STRUCTURE FOR

M.E. ELECTRICAL (CONTROL SYSTEMS) PROGRAMME

UNDER FACULTY OF ENGINEERING

EFFECTIVE FROM JUNE 2013
UNIVERSITY OF PUNE

THE SYLLABUS IS PREPARED BY:

BOS- Electrical Engineering,

University of Pune.

PEER REVIEW BY:

- Prof. Dr. Mrs. G.A. Vaidya, (Chairman)
- Dr. J.G. Ghodekar,
  Ex-Dean FOE, Shivaji University, Kolhapur
- Shri Jayant Badve, (Expert from Industry)
## Structure for M.E. (Electrical) Control Systems 2013 Course

### SEMESTER I

<table>
<thead>
<tr>
<th>CODE</th>
<th>SUBJECT</th>
<th>TEACHING SCHEME</th>
<th>EXAMINATION SCHEME</th>
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**List of Elective Subjects**

Note: Select any one subject from module I and one subject from module II for each Elective.

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<th>Elective-I (5 credits)</th>
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EXAMINATION SCHEME GUIDELINES

A) Compulsory subjects: Credits 4

Total marks: 100

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B) Elective subjects: Credits 5

Total marks: 100

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Chairman
B.O.S.
Electrical Engineering
503101: COMPUTATIONAL TECHNIQUES FOR CONTROL SYSTEMS

Teaching Scheme
Theory: 4Hrs/Week
Credits: 04

Examination Scheme
In Semester Assessment: 50 Marks
End Semester Assessment: 50 Marks

Unit I: Mathematical Concepts

Review of extrema of functions, real valued function, partial derivatives gradient vector, Taylor series, Directional derivatives, direction of steepest descent, local and global extrema, unimodal function, limitations of method of differential calculus, unconstrained extrema of differentiable functions, constrained extrema, method of Lagrange multipliers. (6 Hrs.)

Unit II: Optimization and Classical Techniques

Engineering applications of optimization, optimization problem, classification of optimization problems and techniques, single variable, multivariable optimization with no constraints, equality constraints, inequality constraints unconstrained minimization, steepest descent method, conjugate gradient method, Newton's method. (6 Hrs.)

Unit III: Linear Programming

Linear programming problems, LP problems, involving LE constraints, simplex method, revised simplex method, duality. (6 Hrs.)

Unit IV: Nonlinear Programming

One dimensional minimization method, unimodal function, elimination methods, dichotomous search, Fibonacci method, Golden section method, interpolation methods, unconstrained optimization technique. (6 Hrs.)

Unit V: Dynamic Programming

Multistage decision process, sub optimization and principle of optimality, computational and calculus method of solution, final value and initial value problems dynamic programming in continuous time systems. (6 Hrs.)

Unit VI: Integer and Stochastic Programming

Integer and stochastic programming, zero-one programming, mixed integers, integer linear programming, graphical representation, Gomory cut method, Integer nonlinear programming, and polynomial. Stochastic linear programming, nonlinear programming and dynamic programming. (6 Hrs.)
**Text Book:**

**Reference Books:**


Unit I: Management Process
Motivation- Motives, classification of motives. Leadership – definition, importance – leadership style - models and theories of leadership styles. Group dynamics and teams, theories of group formation, formal organization and informal groups and their interaction. Conflict management, stress management, strategies for solving destructive conflicts. (6 Hrs.)

Unit II: Process Dynamics

Unit III: Feedback Control and PID Controller for Process Management
Process and Instrument Elements of the Feedback Loop, Block Diagram, Control Performance Measures for Common Input Changes, Selection of Variables for Control. PID Controller Tuning for Dynamic Performance - Determining Tuning Constants for Good Control Performance, Ziegler-Nichols method, Correlations for Tuning Constants, Fine-Tuning the Controller Tuning Constants,Controller tuning based on stability –Dead beat and self tuning controller, some important interpretations. (6 Hrs.)

Unit IV: Digital Implementation and Management of Process Control

Unit V: Cascade Control and Feed forward Control
Design Criteria, Cascade control,Feed-forward Performances, Controller Algorithm and Tuning, Implementation Issues. (4 Hrs.)

Unit VI: Multivariable Control
Text Books:


Reference Books:


503103: NON LINEAR CONTROL SYSTEMS

Teaching Scheme
Theory: 4 Hrs/Week
Credits: 04

Examination Scheme
In Semester Assessment : 50 Marks
End Semester Assessment : 50 Marks

Unit I: Introduction to Non Linear System
Classification of non-linearity’s, types of non-linearity in physical system, Peculiarities of nonlinear systems, methods of analysis of non-linear systems and comparison. (6 Hrs.)

Unit II: Phase Plane Analysis
Concept of phase plane, singular points, phase trajectory, phase portraits, methods of plotting phase plane trajectories Vander Pol’s equation, stability from phase portrait, time response from trajectories, Isocline method, Delta method of phase trajectory construction, MATLAB Simulation. (6 Hrs.)

Unit III: Describing Function Method
Describing function, DF of typical nonlinearities, stability analysis using DF method, pole zero shifting transformation, Circle criterion, Popov criterion. (6 Hrs.)

Unit IV: Liapunov Stability

Unit V: Stability Criterion
Linearization of nonlinear systems about equilibrium point, Methods of construction of Liapunov functions, Liapunov's direct method. Stability analysis of nonlinear system using Liapunov's theorems. (8 Hrs.)

Unit VI: Sliding Mode Control
Feedback linearization, Input Output linearization, Concept of sliding mode control, Nonlinear control system design using sliding mode technique. (4 Hrs.)

