ELECTRICAL AND ELECTRONICS ENGINEERING

DEPARTMENT

Structure and syllabus

Of

M. Tech. (Electrical Drives and Control)

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.
Electrical and Electronics Engineering Department

Proposed Teaching and Examination Scheme for
M. Tech. (Electrical Drives and Control) w. e. f. July 2017

**SEMESTER I**

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Name of the Subject</th>
<th>Teaching Scheme (Hours/Week)</th>
<th>Credit</th>
<th>Examination Scheme</th>
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<tbody>
<tr>
<td>MTEDC101</td>
<td>Modern Control System</td>
<td>03 01 -- 04</td>
<td>60</td>
<td>20</td>
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<tr>
<td>MTEDC102</td>
<td>Electrical Machine Modelling and Analysis</td>
<td>03 01 -- 04</td>
<td>60</td>
<td>20</td>
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<td>MTEDC103</td>
<td>DC Drives</td>
<td>03 01 -- 04</td>
<td>60</td>
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<td>MTEDC104</td>
<td>Elective-I</td>
<td>03 - -- 03</td>
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<td>MTEDC105</td>
<td>Elective-II</td>
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<tr>
<td>MBS106</td>
<td>Communication Skills</td>
<td>02 - -- 02</td>
<td>-</td>
<td>25</td>
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<tr>
<td>MTEDC107</td>
<td>PG Lab-I</td>
<td>-- - 03 02</td>
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**Total** 17 03 03 150 50 600

**Elective-I MTEDC104**
1) Advanced Digital Signal Processing
2) Special Electrical Machines
3) Power Quality Assessment and Mitigation

**Elective-II MTEDC105**
1) Modern Power Electronics
2) Advanced Process Control
3) Embedded Systems

**SEMESTER II**

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Name of the Subject</th>
<th>Teaching Scheme (Hours/Week)</th>
<th>Credit</th>
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<tr>
<td>MTEDC201</td>
<td>Adaptive Control System</td>
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<td>MTEDC202</td>
<td>AC Drives</td>
<td>03 01 -- 04</td>
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<td>03 - -- 03</td>
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<td>MTEDC204</td>
<td>Elective-IV</td>
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<td>MTEDC205</td>
<td>Elective-V (Open)</td>
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<td>MTEDC206</td>
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<td>PG Lab-II or Mini Project</td>
<td>-- - 04 02</td>
<td>-</td>
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**Total** 15 02 08 21 100 50 100 50 50 700

**Elective-III MTEDC203**
1) Intelligent Control
2) Power Electronics for Renewable Energy Systems
3) Electric Traction

**Elective-IV MTEDC204**
1) Robotic and Control
2) Electric and Hybrid Vehicles
3) Electromagnetic Interference & Compatibility In Power Electronic System

**Elective-V MTEDC205**
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. (ELECTRICAL DRIVES and CONTROL)

### SEMESTER–III

<table>
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<tr>
<th>Subject Code</th>
<th>Name of the Subject</th>
<th>Teaching Scheme (Hours/Week)</th>
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<td>MTME301</td>
<td>Project Management and Intellectual Property Rights (Self Study)*</td>
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<td>TH -- CA -- PR/OR 50 Tests 50 Total 100</td>
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### SEMESTER–IV

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<th>Teaching Scheme (Hours/Week)</th>
<th>Credit</th>
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<td>MTEDC401</td>
<td>Project work Phase-II</td>
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</table>
SEMESTER I
MTEDC101: 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)

UNIT II: POLE PLACEMENT TECHNIQUES  (07 Hours)

UNIT III: NONLINEAR CONTROL SYSTEM  (10 Hours)

UNIT IV: OPTIMAL CONTROL  (08 Hours)

UNIT V: DIGITAL CONTROL SYSTEMS  (08 Hours)
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.
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.
SEMESTER I
MTEDC102: ELECTRICAL MACHINES MODELING AND ANALYSIS

COURSE OUTCOMES:
At the end of the course the student will be able to:
1) Develop models for linear and nonlinear magnetic circuits
2) Determine the developed torque in an electrical machine of field energy and co energy and determine the dynamic model of a DC machine.
3) Use the reference frame theory for developing machine models
4) Determine the dynamic model of an induction machine based on the dq0 Transformation
5) Determine the torque developed in a salient pole synchronous machine using the Park's transformation.

COURSE CONTENTS:
UNIT I: BASIC PRINCIPLES OF ELECTRICAL MACHINE ANALYSIS (09 Hours)
Magnetically coupled circuits: review of basic concepts, magnetizing inductance, Modeling linear and nonlinear magnetic circuits
Electromechanical energy conversion: principles of energy flow, concept of field energy and co energy, Derivation of torque expression for various machines using the principles of energy flow and the principle of co energy, Inductance matrices of induction and synchronous machines.

UNIT II: THEORY OF DC MACHINES (08 Hours)
Review of the DC machine- State-space model of a DC machine- reduced order model & transfer functions of the DC machine.

