concepts of RTOS.
CO6	To Analyze various examples of embedded systems based on ARM processor.

COURSE OUTCOMES:

UNIT I: INTRODUCTION TO EMBEDDED SYSTEMS (08 Hours)

Introduction to embedded system -Definition and Classification, Design challenges, Optimizing design metrics, time to market, applications of embedded systems and recent trends in embedded systems, memory management, Overview of Processors and hardware units in an embedded system, Software embedded into the system, communication protocols like SPI, I2C, CAN etc.

UNIT II: ARCHITECTURE OF ARM7TDMI (05 Hours)

Introduction to ARM core architecture, ARM extension, family, Pipeline, memory management, Bus architecture, Programming model, Registers, Operating modes, instruction set, Addressing modes, memory interface.

UNIT III: ON CHIP PERIPHERALS AND INTERFACING LPC2148 (08 Hours)

Study of on-chip peripherals – Input/ output ports, Timers, Interrupts, on-chip ADC, DAC, RTC modules, WDT,PLL, PWM,USB, I2C, SPI, CAN etc.

UNIT IV: INTERFACING WITH LPC2148 (08 Hours)

Need of interfacing, interfacing techniques, interfacing of different displays including Graphic LCD, controlling a DC motor using PWM, Keypad controllers, stepper motor controllers.

UNIT V: REAL TIME OPERATING SYSTEMS (08 Hours)

Definitions of process, tasks and threads, I/O Subsystems, Interrupt Routines Handling in RTOS, RTOS Task scheduling models, Handling of task scheduling and latency and deadlines as performance metrics, Co-operative Round Robin Scheduling, Case Studies of Programming with RTOS.

UNIT VI: INTRODUCTION TO ARM 9 (05 Hours)

ARM926EJ-S, Features, Specifications (LPC314x /LPC315x As reference controllers)

REFERENCES:

1) Embedded Systems Architecture, Programming and Design, Rajkamal, TATA McGraw-Hill, First reprint Oct, 2003.

2) Embedded Systems Design, Second Edition, Steve Heath, Elsevier India Pvt. Ltd. 2007.

3) Andrew Sloss, Andew Sloss, “ARM System Developers Guide”
4) Introduction to Embedded systems, Shibu K V, Tata McGraw Hill First print – 2009.
5) An Embedded Software Primer, David E,Simon, Pearson Education Asia, 2000.
6) Embedded Systems Design, A unified Hardware /Software Introduction, Frank Vahid and Tony Givargis, John Wiley, 2002.

Computers as Components; Principles of Embedded Computing System Design Wayne Wolf, Harcourt India, Morgan Kaufman Publishers, First Indian Reprint 2001

MTCS204-1. NON LINEAR DYNAMIC SYSTEMS

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTCS204-1	**NON LINEAR DYNAMIC SYSTEMS**	**elective**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

Course Outcomes:

CO1	To Explore tools for stability analysis and response evaluation of control problems with significant nonlinearities.
CO2	To Compute the performance and stability of the system.
CO3	To Identify the design problem and distinguish between the controls strategies
CO4	Correlate between design parameters and the system performance.

Course Content

Unit-1. Introduction to nonlinear systems, phase plane and describing function methods for analysis of nonlinear systems

Unit-2. Lyapunov stability: autonomous systems invariance principle, linear systems and linearization, non-autonomous systems. Linear time varying systems

Unit-3. Linearization, nonlinear control systems design by feedback linearization, input output linearization.

Unit-4. systems analysis based on Lyapunov's direct method (Krasovaskii's method, variable gradient method), converse theorems, centre manifold theorem, region of attraction, stability of perturbed system, input to state stability

Unit-5 Lyapunov like analysis using Barbalet's lemma, advanced stability theory

References:

1. H. K. Khalil, "Nonlinear Systems", Prentice Hall, 2001.

2. Jean-Jacques E. Slotine, Weiping Li, "Applied nonlinear Control", Prentice Hall, 1991.

3. M Vidyasagar, "Nonlinear systems Analysis", 2nd Edition, Prentice Hall, 1993.

4. Alberto Isidori, "Nonlinear Control System", Vol I and II, Springer, 1999

MTCS204-2. FRACTIONAL ORDER MODELING AND CONTROL

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTCS204-2	**FRACTIONAL ORDER MODELING AND CONTROL**	**elective**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