Text Books:
- Automatic Control System: George J. Thaler Brown, Jaico Publications
- Nonlinear Systems: Hasan A. Khalil, Prentice Hall of India

Reference Books:
- Control Systems Theory and Application: Samarjit Ghosh, Pearson Education
- Introduction to Control Engineering: A. K. Mandal, New Age International Publications
# 503104: RESEARCH METHODOLOGY

## Teaching Scheme
Lectures: 4 Hours / Week  
Credits: 4

## Examination Scheme
In Semester Assessment: 50  
End Semester Assessment: 50

### Unit I:
[8 Hrs]

### Unit II:
Research Formulation – Defining and formulating the research problem - Selecting the problem - Necessity of defining the problem - Importance of literature review in defining a problem – Literature review – Primary and secondary sources – reviews, treatise, monographs-patents – web as a source – searching the web - Critical literature review – Identifying gap areas from literature review - Development of working hypothesis. Summarizing a Technical Paper - summary template  
Online tools - Google, CiteSeer, ACM Digital Library, IEEE, The on-line Computer Science bibliography, Searching patents  
[8 Hrs]

### Unit III:
Research design, sampling design and scaling techniques – Research design – Basic Principles- Need of research design — Features of good design – Important concepts relating to research design, basic principles of experimental designs, implications of sample design, steps in sample design, criteria of selecting sampling procedure, characteristics of good sampling design, different types of sample design. Scaling techniques: measurement scales, sources of error, technique of developing measurement tool, important scaling techniques, scale construction techniques.  
[8 Hrs]

### Unit IV:
Data Collection and analysis:- Observation and Collection of primary and secondary data - Methods of data collection, processing operations, types of analysis, statistics in research, measures of central tendency, measures of dispersion, measures of asymmetry, measures of relationships, simple regression analysis, multiple correlation and regression, partial correlation.  
[8 Hrs]

### Unit V:
[8 Hrs]
Unit VI:

Text Books :
1. Kothari, C.R., Research Methodology: Methods and Techniques. New Age International
3. Suresh Sinha, Anil K Dhiman, Research Methodology, ESS Publications, Volumes 2
5. Wadehra, B.L. Law relating to patents, Trade Marks, copyright designs and geographical indications. Universal Law Publishing

Reference Books:
5. Fink, A., Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications
## 503105 (ELECTIVE – I)

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<td>Project Management</td>
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<td>503105 M1(ii)</td>
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Teaching Scheme
Lectures: 4 Hrs./Week
Credits: 4

Examination Scheme
In-Semester Examination: 25 Marks
End Semester Examination: 50 Marks

Unit I: Introduction
Basic concept of automation, types of automation: fixed, flexible and programmable and their comparative study. Robotics, definition, laws of Robotics, Introduction to NC and CNC machines - Basic concept, block diagram difference and comparison with robots, advantages, disadvantages and applications. Robot like devices such as prostheses, exoskeletons, teletherics, locomotive mechanism, robot manipulator, Concept of Workcell, Basic components of robot, Specifications of robot: degrees of freedom (DOF), accuracy, repeatability, spatial resolution, compliance, loads carrying capacity, speed of response, work volume, work envelope, reach.

(6 Hrs.)

Unit II: Fundamentals of Robot Technology
Basic structure, links and Joints, types of Joints, types of links, types of end effectors: Grippers: Mechanical, Vacuum cups, Magnetic, adhesive and miscellaneous. Tools as end effectors. Wrist configuration: concept of: yaw, pitch and roll.
Robot classification: according to 1) Co-ordinate system: Cartesian, cylindrical, spherical, SCARA, Articulated 2) Control Method: Servo controlled and non-servo controlled, their comparative study 3) Form of motion: P-T-P (point to point), C-P (continuous path), pick and place etc. and their comparative study 4) Drive Technology: Hydraulic, Pneumatic, Electric (stepper motor, D.C. servo motor) in detail with selection criteria. Motion conversion: Rotary to rotary, rotary to linear and vice versa.

(6 Hrs.)

Unit III: Industrial Applications and Robot Programming
Industrial Applications of Robots: Welding, Spray-painting, Grinding, Handling of rotary tools, Parts handling/transfer, Assembly operations, parts sorting, parts inspection, Potential applications in Nuclear and fossil fuel power plant etc. (Details for the above applications are selection criterion of robots, sensors used, selection of drives and actuators, methods of control, peripheral devices used etc) Programming of Industrial Robots: Concept of on-line and off line programming, concept of teach pendant, three levels of robot programming such as 1) Specialized manipulation languages 2) Robot library for an existing computer language 3) Robot library for a new general purpose language. Classification of robot specific languages on the basis of hardware level, point-to-point level, the motion level and structured programming level.

(6 Hrs.)

Unit IV: Robot arm dynamics and transformation

(6 Hrs)

Unit V: Kinematics
Inverse Kinematics: Inverse (back) solution by i) direct approach, ii) Geometric approach, iii) Geometric approach with co-ordinate transformation and iv) manipulation of symbolic T and A matrices.

(6 Hrs.)

Unit VI: Robot Control
Open loop and closed loop control, Linear control Schemes, PI and PID controllers, Torque and Force control of robotic manipulators, Adaptive control, Hybrid control, Impedance control. Manipulator Jacobian, Jacobian for prismatic and revolute joint. Jacobian Inverse, Singularities. Control of Robot manipulator: joint position controls (JPC), Resolved Motion Position Controls (RMPC) and Resolved Motion Rate Control (RMRC).

(6 Hrs.)

Text Books:

Reference Books:
Unit I
Dynamic systems, Examples of dynamic systems, Definitions related to dynamic systems, Classification of system inputs, classification of system models. System modeling and simulation.