UNIT III: REFERENCE FRAME THEORY (09 Hours)
Concept of space vector- types of transformation- condition for power invariance- zero-sequence component- expression for power with various types of transformation - transformations between reference frames - Clarke and Park's Transformations - variables observed from various frames.

UNIT IV: THEORY OF SYMMETRICAL INDUCTION MACHINES (09 Hours)
Voltage and torque in machine variables - derivation of dq0 model for a symmetrical induction machine - voltage and torque equation in arbitrary reference frame variables - analysis of steady-state operation - state-space model of induction machine in 'd-q' variables.

UNIT V: THEORY OF SYNCHRONOUS MACHINES (07 Hours)
Equations in arbitrary reference frame, Park's transformation, derivation of dq0 model for a salient pole synchronous machine with damper windings, torque expression of a salient pole synchronous machine with damper windings and identification of various components.

REFERENCES:
7) R. Krishnan, “Electric Motor Drives – Modelling, Analysis and Control”, PHI.
SEMESTER 1
MTEDC103: DC DRIVES

COURSE OUTCOMES:
1) Explain the basics of Electrical Drives.
2) Specify the appropriate power circuit configuration amongst the phase controlled rectifiers for the speed control of DC motor drives.
3) Specify the appropriate power circuit configuration amongst the chopper for the speed control of DC motor drives.
4) Develop the closed loop controlled DC drives.
5) Describe the modern trends of DC Drives.

COURSE CONTENTS:

UNIT I: INTRODUCTION (06 Hours)
Electrical Drives, advantages, elements of drive system, drive characteristics, criteria for selection of drive components, dynamics of D.C. motor drives, steady-state stability.

UNIT II: PHASE CONTROLLED D.C. MOTOR DRIVES (10 Hours)
Introduction, principle of DC motor speed control, phase controlled converters, steady state analysis of three phase converter controlled DC motor Drive, two quadrant three phase controlled DC drive.

UNIT III: CHOPPER CONTROLLED DC MOTOR DRIVES (10 Hours)
Introduction, Principle of operation of the chopper, Chopper controlled drives, Duty-ratio control, current-limit control, steady state analysis, four quadrant chopper circuit, chopper for inversion, chopper with other power devices, mode of chopper, input to the chopper, steady state analysis of chopper controlled DC Drives, pulsating torques, DC motor Drive with field weakening, four quadrant DC motor drives, converter selection and characteristics.

UNIT IV: CLOSED-LOOP CONTROL OF DRIVES (10 Hours)
Introduction- Basic features of an Electric Drive- Block diagram representation of Drive systems, signal flow graph representation of the systems, Transfer functions, transient response of closed loop drives systems. Speed control of a separately excited DC drive with inner current loop and outer speed loop,

UNIT V: DC DRIVES APPLICATION (06 Hours)
Harmonics and it’s associated problems, modern trends in Electrical Drive, DSP controlled Electrical Drive, Heating/cooling and insulation in motors. Choice of motors and rating. Electromagnetic Control of Motors; .

REFERENCES:

3) Shepherd Hullay & Liag, Power Electronics & Motor Control: Cambridge Univ. Press
4) R.Krishnan, Electric Motor drives – Modelling, Analysis & Control.; PHI India,Ltd.
5) Vedam Subramanyam, Thyristor Control of Electric Drives.
SEMESTER I
ELECTIVE I: MTEDC104: ADVANCED DIGITAL SIGNAL PROCESSING

COURSE OUTCOMES:
1) Apply digital signal processing techniques to analyze LTI systems in time and frequency domain.
2) Design and Analyze FIR digital filters.
3) Design and Analyze IIR digital filters.
4) Understand and be able to implement adaptive signal processing algorithms.
5) Acquire the basics of multirate digital signal processing.
6) Explain and implement digital signal processing techniques on general purpose Digital signal processors.

COURSE CONTENTS:

UNIT I: DISCRETE TIME SIGNALS (08 Hours)
Introduction to Discrete time signals LTI system-stability-properties-sampling frequency domain Representation of discrete time signals and systems, discrete random signals-transforms, Properties, Inverse Z transforms.

UNIT II: DIGITAL FIR FILTER DESIGN (08 Hours)
Design of FIR filters - structures, windowing method, optimal method, Frequency sampling method.

UNIT III: DIGITAL IIR FILTER DESIGN (06 Hours)

UNIT IV: ADAPTIVE DIGITAL FILTERS (08 Hours)
Adaptive filters, Examples of Adaptive filtering, the minimum mean square error criterion; The Windrow and Hoff LMS Algorithm, Recursive least square Algorithm, Applications.

UNIT V: MULTI RATE DIGITAL SIGNAL PROCESSING (06 hours)
The basic sample rate Alteration Devices-Filters with sampling rate Alteration systems, Multistage Design of Decimators and Interpolators, Arbitrating rate sampling rate converter, Polyphase decomposition, digital filter design –Application.

UNIT VI: GENERAL PURPOSE DIGITAL SIGNAL PROCESSORS (06 hours)
Architecture of general purpose Digital signal processors, Implementation of DSP algorithms on general purpose processors.