Course Outcomes:

CO1	To illustrate concept of fractional calculus
CO2	To develop fractional order models.
CO3	To describe fractional control analysis in time domain and frequency domain
CO4	To design and analyze fractional control strategies

Course Content

Unit-1.Review of basic definitions of integer-order (IO) derivatives and integrals and their geometric and physical interpretations, Definition of Riemann-Liouville (RL) integration, Definitions of RL, Caputo and Grunwald-Letnikov (GL) fractional derivatives (FDs), Various geometrical and physical interpretations of these FDs, Computation of these FDs for some basic functions like constant, ramp, exponential, sine, cosine, etc., Laplace and Fourier transforms of FDs.

Unit-2. Study of basic functions like Gamma function, Mittag-Leffler function, Dawson's function, Hypergeometric function, etc, Analysis of linear fractional-order differential equations (FDEs): formulation, Solution with different FDs, Initial conditions, Problem of initialization and the remedies.

Unit-3. Concepts of 'memory' and 'non-locality' in real-world and engineering systems, non-exponential relaxation, 'Mittag-Leffler' type decay and rise, Detailed analysis of fractional-order (FO) modeling of: electrical circuit elements like inductor, capacitor, electrical machines like transformer, induction motor and transmission lines, FO modeling of viscoelastic materials, concept of fractional damping, Models of basic circuits and mechanical systems using FO elements, Concept of anomalous diffusion, non-Gaussian probability density function and the development of corresponding FO model, FO models of heat transfer, A brief overview of FO models of biological systems.

Unit-4. Review of basic concepts of complex analysis, Concepts of multivalued functions, branch points, branch cuts, Riemann surface and sheets, Fractional-order transfer function (FOTF) representation, Concepts like commensurate and noncommensurate TFs, stability, impulse, step and ramp response, Frequency response, non-minimum phase systems, Root locus, FO pseudo state-space (PSS) representation and the associated concepts like solution of PSS model, controllability, observability, etc.

Unit-5. Detailed discussion and analysis of superiority of FO control over the conventional IO control in terms of closed-loop performance, robustness, stability, etc., FO leadlag compensators, FO PID control, design of FO state-feedback, Realization and implementation issues for FO controllers, survey of various realization methods and the comparative study. **Unit-6** Primer on MATLAB and Mathematica, Computation of FDs using MATLAB, Analytical expressions for FDs using Mathematica, Use of Mittag-Leffler functions and various special functions in MATLAB, Analysis of system of non-linear FDEs using these softwares, Use of simulink in analysis of FO systems and control.

References:

1. K. B. Oldham and J. Spanier,. The Fractional Calculus. Dover Publications, USA, 2006.

2. Kilbas, H. M. Srivastava, and J. J. Trujillo. Theory and Applications of Fractional Differential Equations. Elsevier, Netherlands, 2006.

3. Podlubny. Fractional Differential Equations. Academic Press, USA, 1999.

4. A. Monje, Y. Q. Chen, B. M. Vinagre, D. Xue, and V. Feliu. Fractional-order Systems and Control: Fundamentals and Applications. Springer-Verlag London Limited, UK, 2010.

5. R. L. Magin. Fractional Calculus in Bioengineering. Begell House Publishers, USA, 2006.

6. R. Caponetto, G. Dongola, L. Fortuna, and I. Petras. Fractional Order Systems: Modeling and Control Applications. World Scientific, Singapore, 2010.

7. K. S. Miller and B. Ross. An Introduction to the Fractional Calculus and Fractional Differential Equations. John Wiley & Sons, USA, 1993.

8. S. Das. Functional Fractional Calculus for System Identification and Controls. Springer, Germany, 2011.

9. . Ortigueira. Fractional Calculus for Scientists and Engineers. Springer, Germany, 2011.

10. Petras. Fractional-Order Nonlinear Systems: Modeling, Analysis and Simulation. Springer, USA, 2011.

11. W. R. LePage. Complex Variables and the Laplace Transform for Engineers. Dover Publications, USA, 2010.

12. H. Ruskeepaa. Mathematica Navigator: Mathematics, Statistics and Graphics. Academic Press, USA, 2009**.**

MTCS204-3. CONTROL SYSTEM DESIGN AND ESTIMATION.