Unit II: Modeling of Mechanical and Electrical Systems:

Unit III: Fluid Systems:

Unit IV: Transform Methods for Generalized Response:

Unit V: Generalized Modeling Methods:
Frequency response methods, Pulse testing methods, Random signal testing methods, Parameter tracking methods, Multiple regression and least square methods, Subsystem Coupling Methods.

Unit VI: Applications of Distributed Parameter Models
Longitudinal vibrations of a rod, Lumped parameter approximations for rod vibration, Conduction, heat translation in an insulated bar, Lumped parameter approximations for heat transfer in insulated bar. Magnetic levitation system for an Experimental Rail vehicle.

Text Books:
- System Modeling and Response: Theoretical and Experimental Approaches. Ernest O. Dobling, John Wiley and Sons, 1980

Reference Books:
- System Dynamics: Modeling Analysis, Simulation, Design: Ernest O. Dobling, Marcel Dekker Inc.

- Modeling of Dynamical Systems Vol. I: H. Nicholson (Editor), Peter Peregrinus Ltd., on behalf of IEE (Useful for unit 6) 116842, 1980 Edition

503105 M1(iii) : INDUSTRIAL AUTOMATION AND CONTROL

Teaching Scheme
Lectures: 4 Hr/Week
Credits:4

Examination Scheme
In-Semester Examination : 25 Marks
End Semester Examination:50 Marks

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(3wire), 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 layout guidelines of AC drive. Energy Savings with Variable Speed Drives, DC Motor Drives, DC and BLDC Servo Drives. [8Hrs]

References:
503105 M2 (i) : PROJECT MANAGEMENT

Teaching Scheme
Lectures: 1 Hr/Week
Credit: 1

Examination Scheme
In-Semester Examination : 25 Marks

Unit I

**Project Scheduling:** Gantt chart and its application, AOA (Activity on Arrow diagram), AON (Activity on Node) Diagram, Precedence diagramming methods (PDM), Critical Path Method (CPM), Programme Evaluation and Review Technique (PERT), GERT (Graphical Evaluation and Review Technique), Resource allocation, Line of Balancing and crashing the network.

**Project Quality Management:** The processes of project quality management, Quality planning, assurance and control, Quality of procured items, Techniques of quality assurance and control, project execution and control, International Project Management.  

[9Hrs]

Unit II

**Project Risk Management:** Introduction, Managing risks in projects, Measurement and assessment of risk, Sources of risks. Risk: - Adjusted discount rate method, certainly equivalent method, correlation coefficient, portfolio risks, diversible & non-diversible risks, CAPM (Capital Asset pricing model) case studies of project management, computer aided project management.  

[5Hrs]

Text Books:
3. Rosy Burke, “Project Management: planning and control technique”, Wiley India, 2003

Reference Books:
Teaching Scheme
Lectures: 1 Hr/Week
Credit: 1

Unit I:


Unit II:
Copyright: CEN-CENELEC copyright policy, piracy. Industrial design rights
Trademarks: Geographical indication, Protected designation of origin, Trade dress.
Other types: Database right, Fashion law, Indigenous intellectual property, Industrial design rights (or registered designs), Intellectual rights to magic methods, Internet domain name, Know how, Mask work (or Integrated circuit layout design protection), Open-source software, Orphan drug rights, Personality rights, Plant breeders' rights Patent law by region or country: Indian patent law, Australian patent law, Canadian patent law, Patent law of the People's Republic of China, European patent law, Japanese patent law, United States patent law. [7 Hrs]

Text Books:

References:
www.cen.eu, www.cenelec.eu
www.cencenelec.eu
http://ipindia.nic.in/
http://ipindia.nic.in/ipr/patent/patents.htm
http://www.cipo.ic.gc.ca (Canadian patent office)
http://www.epo.org(Europian patent office)
http://www.cas.go.jp/jp/seisaku/hourei/data/PA.pdf
http://nopr.niscair.res.in/bitstream/123456789/12687/1/JIPR%2016%285%29%20377-384.pdf
503105 M2 (iii) : TECHNICAL COMMUNICATION

Teaching Scheme
Lectures: 1 Hr/Week
Credit: 1

Examination Scheme
In-Semester Examination : 25 Marks

Unit I:
Effective Presentation Strategies
Define the purpose of presentation, Analyzing audience and locale, organizing contents, Preparing an Outline, Visual Aids, Understanding the nuance of delivery, sample speech and practice the presentation [3Hrs]

Listening techniques
Types of listening, listening with a purpose, barriers to listening, listening comprehension, effective listening strategies, listening in conversational interaction, team listening [2Hrs]

Speech techniques
Conversation and oral skills, strategies for good conversation, techniques to develop effective word accent, word stress, primary and secondary stress, use of correct stress pattern, developing voice quality, developing correct tone. [2Hrs]

Unit II:
Writing technical reports, research papers, dissertation, thesis and research proposals. Important parts of reports like abstract, results, conclusion. Supplementary parts like list of symbols, list of tables, annexures, references etc. Making title page, writing mathematical equations, including graphics, making tables and writing references using LaTex/ MiKTeX. Assignment for one technical proposal, one research paper and one technical report should be submitted using LaTex/MikTeX for in semester assessment. [7 Hrs]

Reference books

2) Effective Technical Communication, M Ashraf Rizvi, TATA McGRAW HILL
503105 M2 (iv) : SMART GRID TECHNOLOGIES