REFERENCES:
5) Signals and systems, Simon Haylaim and Barry van veen, John wiley and sons India.
COURSE OUTCOMES:
After the completion of the course the students will be able to:
1) Describe the fundamental concepts of permanent magnets and the operation of permanent magnet brushless DC motors.
2) Explain the concepts of permanent magnet brushless synchronous motors and synchronous reluctance motors.
3) Develop the control methods and operating principles of switched reluctance motors.
4) Introduce the concepts of stepper motors and its applications.
5) Explain the basic concepts of other special machines.

COURSE CONTENTS:

UNIT I: Permanent Magnet Brushless DC Motors (08 Hours)

UNIT II: Permanent Magnet Synchronous Motor (08 Hours)

UNIT III: Switched Reluctance Motors (09 Hours)
Constructional features –Principle of operation– Torque prediction–Characteristics Power controllers – Control of SRM drive- Sensor less operation of SRM – Applications.

UNIT IV: STEPPER MOTORS (10 Hours)
High-Speed Operation of Stepper-Motors: Pull-out torque/speed, characteristics of Hybrid stepper motors, calculation of pull-out torque, pull-out torque/speed characteristics for the VR stepper-motors, calculation of the pull out torque.

UNIT V: OTHER SPECIAL MACHINES (07 Hours)
Principle of operation and characteristics of Hysteresis motor – AC series motors – Linear motor – Applications.

REFERENCES:
SEMESTER I

ELECTIVE I: MTEDC104: POWER QUALITY ASSESSMENT AND MITIGATION

COURSE OUTCOMES:

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

1) Understand the different power quality problems and standards.
2) Identify waveform distortion, sources, causes and apply the various ways to reduce the waveform distortion.
3) Describe the voltage sag and interruption and apply techniques to reduce the sag in system.
4) Understand the use of power monitoring procedure to access the power quality
5) Apply the mitigation techniques to reduce the adverse effects of power quality on system and equipment.

COURSE CONTENTS:

UNIT I: INTRODUCTION (7 Hours)
Importance of power quality, terms and definitions of power quality as per IEEE std. 1159 such as transients, short and long duration voltage variations, interruptions, short and long voltage fluctuations, imbalance, flickers and transients. Symptoms of poor power quality. Definitions and terminology of grounding. Purpose of groundings. Good grounding practices and problems due to poor grounding.

UNIT II: FLICKERS AND TRANSIENT VOLTAGE (7 Hours)
RMS voltage variations in power system and voltage regulation per unit system, complex power. Principles of voltage regulation. Basic power flow and voltage drop. Various devices used for voltage regulation and impact of reactive power management. Various causes of voltage flicker and their effects. Short term and long term flickers. Various means to reduce flickers. Transient over voltages, sources, impulsive transients, switching transients, Effect of surge impedance and line termination, control of transient voltages

UNIT III: VOLTAGE SAG AND INTERRUPTIONS (7 Hours)
Definitions of voltage sag and interruptions. Voltage sags versus interruptions. Economic impact of voltage sag. Major causes and consequences of voltage sags. Voltage sag characteristics. Voltage sag assessment. Influence of fault location and fault level on voltage sag. Areas of vulnerability. Assessment of equipment sensitivity to voltage sags. Voltage sag requirements for computer equipment, CBEMA, ITIC, SEMI F 42 curves. Representation of the results of voltage sag analysis. Voltage sag indices. Mitigation measures for voltage sags, such as UPS, DVR, SMEs, CVT etc., utility solutions and end user solutions

UNIT IV: WAVEFORM DISTORTION (7 Hours)

UNIT V: POWER QUALITY MONITORING (7 Hours)
Need of power quality monitoring and approaches followed in power quality monitoring. Power quality monitoring objectives and requirements. Initial site survey. Power quality Instrumentation. Selection of power quality monitors, selection of monitoring location and period. System wide and
discrete power quality monitoring. Setting thresholds on monitors, data collection and analysis. Selection of transducers. Harmonic monitoring, transient monitoring, event recording and flicker monitoring.

**UNIT VI: POWER QUALITY ASSESSMENT AND MITIGATION** (7 Hours)

Power Quality assessment, Power quality indices and standards for assessment disturbances, waveform distortion, voltage and current unbalances. Power assessment under waveform distortion conditions. Power quality state estimation, State variable model, observability analysis, capabilities of harmonic state estimation. Test systems. Mitigation techniques at different environments

**REFERENCES:**

6) IEEE standards 519 and 1159
SEMESTER I
ELECTIVE II: MTEDC105: MODERN POWER ELECTRONICS

COURSE OUTCOMES:

1) Analyze the AC to DC and DC to DC converter.
2) Analyze the DC to AC converter.
3) Apply the modulation techniques for the various types of inverters.
4) Analyze the AC to AC converter.
5) Use the various firing and protection circuit.
6) Demonstrate the multi level inverter

COURSE CONTENTS:

UNIT I: AC TO DC AND DC TO DC CONVERTER (08 Hours)
Classification of chopper, Operation of Jones, multiphase chopper, Performance parameter of converter, Control strategies, Chopper circuit Design, detailed analysis of buck converter, boost converter and buck-boost converter.