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTCS204-3	**CONTROL SYSTEM DESIGN AND ESTIMATION.**	**elective**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

Course Outcomes:

CO1	To understand Kalman filters for state estimation 2.
CO2	To Design of estimator

Course Content

Unit-1Introduction to random variables mean variance, normal distribution, stochastic estimation,

Unit-2 Introduction to Kalman Filter, Kalman filter elementary approach, linearized and extended Kalman filter. Unscented kalman filter, particle filter,

Unit-3 Model based estimation of states and disturbance. Robust estimation. Use of estimation approach for detection and diagnosis.

References:

1. Charles K. Chui, Guanrong Chen," Kalman Filtering: With Real-Time Applications ", Springer Notes

2. Harold Wayne Sorenson," Kalman Filtering: Theory and Application", IEEE Press, 1960 –

ELECTIVE V: MTEDC205-1: MODERN OPTIMIZATION TECHNIQUES

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTCS205-1	MODERN OPTIMIZATION TECHNIQUES	elective	3-0-0	42

Evaluation scheme:

Theory	Test	Continuous Assessmen	Total	Credits
60	20	20	100	4

Course Outcomes:

CO1	To Understand the theoretical workings of the simplex method for linear programming and perform iterations of it by hand
CO2	To Understand the relationship between a linear program and its dual, including strong duality and complementary slackness
CO3	To Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change.
CO4	To Solve specialized linear programming problems like the transportation and assignment problems
CO5	To Solve network models like the shortest path, minimum spanning tree, and maximum flow problems
CO6	To Understand the applications of, basic methods for, and challenges in integer programming

COURSE CONTENTS:

UNIT I: FUNDAMENTALS OF OPTIMIZATION (08 hours)

Definition-Classification of optimization problems-Unconstrained and Constrained optimization-Optimality conditions-Classical Optimization techniques (Linear and non linear programming, Quadratic programming, Mixed integer programming)-Intelligent Search methods (Optimization neural network, Evolutionary algorithms, Tabu search, PSO, Application of fuzzy set theory).

UNIT II: EVOLUTIONARY COMPUTATION TECHNIQUES (10 hours)

Evolution in nature-Fundamentals of Evolutionary algorithms-Working Principles of Genetic Algorithm- Evolutionary Strategy and Evolutionary Programming-Genetic Operators-Selection, Crossover and Mutation-Issues in GA implementation- GA based Economic Dispatch solution-Fuzzy Economic Dispatch including losses- Tabu search algorithm for unit commitment problem-GA for unit commitment-GA based Optimal power flow- GA based state estimation.

UNIT III: PARTICLE SWARM OPTIMIZATION (08 hours)

Fundamental principle-Velocity Updating-Advanced operators-Parameter selection- Hybrid approaches (Hybrid of GA and PSO, Hybrid of EP and PSO) -Binary, discrete and combinatorial PSO-Implementation issues-Convergence issues- PSO based applications to Drive Control

UNIT IV: ADVANCED OPTIMIZA TION METHODS (08 Hours)

Simulated annealing algorithm-Tabu search algorithm-SA and TS for unit commitment-Ant colony optimization- Bacteria Foraging optimization.

UNIT V: MULTI OBJECTIVE OPTIMIZATION (08 Hours)

Concept of pareto optimality-Conventional approaches for MOOP-Multi objective GA-Fitness assignment-Sharing function- MOGA-Multiobjective PSO and its application in Drive Control.

REFERENCES:

1) D. P. Kothari and J. S. Dhillon, “Power System Optimization”, 2ndEdition, PHI learning private limited, 2010.
2) Kalyanmoy Deb, “Multi objective optimization using Evolutionary Algorithms”, John Wiley and Sons, 2008.
3) Kalyanmoy Deb, “Optimization for Engineering Design”, Prentice hall of India first edition, 1988.
4) Carlos A. Coello Coello, Gary B. Lamont, David A. Van Veldhuizen, “Evolutionary Algorithms for solving Multi Objective Problems”, 2ndEdition, Springer, 2007.
5) Kwang Y. Lee, Mohammed A. ElSharkawi, “Modern heuristic optimization techniques”, John Wiley and Sons, 2008.