Teaching Scheme
Lectures: 1 Hr/Week
Credit: 1

Examination Scheme
In-Semester Examination : 25 Marks

Unit: I
Need of Synchro phasor Measurements, Phasor Measurement Unit : Architecture, Functions, Optimal Placement of PMUs, phasor data concentrators and associated communication system. Visualization tools to enhance visibility and control within transmission system, PMU measurements and sampling rates State Estimation & observability by using PMU, phasor data use for real time operation, frequency stability monitoring and trending, power oscillation, voltage monitoring and trending. Alarming and setting system operating limits. Dynamic line rating and congestion management, outage restoration. Application of PMU for wide area monitoring and control. [9Hrs]

Unit: II

Text Books:

Reference Books:
1. “Power System State Estimation”, Mukhtar Ahmad
3. “SMART GRID Infrastructure & Networking”, KRZYSZTOF INIEWSKI, TATA McGRAW-HILL EDITION.
A minimum of eight experiments should be performed under Lab Practice – I. Out of which minimum six experiments should be from the list below. Minimum six experiments should be based on compulsory subjects. A list of experiments that may be performed under various subjects of semester - I is given below as a guideline.

1. **Computational Techniques for Control Systems**
   a) Give Algorithm and flow chart for steepest descent method/conjugate gradient method with suitable example.
   b) State and explain standard LP Problems (or application of simplex method for LPP) with suitable example.
   c) State and explain any one of the method for unconstrained optimization (Dichotomous search, Fibonacci method and Golden section method).
   d) Dynamic programming in continuous time/Discrete time system for optimal solution of control system.

2. **Process Control Management:**
   a) To study the operation of Level transmitter, I/P converter and control valve.
   b) To determine step response of 2\textsuperscript{nd} order system and calculate time domain specifications.
   c) To study PI, PID controller for single loop feedback level control system.
   d) To study the closed loop cascade level sensor/transmitter from supervisory station i.e. from computer.

3. **Nonlinear Control Systems:**
   a) Simulate the various nonlinearities using Op. Amps.
   b) Construct Phase Plane Trajectory by any method and compare it with MATLAB Simulation for a nonlinear system.
   c) Determination of stability of nonlinear systems using Lyapunov function.
   d) Construct trajectories of Vander Pol’s equation.
Section I: Multivariable Control Systems

Unit I
Example of multivariable control systems, differential operator and transfer matrix, state-space models and system solution. (6 Hrs)

Unit II
Controllability, observability, state estimation, pole allocation, stability and reproducibility, minimal realization of multivariable control systems. (6 Hrs)

Unit III
Decoupling and model matching control., Extension of classical theory to Multivariable control systems. Design specifications for Multivariable Systems. (6 Hrs)

Section II: Optimal Control System

Unit IV

Unit V
Pontryagin’s minimum principle, application to optimal control of discrete and continuous systems. (5 Hrs)

Unit VI
Minimum time problems, Bang Bang Control, singular solutions. (5 Hrs)

Text Books:
- Linear Multivariable Control System: Y. S. Apte, New Age International Publication 1996
- Multivariable Control System: W. M. Wonham, Springer-Verlag, 1985

Reference Books:
- Control System Design: Goodwin, Graebe, Salgado
- Optimization Theory and Applications: S. Rao, Wiley Eastern
Unit I: Introduction to Identification techniques
Basic concepts of Identification and Adaptive Control Systems.
Identification Techniques -

- Parametric Methods: Least Square Estimation, Maximum Likelihood, Instrumental Variable Method
- Computation Methods: Levi son-type, Kalman- type and QR-type. (6 Hrs)

Unit II
Convergence and Consistency, Recursive Estimation, Bootstrapping, Experiment Design, Choice of Input, Model Structure and Order Determination, Model Validation, Practical Application. (5 Hrs)

Unit III: Learning Systems and Methods
Learning in Redundant computer configuration, Learning and pattern recognition, Parametric and non parametric training methods, Linear discreminal function, Learning systems with and without supervision, Decision theoretic methods, Bayesian learning. (6 Hrs)

Unit IV: Introduction to Adaptive Control and Real-Time Parameter Estimation

Unit V: Self-Tuning Regulators (STR)

Unit VI: Model-Reference Adaptive Systems (MRAS)

Text Books:

Reference Books:

503109: ADVANCED DIGITAL CONTROL TECHNIQUES

Teaching Scheme
Theory: 4 Hrs/Week
Credits: 4

Examination Scheme
In Semester Assessment: 50 Marks
End Semester Assessment: 50 Marks

Unit I: Digital Simulation and Digital Redesign
Introduction, Digital modeling with sample and hold devices, State variable formulation, Numerical integration, Frequency domain characteristics, Warping and Prewarping, Digital Redesigning, Closed form solution for Digital System, Partial matching of states, solution of the feedback matrix by series expansion, Stability consideration and Constraints on the selection of weighing matrix. (8 Hrs)

Unit II: Design of Discrete Data control Systems by Conventional Methods
Digital P, PI, PID controller, Design of Discrete Data System using Z-Transform method, Simple lag, lead and lag-lead compensators. (4 Hrs)

Unit III: Pole Placement Design and State Observer
Stability improvement by linear state feedback, Necessary and Sufficient conditions for arbitrary pole placement, State regulator design, Design of full State Observers, Design by separation principle. State feedback with integral control, digital control system with state feedback, deadbeat observer, Concept of Adaptive Control. (6 Hrs)

Unit IV
Multirate DSP, Decimation, Interpolation, Design of Practical Sampling, Rate Conversion, Design of FIR and IIR Filters, Finite word length effect in digital filters, discrete wavelet transform, adaptive filter components, algorithms. (8 Hrs)

Unit V
Digital Signal Processors - Features, Fixed and Floating point DSP, Selection of DSP, Architecture and Instruction set of TMS 320C5X, instruction pipelining, Application Programs. (5 Hrs)