UNIT II: DC TO AC CONVERTER (06 Hours)

UNIT III: MODULATION TECHNIQUES (06 Hours)
Voltage control PWM techniques (Simple PWM, Multiple PWM, Sinusoidal PWM, and Modified Sinusoidal PWM). Low and high frequency switching operation. Voltage control of three phase inverters – Space Vector PWM. Application of modulation techniques

UNIT IV: AC TO AC CONVERTER (08 Hours)
Principle of operation of cyclo-converters - three phase to single phase - three phases to three phase - input and output performances - output voltage and frequency ranges - harmonics - pulse generation and controls for cyclo-converter.
Single phase and three phase ac voltage controller-output voltage control. Phase angle range, Input and output performance.

UNIT V: PROTECTION AND FIRING CIRCUIT (08 Hours)
Over-voltage and over-current protection, Gate protection, EMI, Snubber circuit, Different Heat sinks, Commutation circuit.
Firing Circuit: R, RC firing circuit, micro-processor based firing scheme for three phase full bride converter.

UNIT VI: DC-AC MULTILEVEL CONVERTERS (06 Hours)
Multi-level Inversion - concept, classification of multilevel inverters, Principle of operation, main features and analysis of Diode clamped, Flying capacitor and cascaded multilevel inverters.

REFERENCES:

4) P.S. Bimbhra, “Power Electronics” Khanna Publication.
SEMESTER I

ELECTIVE II: MTEDC105: ADVANCED PROCESS CONTROL

COURSE OUTCOMES:
Upon successful completion of this course, a student should be able to:
1) Understand the application of different process control systems.
2) Analyze the application of different controllers and their applications to suitable process.
3) Understand the constructional details, principle of operation, and performance of different unit operations and their Instrumentation.
4) Analyze the advanced control concepts, system identification and process modelling.
5) Perform Testing, Erection, Commissioning of typical process industry

COURSE CONTENTS:

UNIT I: INTRODUCTION TO PROCESS CONTROL (08 Hours)
Introduction to performance characteristics of different transducers and systems, Dynamic analysis of measurement systems, errors in instrumentation systems. Introduction to process control, representative process control problems, classification of process control strategies, Major steps in control system developments. Introduction to Unit Operations and theoretical modeling, concept of Unit and Unit Operation, Material Balance and Energy Balance, Introduction to Evaporation, Distillation, Crystallization processes and associated Instrumentation and control. Introduction to process equipments like Continuous Stirred Tank Reactor (CSTR), Heat Exchanger, liquid storage systems and their modeling, dynamic behavior of first and second order processes, dynamic response of the processes, development of empirical models for process data.

UNIT II: OVERVIEW OF PROCESS CONTROL SYSTEM DESIGN (06 Hours)
Introduction, degree of freedom for process control, selection of controlled, manipulated and measured variable, process safety and process control.

Unit III: FEEDBACK CONTROL AND PID CONTROLLER FOR PROCESS CONTROL (10 Hours)

UNIT IV: CASCADE CONTROL, RATIO AND FEED FORWARD CONTROL (06 Hours)
Introduction to Feed forward and ratio control, cascade control and their design consideration, controller algorithm, tuning.

UNIT V: MULTIVARIABLE CONTROL (07 Hours)
UNIT VI: PROCESS TESTING, ERECTION, COMMISSIONING (05 Hours)
Project Documentation, Specification Sheet, Index Sheet, Flow Diagram, Schedules used in typical process industry erection.
Testing, Erection, Commissioning of typical process industry.

REFERENCES:
3) Process control by Peter Harriot Tata McGraw hill.
4) Automatic process control by D. Ekman, Wiley Eastern Ltd.
5) Process control system Application, Design and tuning by F.G. Shinsky McGraw hill.
6) Unit operation and chemical engineering by Mc Cabe McGraw hill Publication.
SEMESTER I
ELECTIVE II: MTEDC105: EMBEDDED SYSTEMS

COURSE OUTCOMES:
1) Define and explain embedded systems and the different embedded system design technologies explain the various metrics or challenges in designing an embedded system
2) Become aware of the architecture of the ARM processor and its programming aspects (assembly Level)
3) Foster ability to understand the internal architecture Processor LPC 2148
4) Understand key concepts of embedded systems like IO, timers, interrupts, interaction with peripheral devices
5) Design real time embedded systems using the concepts of RTOS.
6) Analyze various examples of embedded systems based on ARM processor.