ELECTIVE V: MTCS 205-3: ENERGY MANAGEMENT AND AUDITING

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTCS205-3	ENERGY MANAGEMENT AND AUDITING	elective	3-0-0	42

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

Course Outcomes:

CO1	To Identify and describe present state of energy security and its importance.
CO2	To Identify and describe the basic principles and methodologies adopted in energy audit of utility
CO3	To Describe the energy performance evaluation of some common electrical and thermal installations and identify the energy saving opportunities
CO4	To Analyze the data collected during performance evaluation and recommend energy saving measures

COURSE CONTENTS:

UNIT I: BASIC PRINCIPLES OF ENERGY AUDIT (08 Hours)

Energy audit- definitions, concept, types of audit, energy index, cost index ,pie charts, Sankey diagrams, load profiles, Energy conservation schemes- Energy audit of industries- energy saving potential, energy audit of process industry, thermal power station, building energy audit Need for energy management – energy basics – designing and starting an energy management program – energy audit process. Need for energy management – energy basics – designing and starting an energy management program – energy accounting – energy monitoring, targeting and reporting.

UNIT II: ENERGY COST AND LOAD MANAGEMENT (06 Hours)

Important concepts in an economic analysis – economic models – time value of money –utility rate structures – cost of electricity – loss evaluation. Load management: demand control techniques – utility monitoring and control system-HVAC and energy management – economic justification.

UNIT III: ENERGY EFFICIENT MOTORS (06 Hours)

Energy efficient motors, factors affecting efficiency, loss distribution, constructional details, characteristics - variable speed, variable duty cycle systems, RMS hp- voltage variation-voltage unbalance - over motoring - motor energy audit applications to Systems and equipment such as: electric motors – transformers and reactors – capacitors and synchronous machines.

UNIT IV: METERING FOR ENERGY MANAGEMENT (06 Hours)

Relationships between parameters – Units of measure – typical cost factors – utility meters – timing of meter disc for kilowatt measurement – demand meters – paralleling of current transformers – instrument transformer burdens – multitasking solid-state meters – metering location vs. requirements – metering techniques and practical examples.

UNIT V: LIGHTING SYSTEMS AND COGENERATION (08 Hours)

Concept of lighting systems – the task and the working space – light sources – ballasts –luminaries – lighting controls – optimizing lighting energy – power factor and effect of harmonics on power quality

– cost analysis techniques – lighting and energy standards. Cogeneration: forms of cogeneration – feasibility of cogeneration – electrical interconnection.

UNIT VI: ECONOMIC ASPECTS AND ANALYSIS (08 Hours)

Economics Analysis-Depreciation Methods, time value of money, rate of return , present worth method , replacement analysis, life cycle costing analysis- Energy efficient motors- calculation of simple payback method, net present worth method- Power factor correction, lighting - Applications of life cycle costing analysis, return on investment.

REFERENCES:

1) Eastop T.D and Croft D.R, "Energy Efficiency for Engineers and Technologists", Logman Scientific & Technical, 1990.
2) Reay D.A., "Industrial Energy Conservation", first edition, Pergamon Press, 1977.
3) IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE, 1996.
4) Amit K. Tyagi, "Handbook on Energy Audits and Management", TERI, 2003.
5) Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, "Guide to Energy Management", Fifth Edition, The Fairmont Press, Inc., 2006.

SEMESTER II

ELECTIVE V: MTCS205-5: RESEARCH METHODOLOGY

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTCS205-5	**RESEARCH METHODOLOGY**	**elective**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

Course Outcomes:

CO1	To Understand the research meaning apply the same for doing the research work
CO2	To Identify and formulate the research problem

CO3	To Design the research work in the proper structured manner using sample techniques.

COURSE CONTENTS:

UNIT I: Foundations of Research (0 7 Hours)

Meaning, Objectives, Motivation, Utility. Concept of theory, empiricism, deductive and inductive theory. Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition, Variable. Research Process

UNIT II: Problem Identification & Formulation (0 7 Hours)

Research Question – Investigation Question – Measurement Issues – Hypothesis – Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance.

UNIT III: Research Design (0 7 Hours)

Concept and Importance in Research – Features of a good research design – Exploratory Research Design – concept, types and uses, Descriptive Research Designs – concept, types and uses. Experimental Design: Concept of Independent & Dependent variables.