Unit VI
Digital Signal Processors - Features, Fixed and Floating point DSP, Selection of DSP, Architecture and Instruction set of TMS320C54X DSP Processor, instruction pipelining, Application Programs. (5 Hrs)

Text Books:
- Discrete Time Control Systems, Pearson Education Asia, Katsuhiko Ogata
- Digital Control and State Variable Methods (conventional and Neuro Fuzzy Control), Tata McGraw Hill, M. Gopal
- Digital Signal Processing Implementation using DSP Microprocessors with Examples from TMS 320C54XX, Thomas Publication, Avatar Singh, S. Srinivasan
• Digital Signal Processor, B. Venkatramani, M. Bhaskar, Tata McGraw Hill

Reference Books:
• Digital Control Systems, Oxford Press, Koop
• Digital Signal Processing, Pearson Education, Ifeachar Jervis
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<td>503110 M2(ii)</td>
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<td>503110 M2(iv)</td>
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<td>503110 M2(v)</td>
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503110 M1 (i) : ROBUST CONTROL SYSTEMS

Teaching Scheme
Lectures: 4 Hrs./Week
Credits: 4

Examination Scheme
In-Semester Examination : 25 Marks
End Semester Examination: 50 Marks

Unit I: Introduction
Some common robust control problems. Linear system tools: Jordan and Real Jordan canonical forms, structural decomposition. (4 Hrs)

Unit II: Structural mapping of Bilinear Transformations:
Mapping of continuous time to discrete time and vice a versa, existence condition of $H_\infty$ sub optimal controllers, continuous time system and discrete time system. (7 Hrs)

Unit III: Solution to Discrete time Riccati Equations:
Solutions to general DARE and $H_\infty$-DARE. (7 Hrs)

Unit IV: Information in continuous time and discrete time $H_\infty$ optimization:
Full information feedback, output feedback, plants with imaginary axis zeros/unit circle zeros. (6 Hrs)

Unit V: Solutions to continuous time and discrete time $H_\infty$ problems:
Full state feedback, full order output feedback, reduced order output feedback. (6 Hrs)

Unit VI
Robust and perfect tracking of continuous time and discrete time systems, solvability conditions and solutions; solutions to measurement feedback. (6 Hrs)

Text Books:
- Robust and $H_\infty$ Control: Ben M. Chen, Springer Verlag, London, 2000

Reference Books:
- Robust Adaptive Control: Petros A. Ioannou, Jing Sun, Prentice Hall Int. Upper Saddle River, NJ07458
- Robust Process Control: M. Morari and E. Zafiriou, Prentice Hall 1989
- A Course in $H_\infty$ Control Theory: Francis
503110 M1(ii) : LARGE SCALE SYSTEMS

**Teaching Scheme**
- Lectures: 4 Hrs./Week
- Credits: 4

**Examination Scheme**
- In-Semester Examination : 25 Marks
- End Semester Examination: 50 Marks

**Unit I: Modeling and parameter estimation**
Introduction to probability theory, elements of estimation theory, application to parameter estimation for a dynamical model, some methods for the determination of transfer functions. (5 Hrs)

**Unit II: Parameter estimation for large scale systems**
Hierarchical parameter estimation, the multiple projection approach, recursive algorithm for the minimum variance estimator, simulation results. (5 Hrs)

**Unit III: Aggregation**
Aggregation of control systems, problem statement, properties of the aggregated system matrix, determination of the Aggregation matrix; Generation of feedback controls: linear dynamic optimization, bounds on sub optimality, eigenvalue assignment. (8 Hrs)

**Unit IV: Model reduction techniques**
Model analysis approach, mathematical development, three basic methods, and a general approach. Subspace projection methods, projection error minimization, and derivation of reduced model. Optimal order reduction, problem formulation, conditions of optimality, numerical algorithm, polynomial input functions. A comparative study. Extension to discrete systems, preliminary analysis, two model reduction techniques, output error minimization. Examples. (6 Hrs)

**Unit V**
Model simplification using frequency domain techniques. Simplification by continued function expansions: three Cauer forms, a generalized Routh algorithm, simplified models, relationship to aggregation, and extension to discrete models; Approximation methods for simplification: time moment matching, Padetype approximations, Routh-Hurwitz method. Minimal realization algorithms: conditions of reliability, Padé - type realizable models, aggregated model of Routh approximants. (6 Hrs)

**Unit VI: Time scale analysis**
Block-diagonalization of continuous systems: problem statement, numerical algorithms, basic properties, relation to model aggregation. Feedback control design: two stage eigenvalue placement. Decoupling of discrete systems:, state feedback design. (6 Hrs)

**Text Books:**
- Prof. B. Bandopadhyay – “Large scale systems”
Reference Books:

- Yacov Y. Haimes – “Large scale systems”, Publisher: North Holland publishing Co. Amsterdam.
503110 M2(i) : ELECTRIC VEHICLES

Teaching Scheme
Lectures: 1 Hr/Week
Credit : 1

Examination Scheme
In-Semester Examination : 25 Marks

Unit I
History and development of on-road Electric Vehicles (EV). Different configurations of hybrid EVs with block diagram representation, merits & demerits of different configurations in view of vehicle efficiency and energy storage system. [7 Hrs]

Unit II
Energy storage systems – Basics of EV batteries, specifications, power density, Energy density, Charging & Discharging cycle and recommended methodologies for charging. Recommended drives for EV and converter topology used in EVs. [7 Hrs]

Reference books –
1] Ron Hodkinson & John Fenton, Light Weight Electric/ Hybrid Vehicle design, Butterworth Publications, Heinemann
2] H. A. Kiehne, Battery Technology Handbook, MARCEDLE KKEIRN,C
3] Sandeep Dhameja, Electric vehicle battery systems, Butterworth–Heinemann
503110 M2 (ii) : FUNDAMENTALS OF CYBER SECURITY