COURSE CONTENTS:
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:
3) Andrew Sloss, Andrew Sloss, “ARM System Developers Guide”

SEMESTER-I

MTEDC106: COMMUNICATION SKILLS

COURSE OUTCOMES:

At the end of the course, the student will be able to:
1) Students are found to be confident while using English.
2) Engage in analysis of speeches or discourses and several articles.
3) Identify and control anxiety while delivering speech.
4) Write appropriate communications (Academic/Business).
5) Prepared to take the examinations like GRE/TOFEL/IELTS.
6) Identify and control the tone while speaking.
7) Develop the ability to plan and deliver the well-argued presentations.

COURSE CONTENTS:

UNIT I: COMMUNICATION AND COMMUNICATION PROCESSES (04 Hours)
Introduction to Communication, Forms and functions of Communication, Barriers to Communication and overcoming them, Verbal and Non-verbal Communication, Ways of Effective Communication.

UNIT II: ORAL COMMUNICATION (06 Hours)

UNIT III: STUDY OF SOUNDS IN ENGLISH (04 Hours)
Introduction to phonetics, Study of Speech Organs, Study of Phonemic Script, Articulation of Different Sounds in English, Stress Mark.

UNIT IV: ENGLISH GRAMMAR (04 Hours)
Grammar: Forms of Tenses, Articles, Prepositions, Use of Auxiliaries and Modal Auxiliaries, Synonyms and Antonyms, Common Errors, Sentence Formation and Sentence Structures, Use of Appropriate Diction.

UNIT V: WRITING SKILLS (06 Hours)

UNIT VI: READING SKILLS & LISTENING SKILLS (04 Hours)
Reading: Introduction to Reading, Barriers to Reading, Types of Reading: Skimming, Scanning, Fast Reading, Strategies for Reading, Comprehension.
Listening: Importance of Listening, Types of Listening, Barriers to Listening.

REFERENCES:

**SEMESTER-I**

**MTEDC107: PG LAB-I**

Students are instructed to frame and perform laboratory assignment based on each of the 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.
SEMESTER II

MTEDC201: ADAPTIVE CONTROL SYSTEM

COURSE OUTCOMES:
At the end of the course, the student will be able to:
1) Design and Implement System Identification Experiments.
2) Estimate Parameters in Dynamical System.
3) Use System Identification Methods to Design Adaptive Controllers.
4) Design Direct and Indirect Self-Tuning Regulators via Minimum Degree Pole Placement.
5) Design Model Reference Adaptive Controllers via the MIT Rule.
7) Explain the Advantages and Disadvantages of Adaptive Control Relative to Other Control Approaches.

COURSE CONTENTS:

Unit I: INTRODUCTION TO ADAPTIVE CONTROL (07 Hours)

Unit II: PARAMETER ESTIMATION (07 Hours)

Unit III SELF-TUNING REGULATORS (STR) (07 Hours)

Unit III: MODEL REFERENCE ADAPTIVE SYSTEM (07 Hours)

Unit V: GAIN SCHEDULING (07 Hours)

Unit VI: ADAPTIVE CONTROL APPLICATIONS (07 Hours)

REFERENCES:

SEMESTER II
MTEDC202: AC DRIVES

COURSE OUTCOMES:

1) Explain the basics methods of speed control of Induction motor.
2) Apply the various speed control methods for controlling the speed of Induction motor.
3) Apply the various speed control methods for controlling the speed of synchronous motor.
4) Use vector control method for controlling the Induction motor drive.
5) Use vector control method for controlling the synchronous motor drive.

COURSE CONTENTS:

UNIT I: AC DRIVES (08 Hours)
Principles of speed control, Various methods of Induction motor drive, Variable voltage operation, Variable frequency operation, Constant flux operation, Torque-Slip characteristic, Constant Torque and Constant power operation, Implementation of V/f control with slip compensation scheme

UNIT II: SPEED CONTROL OF INDUCTION MOTOR (09 Hours)
Speed control of VSI and CSI fed drives - design examples. Closed loop control schemes - dynamic and regenerative braking - speed reversal. Torque slip characteristics - speed control through slip - rotor resistance control - chopper controlled resistance equivalent resistance combined stator voltage control and rotor resistance control - design solutions. Closed loop control scheme. Slip power recovery - torque slip characteristics - power factor considerations.

UNIT III: SPEED CONTROL OF SYNCHRONOUS MOTOR (08 Hours)
Need for leading PF operation - open loop VSI fed drive - group drive applications. Self control - margin angle control - torque angle control - power factor control - simple design examples.

UNIT IV: VECTOR CONTROL OF INDUCTION MOTOR DRIVE (08 Hours)
Review of dq0 model of 3-Ph IM, Principle of vector control of IM - Direct vector control - Indirect vector control with feedback - Indirect vector control with feed-forward - Indirect vector control in various frames of reference, Decoupling of vector control with feed forward compensation - Direct Torque Control of IM

UNIT V: VECTOR CONTROL OF SYNCHRONOUS MOTOR DRIVES (09 Hours)
Three phase synchronous machine and analysis of steady state operation - voltage and torque equations in machine variables and rotor reference frame variables (Park’s equations) – analysis of dynamic performance for load torque variations. Types of PM Synchronous motors - Torque developed by PMSM - Model of PMSM - Implementation of vector control for PMSM

REFERENCES:

SEMESTER II

ELECTIVE III: MTEDC203: INTELLIGENT CONTROL

COURSE OUTCOMES:
After completing the course, students will be able to:
1) Identify the basic neural networks paradigms.
2) Describe the basic concepts of training in neural networks.
3) Describe the concept of fuzziness involved in various systems.
4) Understand the basic concepts of about fuzzy set theory.
5) Analyze the different techniques used for modelling and control of the AC and DC drives.
6) Apply neural network and fuzzy techniques for designing successful applications.