UNIT IV: Qualitative and Quantitative Research (0 7 Hours)

Qualitative research – Quantitative research – Concept of measurement, causality, generalization, replication. Merging the two approaches.

UNIT V: Sampling (0 7 Hours)

Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Non Response. Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage sampling. Determining size of the sample – Practical considerations in sampling and sample size.

UNIT VI: Data Analysis (0 7 Hours)

Data Preparation – Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis – Cross tabulations and Chi-square test including testing hypothesis of association.

REFERENCES:

1) Business Research Methods – Donald Cooper & Pamela Schindler, TMGH, 9th edition

2) Business Research Methods – Alan Bryman& Emma Bell, Oxford University Press.

MTCS205-6 FINANCE MANAGEMENT

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTCS205-6	**FINANCE MANAGEMENT**	**Elective-V**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	3

Course outcomes:

Upon successful completion of this course the student will be able to:

CO1	Apply selection criteria and select an appropriate project from different options
CO2	Write work break down structure for a project and develop a schedule based on it.
CO3	Identify opportunities and threats to the project and decide an approach to deal with them strategically.
CO4	Use Earned value technique and determine & predict status of the project.
CO5	Capture lessons learned during project phases and document them for future reference

Course Contents:

Unit-I Overview of Indian Financial System [8]

Characteristics, Components and Functions of Financial System. **Financial Instruments:** Meaning, Characteristics and Classification of Basic Financial Instruments — Equity Shares, Preference Shares, Bonds-Debentures, Certificates of Deposit, and Treasury Bills.

Financial Markets: Meaning, Characteristics and Classification of Financial Markets — Capital Market, Money Market and Foreign Currency Market.

Financial Institutions: Meaning, Characteristics and Classification of Financial Institutions — Commercial Banks, Investment-MerchantBanks and Stock Exchanges

Unit-II Concepts of Returns and Risks [8]

Measurement of Historical Returns and Expected Returns of a Single Security and a Two-security Portfolio; Measurement of Historical Risk and Expected Risk of a Single Security and a Two-security Portfolio.

Time Value of Money: Future Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Present Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Continuous Compounding and Continuous Discounting.

Unit-III Overview of Corporate Finance [8]

Objectives of Corporate Finance; Functions of Corporate Finance—Investment Decision, Financing Decision, and Dividend Decision.

Financial Ratio Analysis: Overview of Financial Statements—Balance Sheet, Profit and Loss Account, and Cash Flow Statement; Purpose of Financial Ratio Analysis; Liquidity Ratios; Efficiency or Activity Ratios; Profitability Ratios; Capital Structure Ratios; Stock Market Ratios; Limitations of Ratio Analysis.

Unit-IV Capital Budgeting **[8]**

Meaning and Importance of Capital Budgeting; Inputs for Capital Budgeting Decisions; Investment Appraisal Criterion—Accounting Rate of Return, Payback Period, Discounted Payback Period, Net Present Value(NPV), Profitability Index, Internal Rate of Return (IRR), and Modified Internal Rate of Return (MIRR).

Unit-V Working Capital Management **[10]**

Concepts of Meaning Working Capital; Importance of Working Capital Management; Factors Affecting an Entity's Working Capital Needs; Estimation of Working Capital Requirements; Management of Inventories; Management of Receivables; and Management of Cash and Marketable Securities.

REFERENCES:

1. Fundamentals of Financial Management, 13th Edition (2015) by Eugene F. Brigham and Joel F. Houston; Publisher: Cengage Publications, New Delhi.

2. Analysis for Financial Management, 10th Edition (2013) by Robert C. Higgins; Publishers: McGraw Hill Education, New Delhi.

3. Indian Financial System, 9th Edition (2015) by M. Y. Khan; Publisher: McGraw Hill Education, New Delhi.

4. Financial Management, 11th Edition (2015) by I. M. Pandey; Publisher: S. Chand (G/L) & Company Limited, New Delhi.

MTCS205-7 INTELLIGENT SYSTEMS

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTCS205-7	INTELLIGENT SYSTEMS	Elective-V	3-0-0	42

Evaluation scheme:

Theory	Test	Continuous Assessmen	Total	Credits
60	20	20	100	3

Course outcomes:

Upon successful completion of this course the student will be able to:

CO1	To understand concepts of neural network
CO2	To understand various models of ANN
CO3	To understand various learning methods of ANN
CO4	To understand fuzzy theory and system development
CO5	To apply ANN and Fuzzy technique in engineering problems.