Teaching Scheme
Lectures: 1 Hr/Week
Credit : 1

Examination Scheme
In-Semester Examination : 25 Marks

Unit I:
Introduction cyber security
Ethics and Law, What is a Cyber Crime / Social Theories, Computer Security: Then and Now,
Computer System Security / Access Controls, Intrusion Detection: An Overview, Malicious
Software Use and Detection [4 Hrs]

Security principles, threats and attack techniques: Introduction to security, Information
security, Security triad: Confidential, Integrity, Availability, Focus of control, Security threats
and attacks, Security management [2 Hrs]

Authentication and access control: Identification, Authentication, Authentication by
passwords, Protecting passwords, Access control structures, Types of access control [2 Hrs]

Unit II:
Lattice and reference monitors: Security levels and categories, Lattice diagram, Reference
monitors, Security kernel, Hardware security features, protecting memory [2 Hrs]

Security models: Bell-LaPadula, Biba, Non-deducibility, Non-interference, Other models [2 Hrs]

Cryptography: Cryptographic mechanisms, Digital signatures, Encryption, Certificates [2 Hrs]

Reference Books
86293-9
ISBN: 10: 0596006691

WEBSITES:
1) www.cert.org
2) www.microsoft.com/security/
3) www.sans.org
4) www.us.cert.gov
503110 M2 (iii) : DISASTER MANAGEMENT

Teaching Scheme
Lectures: 1 Hr/Week
Credit : 1

Examination Scheme
In-Semester Examination : 25 Marks

Unit I: Disaster, Hazards and Vulnerability
Concept of disaster, different approaches, concept of risk, levels of disasters Disaster phenomena and events, Natural and man-made hazards; response time, frequency and forewarning levels of different hazards, Characteristics and damage potential of natural hazards; hazard assessment, dimensions of vulnerability factors; vulnerability assessment, Vulnerability and disaster risk, Vulnerabilities to flood and earthquake hazards. [7 Hrs]

Unit II: Disaster management mechanism and Planning
Concepts of risk management and crisis management, Disaster management cycle Response and Recovery, Development, Prevention, Mitigation and Preparedness Planning for relief, Strategies for disaster management planning, Steps for formulating a disaster risk reduction plan, Disaster management Act and Policy in India, Organizational structure for disaster management in India, Preparation of state and district disaster management plans. [7Hrs]

Students shall submit a detailed case study report on any disaster, prevention and preparedness.

Text books

References
2. Disaster Management in India, Ministry of Home Affairs, Government of India, New Delhi, 2011.
5. http://nidm.gov.in/ - National Institute of Disaster Management (NIDM) (Ministry of Home Affairs, Govt. of India) website
503110 M2 (iv) : COMMUNICATION PROTOCOLS IN SCADA SYSTEM

Teaching Scheme
Lectures: 1 Hr/Week
Credit: 1

Examination Scheme
In-Semester Examination : 25 Marks

Unit I
SCADA Systems: Introduction and definitions of SCADA
Basic SCADA system Architecture: Human Machine Interface, Master Terminal Unit, Remote Terminal Unit Communications for SCADA systems, Configuration of SCADA systems, SCADA system applications, SCADA systems in operation and control of interconnected power systems, Functions of SCADA systems, Common features of SCADA systems Automatic substation control, SCADA configuration, Energy management system, system operating states, system security, State estimation

(7 Hrs)

Unit II
Communication in power systems: Inductive coordination, Voice communication, carrier systems, Power line carrier systems, Microwave systems, co axial cable and optical fiber system, two way mobile radio systems.

(7 Hrs)

Text Books:

Reference Books:
1. Gordan Clark, Deem Reynders, “Practical Modern SCADA Protocols”
503110 M2 (v) : MECHATRONICS

Teaching Scheme
Lectures: 1 Hr /Week
Credit : 1

Examination Scheme
In-Semester Examination : 25 Marks

Unit I: Introduction
Electrical Systems: Mathematical modeling of electro mechanical systems, RLC circuits, active and passive electrical circuits, PMDC motor, servo motor.
Mechanical Systems: Introduction to various systems of units, mathematical modeling of mechanical systems, Newton’s laws, moment of inertia, forced response and natural response, rotational systems, spring mass system, free vibration, spring mass damper system, mechanical systems with dry friction, work energy and power.
Fluid and Thermal Systems: mathematical modeling of liquid level system, resistance and capacitance of liquid level systems with interaction.
Pneumatic Systems: mathematical modeling, resistance and capacitance of pneumatic systems, linearization of non-linear systems. [7 Hrs]

Unit II: Design and Sensor Interfacing
A) Design of mechanical elements: design considerations, codes and standards, optimum design process, design variables, cost functions, design constraints, optimum design. Design of hydraulic system: hydraulic circuit design, actuator design, selection of pumps, selection of valves, design of control circuits.
b) Sensor Interfacing: analog and digital sensors, sensors for motion measurement, digital transducers, human–machine and machine-machine interfacing devices and strategy. [7 Hrs]

Reference Books:
503111: LAB PRACTICE – II

Teaching Scheme
4 Hrs/Week
Credits: 4

Examination Scheme
Term Work : 50 Marks
Oral : 50 Marks

A minimum of eight experiments should be performed under Lab Practice – II. Out of which minimum six experiments should be from the list below. Minimum six experiments should be based on compulsory subjects. A list of experiments that may be performed under various subjects of semester -II is given below as a guideline:

1. Multivariable & Optimal Control Systems
   a) Representation of multivariable control system in S.S, D.O and T. M. form.
   b) Pole placement using linear state variable form
   c) Numerical solution of matrix Riccati equation.
   d) Full order observer design/minimum time (Bang-Bang) control.