COURSE CONTENTS:

UNIT I: ARTIFICIAL NEURAL NETWORKS (08 hours)
Biological Neuron and Their Artificial Model; Models of Artificial Neural Network: Single Layer and Multilayer, Feed-forward Network, Feedback Network; Neural Processing; Types of Neuron Activation Function; Learning Strategy: Supervised, Unsupervised, Reinforcement; Learning Rules; Auto-Associative and Hetro-Associative Memory.

UNIT II: BACK PROPAGATION NETWORKS (08 hours)

UNIT III: INTRODUCTION TO FUZZY LOGIC (08 hours)
Classical Sets and Fuzzy Sets: Operations and Properties; Classical relations and fuzzy relations: Cartesian product, Crisp relations, Fuzzy relations, Operations on fuzzy relations, Properties of Fuzzy Relations, Fuzzy Cartesian Product and Composition; Tolerance and Equivalence Relations; Fuzzy Tolerance and Equivalence Relations; Value Assignments.

UNIT IV: FUZZY LOGIC SYSTEM (08 hours)
Membership Function: Various Forms, Membership Value Assignments; Fuzzification and Defuzzification Module, Rule Base, Choice of Variable and Contents of Rules, Derivation of Rules, Data Base, Fuzzy Inference System, Choice of Membership Function and Scaling Factors, Choice of Fuzzification and Defuzzification Procedure, Various Methods; Fuzzy Associative Memories.

UNIT V: APPLICATIONS OF NEURAL NETWORKS AND FUZZY LOGIC (10 hours)
Speed Control of DC Motor, Induction Motor, Switched Reluctance, Brushless DC Motor, Synchronous Machine, Modelling and Control of DC and AC Drive, Hybrid Neuro-Fuzzy Applications.
REFERENCES:

5. Siman Haykin, “Neural Networks”, Prentice Hall of India.
SEMESTER II

ELECTIVE III: MTEDC203: POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

COURSE OUTCOMES:
1) Provide knowledge about the stand alone and grid connected renewable energy systems.
2) Equip with required skills to derive the criteria for the design of power converters for renewable energy applications.
3) Analyze and comprehend the various operating modes of wind electrical generators and solar energy systems.
4) Design different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems.
5) Develop maximum power point tracking algorithms.

COURSE CONTENTS:

UNIT I: INTRODUCTION (08 Hours)
Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources ocean, Biomass, Hydrogen energy systems: operating principles and characteristics of: Solar PV, Fuel cells, wind electrical systems-control strategy, operating area.

UNIT II: ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION (08 Hours)
Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG.

UNIT III: POWER CONVERTERS (09 Hours)

UNIT IV: ANALYSIS OF WIND AND PV SYSTEMS (09 Hours)
Stand alone operation of fixed and variable speed wind energy conversion systems and solar system, Grid connection Issues, Grid integrated PMSG and SCIG Based WECS, Grid Integrated solar system

UNIT V: HYBRID RENEWABLE ENERGY SYSTEMS (08 Hours)
Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PV-Maximum Power Point Tracking (MPPT).

REFERENCES:
SEMESTER II
ELECTIVE III: MTEDC 203: ELECTRIC TRACTION

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

1) Understand the basics of Electric Traction System.
2) Identify different Traction Drives and controlling techniques.
3) Develop protection system for Electric Locomotive.
4) Design the Electric Traction Sub-Systems (Overhead Equipment).
5) Analyze Train signaling and conditioning.

COURSE CONTENTS:

UNIT I: ELECTRIC TRACTION- PRINCIPLE AND HISTORY (08 Hours)

UNIT II: TRACTION MOTOR DRIVES- PRINCIPLES AND GEAR (10 Hours)
Type of traction motor best suited for traction duties, Available motor characteristics and their suitability for traction duties, Optimization of design and construction features for improved power to weight ratio, Power Factor and Harmonics, Tractive Effort and Drive Ratings, Important Features of Traction Drives, conventional DC and AC Traction drives, Semiconductor Converter Controlled Drives, DC Traction using Chopper Controlled Drives, Poly phase AC motors for Traction Motors, DC /AC Traction employing Poly-phase motors, Diesel Electric Traction, Traction control of DC locomotives and EMU’s, Traction control system of AC locomotives, Control gear, PWM control of induction motors, Power & Auxiliary circuit equipment (Other than traction motors).