COURSE CONTENTS:

Unit I: Introduction to Neural Networks Introduction, Humans and Computers, Biological Neuron, Biological and Artificial Neuron Models, Historical Developments. Essentials of Artificial Neural Networks: Artificial Neuron Model, Operations of Artificial Neuron, Types of Neuron Activation Function, ANN Architectures, Classification Taxonomy of ANN-Connectivity, Neural Dynamics: Activation and Synaptic, Learning Strategy: Supervised, Unsupervised, Reinforcement, Learning Rules. (6 Hrs)

Unit II: Feed Forward Neural Networks Introduction, Perceptron Models: Discrete, Continuous and Multi-Category, Training Algorithms: Discrete and Continuous Perceptron Networks, Perceptron Convergence theorem. Multilayer feed forward Neural Networks. Credit Assignment Problem, Generalized Delta Rule, Derivation of Back propagation (BP) Training, Summary of Back propagation Algorithm, Learning Difficulties and Improvements. (6 Hrs)

Unit III: Associative Memories Paradigms of Associative Memory, Pattern Mathematics, Hebbian Learning, General Concepts of Associative Memory: Associative Matrix, Association Rules, Hamming Distance, The Linear Associator, Matrix Memories, Content Addressable Memory, Bi-directional Associative Memory (BAM) Architecture, BAM Training Algorithms: Storage and Recall Algorithm, BAM Energy Function, Proof of BAM Stability Theorem. Self-Organizing Maps (SOM) and Adaptive Resonance Theory (ART). Introduction, Competitive Learning, Vector Quantization, SelfOrganized Learning Networks, Kohonen Networks, Linear Vector Quantization, StabilityPlasticity Dilemma, Feed forward competition, ART1, ART2. (6 Hrs)

Unit IV: Fuzzy set Theory Fuzzy versus crisp, Crisp sets: operation, properties, partition and covering, fuzzy sets: membership function, Basic fuzzy set operations, properties of fuzzy sets, crisp relations: Cartesian product, operation and relations, fuzzy relations: Fuzzy Cartesian product, operation on fuzzy relations. (6Hrs)

Unit V: Fuzzy systems Crisp logic: Laws on prepositional logic, Inference in prepositional logic, predicate logic: Interpretation of predicate logic formula, Inference in predicate logic, fuzzy logic: Fuzzy quantifiers, fuzzy Inference, fuzzy rule based system, defuzzification methods. (6 Hrs)

Unit VI: Applications based on ANN and Fuzzy Logic Technique Neural network applications: Pattern recognition, control and Process Monitoring, fault diagnosis and load forecasting. Fuzzy logic application: Greg viot's fuzzy cruise controller, Air conditioner controller. (6 Hrs)

References:

1. Neural Network Design-Hagan, Demuth, Beale- Thomas Learning, Vikas Publishing House

2. Introduction to Artificial Neural Systems - Jacek M. Zuarda, Jaico Publishing House, 1997.

3. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan and Rai - PHI Publication.

4. Neural and Fuzzy Systems: Foundation, Architectures and Applications, - N. Yadaiah and S. Bapi Raju, Pearson Education

5. Neural Networks - James A Freeman and Davis Skapura, Pearson, 2002.

6. Neural Networks - Simon Hykins, Pearson Education 4. Neural Engineering by C. Eliasmith and CH. Anderson, PHI

SEMESTER II

MTCS206: SEMINAR-I

Seminar-I shall be on state of the art topic of student's own choice based on relevant specialization approved by an authority. Student should deliver seminar on the state of the art topic in front of the external examiners/internal examiners, staff and student colleagues. Prior to presentation student should carry the details of literature survey form standard references such as international journals and periodicals, recently published reference books etc. The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work by the concerned Guide and Head of the department/institute. The assessment shall be based on selection of topic its relevance to present context, report documentation and presentation skills.