2. System Identification & Adaptive Control:
   a) Study of Nonparametric methods of system identifications.
   b) Simulation of Self Tuning Regulator
   c) Obtaining the time response of Model Reference Adaptive Control using MATLAB

3. Advanced Digital Control Technique:
   a) MATLAB based program for digital modeling with sample and Hold device / state variable formulation /Numerical Integration.
   b) MATLAB based simulation for study of concept of ‘warping & pre-warping’ principle.
   c) Design an existing control system using digital PID controller
   d) Comparison of TMS320C5X & TMS320C54X DSP based program.
503112 : SEMINAR – I

Teaching Scheme
4 Hrs/Week
Credits : 4

Examination Scheme
Term Work : 50 Marks
Oral/ Presentation : 50 Marks

Seminar I shall be on state of the art topic of student’s own choice based on relevant specialization approved by an authority. 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.
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)
Text Books:

Reference Books:
   1. V. Subrahmanyam, “Electric Drives-Concepts and Applications”, TMH
Unit I: Introduction
Application of software and simulink for control system design. Review of compensation technique and choice of optimum parameters to obtain desired performance. Absolute stability and relative stability concepts. (5 Hrs)

Unit II: Design of Linear Control Systems
Transient and steady state response; Polar, Bode, Root locus plots; Reshaping of these plots to obtain desired response, Initial condition and forced response. (7 Hrs)

Unit III: Design of control systems by state variable techniques
Controllability, Observability; Stability by using computer methods; solution of state and output equations of closed loop systems. Pole placement design, Full and reduced order observers, Linear Regulator problem, Quadratic performance Criterion. (6 Hrs)

Unit IV: Design of nonlinear control systems
Phase plane technique, Describing Function method for nonlinearities like saturation, dead space, ON/OFF nonlinearities. Simulation techniques. (6 Hrs)

Unit V: PID Controller
Tunable PID controller, Ziegler – Nichol’s method, Simulation of multi-loop control system using P, PI, PID controller and finding the system response. Standard compensator structures: P, PI and PID control. (6 Hrs)

Unit VI: Design of digital control system
Technique and methodology; Computation of digital equivalent of the analog controller, simulation and performance. Digital controller design, Regulator and observer design. (6 Hrs)

Text Books:
Reference Books:

### 603103: (ELECTIVE III)

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<td>603103 M3(v)</td>
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Unit I: Introduction to Neural Networks

(6 Hrs)

Unit II: Feed Forward Neural Networks

(6 Hrs)

Unit III: Associative Memories

(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.

(6 Hrs)

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

(6 Hrs)
**Text Books:**
1. Neural Network Design-Hagan, Demuth, Beale- Thomas Learning, Vikas Publishing House
3. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan and Rai - PHI Publication.

**Reference Books:**
3. Neural Networks - Simon Hykins, Pearson Education
4. Neural Engineering by C. ElıaSMıth and CH. Anderson, PHI
603103 M1 (ii) : SCADA SYSTEMS AND APPLICATIONS

Teaching Scheme  
Lectures: 4 Hrs./Week  
Credits: 4

Examination Scheme  
In-Semester Examination : 25 Marks  
End Semester Examination:50 Marks

Unit I: Introduction to SCADA and PLC:  
SCADA: Data acquisition system, evaluation of SCADA, communication technologies, monitoring and supervisory functions. PLC: Block diagram, programming languages, Ladder diagram, Functional block diagram, Applications, Interfacing of PLC with SCADA.  
(8 Hrs)

Unit II: SCADA system components:  
Schemes, Remote Terminal Unit, Intelligent Electronic Devices, Communication Network, SCADA server.  
(5 Hrs)

Unit III: SCADA Architecture  
Various SCADA Architectures, advantages and disadvantages of each system, single unified standard architecture IEC 61850 SCADA / HMI Systems.  
(6 Hrs)

Unit IV: SCADA Communication  
Various industrial communication technologies- wired and wireless methods and fiber optics, open standard communication protocols.  
(6 Hrs)

Unit V: Operation and control of interconnected power system  
Automatic substation control, SCADA configuration, Energy management system, system operating states, system security, state estimation.  
(6 Hrs)

Unit VI: SCADA applications  
Utility applications, transmission and distribution sector operation, monitoring analysis and improvement. Industries oil gas and water. Case studies, implementation, simulation exercises.  
(5 Hrs)

Text Books:  
- Stuart A Boyer: SCADA supervisory control and data acquisition, International Society of Automation, 2010  
- Gordan Clark, Deem Reynders, Practical Modern SCADA Protocols

Reference Book:  
603103 M2(i) : ARTIFICIAL INTELLIGENT TOOLS

Teaching Scheme
Lectures: 1 Hr /Week
Credit : 1

Examination Scheme
In-Semester Examination : 25 Marks

Unit I: Fuzzy Logic System
Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control. Fuzzification, inferencing and defuzzification. Fuzzy knowledge and rule bases. Fuzzy modeling and control schemes for nonlinear systems. Self-organizing fuzzy logic control. Case studies and assignment based on applications of fuzzy logic. [ 7Hrs]

Unit II Genetic Algorithm
Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Concept on some other search techniques like tabu search and and-colony search techniques for solving optimization problems. GA application to power system optimization problem, Case studies: based on use of GA for optimization. [ 7Hrs ]

Text Books:
1) M. Ganesh “Introduction to Fuzzy Sets and Fuzzy Logic”, Prentice Hall, India.