UNIT III: PROTECTION OF ELECTRIC LOCOMOTIVE EQUIPMENT AND CIRCUITS (09 Hours)
Broad strategy for protection, Surge protection, Overload protection of main power circuits, Earth fault protection of power of auxiliary circuits, Protection from over-voltage and under-voltage, Differential protection of traction circuits, Protection against high and low air pressure in the compressed air circuit, Temperature monitoring, Protection of transformer by Bucholz relay, Protection against accidental contact with HT equipment Protection against fires.

UNIT-IV: ELECTRIC TRACTION SUB-SYSTEMS (OVERHEAD EQUIPMENT) (09 Hours)
Overhead Equipment (OHE), Sectionalizing, Bonding of Rails and Masts, Materials Employed in OHE Electric Traction Sub-Systems (Power Supply Installations): Lay out design of 137/25 KV Traction Substation/ Protection, Booster Transformers and Return Conductor, Salient 2x25 Kv AC System/SCADA.

UNIT-V: RAILWAY SIGNALING: (06 Hours)
Block Section Concept, Track Circuits, Interlocking Principle, Train speed and signaling, Solid state Interlocking, Automatic Warning Systems, CAB signaling, Signaling level crossing.

REFERENCES:

SEMESTER II
ELECTIVE IV: MTEDC204: ROBOTICS AND CONTROL

COURSE OUTCOMES:
1) Understand robot terminologies and robotic sensors.
2) Analyze direct and inverse kinematic relations.
3) Formulate manipulator Jacobians and introduce path planning techniques.
4) Analyze robot dynamics.
5) Apply robot control techniques to real world applications.

COURSE CONTENTS:
UNIT I: INTRODUCTION AND TERMINOLOGIES (09 hours)
Definition, Classification, History, Robots components, Degrees of freedom, Robot joints coordinates Reference frames, workspace, Robot languages, actuators, sensors, Position, velocity and acceleration sensors, Torque sensors, tactile and touch sensors, proximity and range sensors, vision system, social issues.

UNIT II: KINEMATICS (08 hours)
Mechanism, matrix representation, homogenous transformation, DH representation Inverse kinematics, solution and programming, degeneracy and dexterity.

UNIT III: DIFFERENTIAL MOTION AND PATH PLANNING (08 hours)
Jacobian, differential motion of frames, Interpretation, calculation of Jacobian, Inverse Jacobian, Robot Path planning.

UNIT IV: DYNAMIC MODELLING (08 hours)
Lagrangian mechanics, Two-DOF manipulator, Lagrange-Euler formulation, Newton Euler formulation, Inverse dynamics.

UNIT V: ROBOT CONTROL SYSTEM (09 hours)
Linear control schemes, joint actuators, decentralized PID control, computed torque control, force control, hybrid position force control, Impedance/ Torque control.

REFERENCES:
Indian Reprint 2010.

SEMESTER II
ELECTIVE IV: MTEDC204: ELECTRIC AND HYBRID VEHICLES

COURSE OUTCOMES:

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<thead>
<tr>
<th>CO1</th>
<th>Describe the configuration and performance of Electric vehicles</th>
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<tr>
<td>CO2</td>
<td>Design the structure of Hybrid Electric Vehicle</td>
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<td>CO3</td>
<td>Describe the operation of Fuel Cells</td>
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<td>CO4</td>
<td>Explain Electric propulsion system and Motor control systems</td>
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<td>CO5</td>
<td>Discuss energy storage devices and generators</td>
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COURSE CONTENTS:

UNIT I ELECTRIC VEHICLES (08 Hours)

UNIT II: HYBRID VEHICLES (08 Hours)
Concepts of Hybrid Electric Drive Train, Architectures of Series Hybrid Electric Drive Trains, Architectures of Parallel Hybrid Electric Drive Trains, Merits and Demerits, Series Hybrid Electric Drive Train Design, Parallel Hybrid Electric Drive Train Design.

UNIT III: FUEL CELLS & SOLAR CARS (08 Hours)

UNIT IV: ELECTRIC PROPULSION SYSTEM AND MOTOR CONTROL SYSTEM (10 Hours)
DC Motors Characteristics, Speed and Torque Control, Regenerative Braking.
AC Motors Characteristics, Speed and Torque Control.
PM- BLDC Motors Characteristics, Speed and Torque Control.
Reluctance Motors Characteristics, Speed and Torque Control, Regenerative Braking.

UNIT V: ENERGY STORAGES & GENERATORS (08 Hours)

REFERENCES:

SEMESTER II
ELECTIVE IV: MTEDC204: ELECTROMAGNETIC INTERFERENCE & COMPATIBILITY IN POWER ELECTRONIC SYSTEM

COURSE OUTCOMES:
At the end of the course the student will be able to:
1) Recognize the sources of conducted and radiated EMI in Power Electronic converters and consumer appliances and suggest remedial measures to mitigate the problems.
2) Assess the insertion loss and design EMI filters to reduce the loss.
3) Design EMI filters, common mode chokes, and snubber circuits measures to keep the interference within tolerable limits.