SEMESTER II

MTCS207: PGLAB-II or MINI PROJECT

Students are instructed to frame and perform laboratory assignment/experiments based on each of theory Course. The assignment should encompass the hardware and engineering computation software such as MATLAB, PSCAD, ETAP etc. techniques/tools introduced in the concerned subjects and should prove to be useful for the PG program in the relevant field with moderate to high complexity. Assignment should be a full-fledged system design problems with multidimensional solutions suggested.

Or

The student should select a small project (as suggested by faculty adviser) relevant to Electrical Drives or Control System. Project work based on signal analysis, signal conditioning, state of art, professional software acquaintance like MATALAB, ETAP, PSCAD, PSIM similar work.

SEMESTER III

MTME301: PROJECT MANAGEMENT AND INTELLECTUAL PROPERTY RIGHTS

COURSE OUTCOMES:

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

1) Enumerate and demonstrate fundamental terms such as copy-rights, Patents, Trademarks etc.
2) Interpret and follow Laws of copy-rights, Patents, Trademarks and various IP registration Processes to register own project research.
3) Exhibit the enhance capability to do economic analysis of IP rights, technology and innovation related policy issues and firms' commercial strategies.
4) Develop awareness at all levels (research and innovation) of society to develop patentable technologies.
5) Apply trade mark law, copy right law, patent law and also carry out intellectual property audits.
6) Manage and safeguard the intellectual property and protect it against unauthorized use.

COURSE CONTENTS:

A. PROJECT MANAGEMENT:
UNIT I:

Introduction to Project management**:** Characteristics of projects, Definition and objectives of Project Management, Stages of Project Management, Project Planning Process, Establishing Project organization. Work definition: Defining work content, Time Estimation Method, Project Cost Estimation and budgeting, Project Risk Management, Project scheduling and Planning Tools: Work Breakdown structure, LRC, Gantt charts, CPM/PERT Networks.

UNIT II:

Developing Project Plan (Baseline), Project cash flow analysis, Project scheduling with resource constraints: Resource Leveling and Resource Allocation. Time Cost Trade off: Crashing Heuristic.

UNIT III:

Project Implementation: Project Monitoring and Control with PERT/Cost, Computers applications in Project Management, Contract Management, Project Procurement Management. Post-Project Analysis.

B. IPR:
UNIT IV:

Introduction to IPR; Overview & Importance; IPR in India and IPR abroad; Patents ;their definition; granting; infringement; searching & filing; Utility Models an introduction.

UNIT V:

Copyrights; their definition; granting; infringement; searching & filing, distinction between related and copy rights; Trademarks, role in commerce, importance, protection, registration; domain names.

UNIT VI:

Industrial Designs ; Design Patents; scope; protection; filing infringement; difference between Designs & Patents' Geographical indications , international protection; Plant varieties; breeder's rights, protection; biotechnology& research and rights managements; licensing, commercialization;

legal issues, enforcement ;Case studies in IPR.

REFERENCES:

1) Shtub, Bard and Globerson, Project Management: Engineering, Technology, and Implementation, Prentice Hall, India.
2) Lock, Gower, Project Management Handbook.
3) Prabuddha Ganguli, IPR published by Tata McGraw Hill 2001.

SEMESTER III

MTCS302: PROJECT STAGE-I

The dissertation Seminar will consist of a type written report covering the topic selected for Final Dissertation. This should include the Extensive literature survey, technical details, Data collection from R&D organizations/Industries/etc, Study of the viability, applicability and scope of the dissertation, Detailed Design (H/W and S/W as applicable) and related data required for the proposed dissertation work. The candidate will make a comprehensive project Phase-I make a comprehensive project Phase-I report in detail and make the presentations along with the future work towards fulfillment of the dissertation and deliver the dissertation seminar on the topic which will be judged by two examiners appointed by the University (one external and one internal guide). The assessment shall be based on selection of topic its relevance to present context, report documentation and presentation skills, utility of the dissertation work & publications based on the same.

SEMESTER IV

MTCS401: PROJECT STAGE-II

The student shall be allowed to submit the dissertation- II report only after the completion of dissertation- I. Student should deliver Viva-Voca Presentation on topic of Dissertation-II in front of the external examiners and internal examiners appointed by the University, staff and student colleagues. The assessment shall be based on design and implementation aspects, report documentation and presentation skills, utility of the dissertation work & publications based on the same.