Reference Books:
Teaching Scheme
Lectures: 1 Hr/Week
Credit: 1

Examination Scheme
In-Semester Examination: 25 Marks

Unit I: Introduction
Sensors: primary sensing principles and measurement variables, sensor performance characteristics and terminology. Instrumentation: transducer measurement circuit, signal conditioning circuit, Data conversion: DAC, ADC, virtual instrumentation with Lab View. [7 Hrs]

Unit II: Smart Sensors
Primary sensors; excitation; compensation; information coding/processing; data communication; standards for smart sensor interface. Recent trends in sensor technologies: Introduction; film sensors (thick film sensors, thin film sensors); semiconductor IC technology standard methods; Micro Electro-Mechanical Systems (micro-machining, some application examples); nanosensors. [7 Hrs]

Textbooks:

Reference Book:
Teaching Scheme
Lectures: 1 Hr/Week
Credit : 1

Unit 1:
Human Rights – Concept, Development, Evolution
- Philosophical, Sociological and Political debates
- Benchmarks of Human Rights Movement.
Human Rights and the Indian Constitution
- Constitutional framework
- Fundamental Rights & Duties
- Directive Principles of State Policy
- Welfare State & Welfare Schemes
Human Rights & State Mechanisms
- Police & Human Rights
- Judiciary & Human Rights
- Prisons & Human Rights
- National and State Human Rights Commissions [ 7 Hrs]

Unit 2:
Human Rights of the Different Sections and contemporary issues
- Unorganized Sector
- Right to Environment,
- Globalization and Human Rights
- Right to Development,
Citizens’ Role and Civil Society
- Social Movements and Non-Governmental Organizations
- Public Interest Litigation
- Role of Non Government organizations in implementation of Human rights.
- Right to Information
  Human Rights and the international scene –Primary Information with reference to Engineering Industry
- UN Documents
- International Mechanisms (UN & Regional)
- International Criminal Court [7Hrs]

References:
1) Study material on UNESCO,UNICEF web site
2) HUMAN RIGHTS IN INDIA A MAPPING, Usha Ramanathan
   Available at: http://www.ielrc.org/content/w0103.pdf
Unit I : Sustainability and Building design
Sustainability, objectives of sustainable development, Sustainable aspects of habitat design, sustainable buildings, principles, approaches and characteristics, climate data, climate parameters and zones, comparative analysis of various climatic zones, site planning recommended check list for identifying site characteristics, site development and layout. Efficient water management and waste water treatment, solid waste management. [7 Hrs]

Unit II : Energy efficiency :
Solar passive techniques in building design to minimize load on conventional system i.e. heating, cooling, ventilation and lighting. Designing Energy efficient lighting and HVAC systems. Use of renewable energy system to meet part of building load. Green building certification. Overview various green building in India. Policy and regulatory mechanism. [7 Hrs]

Text Book :
Seven wonders of Green Building Technology- Karen Sirvaitis, Twenty first century books.

References :
1 Sustainable Building Design Manual, Volume 2, TERI, New Delhi
2 Energy Efficient Buildings in India, TERI, New Delhi
3 Sustainable Building Design Manual, Volume 1 TERI, New Delhi
603103 M2 (v) : MEMS AND APPLICATIONS

Teaching Scheme
Lectures: 1 Hr/Week
Credit : 1

Examination Scheme
In-Semester Examination : 25 Marks

Unit I: Introduction
Characteristics of MEMS, energy domains and transducers, sensors and actuators, Introduction to micro fabrication, silicon based MEMS processes, new materials, and review of electrical and mechanical concepts in MEMS, semiconductor devices, stress and strain analysis. [7 Hrs]

Unit II: Sensors and Actuators
Piezo-resistive sensors and piezoelectric sensors – sensor materials - applications to inertia, pressure, and flow. [7 Hrs]

Textbook:

Reference Books:
603104 : SEMINAR – II

Teaching Scheme
4 Hrs / Week
Credits : 4

Examination Scheme
Term Work : 50 Marks
Oral/ Presentation : 50 Marks

Seminar II shall be on the topic relevant to latest trends in the field of concerned branch, preferably on the topic of specialization based on the electives selected by him/her approved by authority. The student shall submit the seminar report in standard format, duly certified for satisfactory completion of the work by the concerned guide and head of the Department/Institute.
### 603105: PROJECT STAGE – I

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Examination Scheme</th>
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</thead>
<tbody>
<tr>
<td>8 Hrs/Week</td>
<td>Term Work : 50 Marks</td>
</tr>
<tr>
<td>Credits: 8</td>
<td>Oral/ Presentation : 50 Marks</td>
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<td></td>
<td>Total : 100 Marks</td>
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</tbody>
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Project work Stage – I is an integral part of the project work. In this, the student shall complete the partial work of the project which will consist of problem statement, literature review, project overview, scheme of implementation (Mathematical Model/block diagram/PERT chart, etc.) and Layout & Design of the Set-up. As a part of the progress report of Project work Stage-I, the candidate shall deliver a presentation on the advancement in Technology pertaining to the selected dissertation topic.

The student shall submit the duly certified progress report of Project work Stage-I in standard format for satisfactory completion of the work by the concerned guide and head of the Department / Institute.
603106 : SEMINAR- III

Teaching Scheme
5 Hrs/Week
Credits:5

Examination Scheme
Term Work : 50 Marks
Oral/ Presentation : 50 Marks
Total : 100 Marks

Seminar III shall preferably be an extension of seminar II. 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.
In Project Work Stage – II, the student shall complete the remaining part of the project which will consist of simulation, fabrication of set up required for the project, work station, conducting experiments and taking results, analysis & validation of results and conclusions.

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