COURSE CONTENTS:

UNIT I: INTRODUCTION (10 Hours)
Fundamentals of EMI and EMC Electromagnetic Fields: static, quasi-static and high frequency fields, Sources of EMI and their classifications, propagation and crosstalk, effect of EMI on devices and systems, general interference control techniques, Human exposure limits to EM fields measuring instruments, conducted EMI references, EMI in power electronic equipment EMI from power semiconductors circuits.

UNIT II: EMC COMPLIANCE (11 Hours)
Need for EMC compliance, EMC standards, Measurement and testing, general EMC design principles for power electronic systems, EMI/ EMC Design for PCBs Fundamentals,
sources, grounding, return circuit design, controlling EMI sources, decoupling power/ground planes.

UNIT III: NOISE (10 Hours)
Noise suppression in relay systems: AC switching relays, shielded transformers, capacitor filters, EMI generation and reduction at source, influence of layout and control of parasites. Troubleshooting and solutions for minimization of emissions, Software and hardware tools for EMC.

UNIT IV: Filters (11 Hours)
EMI filter elements: Capacitors, choke coils, resistors, EMI filter circuits. EMI filter design for insertion loss; Worst case insertion loss, design method for mismatched impedance condition and EMI filters with common mode choke-coils.

REFERENCES:
1) “Power Electronics, Converters, Applications & Design”, N.Mohan, T.M.Undeland, W.P Robbins, Wiley India Pvt.Ltd.

SEMESTER II

ELECTIVE V: MTEDC205: ENERGY MANAGEMENT AND AUDITING

COURSE OUTCOMES:
Upon successful completion of this course the student will be able to:
1) Identify and describe present state of energy security and its importance.
2) Identify and describe the basic principles and methodologies adopted in energy audit of utility.
3) Describe the energy performance evaluation of some common electrical and thermal installations and identify the energy saving opportunities.
4) 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)
UNIT III: ENERGY EFFICIENT MOTORS (06 Hours)
Energy efficient motors, factors affecting efficiency, loss distribution, construalional 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)

UNIT V: LIGHTING SYSTEMS AND COGENERATION (08 Hours)

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:
COURSE OUTCOMES:
After the completion of the course the students will be able to:
1) Understand the research meaning apply the same for doing the research work
2) Identify and formulate the research problem.
3) Design the research work in the proper structured manner using sample techniques.

COURSE CONTENTS:

UNIT I: Foundations of Research (0 7 Hours)

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

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)

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.

SEMESTER II
ELECTIVE V: MTEDC205: MODERN OPTIMIZATION TECHNIQUES

COURSE OUTCOMES:
After the completion of the course the student will be able to
1) Understand the theoretical workings of the simplex method for linear programming and perform iterations of it by hand.
2) Understand the relationship between a linear program and its dual, including strong duality and complementary slackness.
3) Perform sensitivity analysis to determine the direction and magnitude of change of a model’s optimal solution as the data change.
4) Solve specialized linear programming problems like the transportation and assignment problems.
5) Solve network models like the shortest path, minimum spanning tree, and maximum flow problems.
6) 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)

**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 OPTIMIZATION 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:

**SEMESTER II**

**MTEDC206: 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**

**MTEDC207: 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 MATLAB, 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:

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:

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:

SEMESTER III
MTEDC302: 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
MTEDC401: 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.
# Model lesson plan

**Lesson Plan for the academic year 2016-17**

**Class:** M.Tech (EPS)  **Semester:** 1  **Subject:** Electrical and hybrid vehicle

<table>
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<tr>
<th>Unit</th>
<th>Period</th>
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<td>01</td>
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<td><strong>Electric Vehicles</strong></td>
<td>Chalk and board</td>
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<td>Introduction</td>
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<td>Layout of an Electric Vehicle</td>
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<td>Performance of Electric Vehicles</td>
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<td>04</td>
<td>a) Traction Motor Characteristics</td>
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<td>b) Traction Effort and Transmission Requirements</td>
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<td>c) Vehicle Performance</td>
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<td>Energy Consumption</td>
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<td>Specifications</td>
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<td>System Components</td>
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<td>Electronic Control System</td>
<td>Chalk and board</td>
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<td><strong>Hybrid vehicles</strong></td>
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<td>Concepts of Hybrid Electric Drive Train</td>
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<td>Architectures of Series Hybrid Electric Drive Trains</td>
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<td>Architectures of Parallel Hybrid Electric Drive Trains</td>
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<td>Merits and Demerits</td>
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<td>Series and parallel Hybrid Electric Drive Train Design</td>
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<td>03</td>
<td>18</td>
<td><strong>Fuel cells and solar car</strong></td>
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<td>Solar Cars</td>
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<td>Fuel Cells - Construction &amp; Working</td>
<td>PP T &amp; Chalk and board</td>
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<td>20</td>
<td>Equations</td>
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<td>Possible Fuel Sources</td>
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<td>22</td>
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<td>Cost Comparison</td>
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<td><strong>Electric Propulsion System and Motor Control system</strong></td>
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**Text Book**

**Reference Books**
