Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

Course Contents (Syllabus) for

T.Y. B. Tech (Electrical Engineering)
Sem. V to VI

AY 2020-21

Title of the Course: Power System Analysis and Stability Course Code: 4EL301	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: Electrical transmission and distribution and A.C. Machines

Textbooks:

1. I.J. Nagrath and D.P. Kothari, *"Power System Analysis", 2nd* Edition and TMH Publication 2015.

References:

1. Glover, Sharma, Overbye *Power Systems Analysis and Design*, Thompson, 5th Ed., 2012.
2. Hadi Saadat, *Power System Analysis*, TMH, 1st Edition, 2002.
3. Stevenson W.D., *Elements of Power System Analysis*, TMH, 4th Edition, 2014.

Course Objectives :

1. To gain knowledge of load flow analysis and short circuit studies.
2. The course aims to provide knowledge about stability problems and dynamic mechanisms in electric power systems.
3. This course will develop analytical skills in the students for investigating issues related to power systems.
4. This course will help students in preparing for competitive examinations.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Summarize** the use of various load flow analysis method and assess the power system under symmetrical fault.	2	Understanding
CO2	**Analyze** symmetrical components of network and power system under unbalanced fault.	4	Analyzing
CO3	**Evaluate** the rotor angle, voltage stability and solve swing equation by various methods.	5	Evaluating

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2												2	
CO2		3											2	
CO3		2			2								2	

Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion.[One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2]
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Power Flow Analysis	Hrs.
Bus classification, bus admittance matrix, general form of power flow equations, GS, NR and FD load flow methods and Comparison of PFA Methods.	**7**
Module 2: Symmetrical Components	**Hrs.**
Symmetrical components, Dr. Fortescue Theorem, Component synthesis, Component analysis, sequence impedances and sequence networks, sequence impedances of transmission lines, transformers, and synchronous machines, construction of sequence network of a power system.	**6**
Module 3: Fault Analysis: Balanced Fault	**Hrs.**
Introduction, Classification, Severity and occurrence of fault, Effect of faults, Balanced three phase fault, Transient on transmission line, Short circuit capacity, Symmetric fault analysis using bus impedance matrix.	**6**
Module 4: Fault Analysis: Unbalanced Fault	**Hrs.**
Introduction, Assumptions, Sequence voltages of generator, general procedure for analysis of various faults, Analysis of unbalanced faults-SLG,LL and DLG, short circuit studies of a large power system network.	**6**
Module 5: Power System Stability	**Hrs.**
Basic concepts and definitions, Classification of stability ,Power angle curve, An elementary view of transient stability ,swing equation ,M and H constant, Equal Area Criterion and its applications, critical clearing angle, Rotor angle stability, Voltage stability, Factors influencing transient stability.	**7**
Module 6: Numerical Integration Methods And Application To Stability Evaluation	**Hrs.**
Numerical integration methods – Euler's method, Modified Euler's method -,Runge - Kutta methods and Solution of swing equation by point by point method.	**5**

Module wise Measurable Students Learning Outcomes :

After the completion of the course the student will be able to

1. Analyze load flow using different techniques like GS method, NR method and Fast decoupled method.
2. Design sequence network of a power system analysis.
3. Evaluate and Analyze Balanced Fault and short circuit study.
4. Grasp different techniques of determination of fault current for various faults in power system.
5. Introduce the concept of power system stability and mathematical formulation for SMIB.
6. Implement numerical methods for carrying out the stability studies.

Title of the Course: Control System Engineering Course Code: 4EL302	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: Engineering Mathematics III, Signals and Systems, Electrical Circuit Analysis

Textbooks:

1. Norman Nise, 'Control System Engineering', John Wiley, Sixth Edition, 2011.
2. I.J. Nagrath and M. Gopal,'Control System Engineering', Anshan Publishers, Fifth edition, 2008.

References:

1. M Gopal, 'Control System Principle & Design', T.M.H., Fourth Edition, 2012.
2. K Ogata, 'Modern Control Engineering', P.H.I., Fourth Edition, 2002.
3. Dorf and Bishop, 'Modern Control System', Adison Wesley Longman, Eight Edition, 1998.

Course Objectives :

1. The course aims at imparting knowledge for modelling physical systems.
2. The course intends to analyze physical systems using various time and frequency domain methods.
3. It is aimed to enable students for determining the stability of linear systems using different methods.
4. Introduce the use of state space method for system analysis.

Course Learning Outcomes:

CO	**After the completion of the course the student will be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	**Calculate** system transfer function and system characteristics of different Systems.	3	**Applying**
CO2	**Analyze** performance of physical systems using mathematical models.	4	**Analyzing**
CO3	**Check** the stability of linear systems in time and frequency domain.	5	**Evaluating**

CO-PO Mapping :

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1		3												
CO2		3												2
CO3		3												2

Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

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MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Analysis of system in the Frequency Domain	Hrs.
History of control systems, Laplace transforms review, transfer function of Electrical systems, Mechanical systems, Rotational Systems, Electrical circuit analogs, Transfer function of DC motor	**6**
Module 2: Analysis of system in the Time Domain	**Hrs.**
State space representation, Converting transfer function to state space: Phase Variable Form, State space to transfer function, State Transition Matrix, Solution of state equation, Controllability, Observability.	**6**
Module 3: Transient Response and Reduction of multiple subsystem	**Hrs.**
Time response, poles, zero and system response, Response of first, second and general second order system, system response with additional poles, additional zeros Block diagram analysis and design of feedback systems, signal flow graph, mason's rule, signal flow graphs of state equation, similarity transformation.	**6**
Module 4: Steady State Error	**Hrs.**
Steady state error for unity feedback systems, static error constants, and system type. Steady state error specifications, steady state error for system with disturbances, non-unity feedback systems. steady state error for systems in state space, PID Controllers.	**6**
Module 5: Stability Analysis: Routh Criterion and Root Locus	**Hrs.**
Routh criterion for stability and stability in state space, Sketching the root locus, transient response design via gain adjustment, Root locus for positive feedback system, pole sensitivity, lag, lead, lag-lead compensators in root locus domain.	**6**
Module 6: Stability Analysis: Bode Plot and Nyquist Plot , Compensators	**Hrs.**
Bode plot, Nyquist criterion, Determination of stability, gain margin, phase margin via the Nyquist diagram and bode plots Introduction to Compensators, lag, lead, lag-lead compensator in frequency domain.	**6**

Module wise Measurable Students Learning Outcomes :

After completion of the course students will be able to:

1. Calculate system transfer function model of electrical, mechanical and electromechanical system.
2. Construct State Space Model of a system and analyze system performance.
3. Apply block diagram reduction and signal flow graph technique for system simplification. Use poles and zeros to determine time response of a system.
4. Assess the stability and Steady State Error of a control system.
5. Construct the root locus and analyze the system performance and check system stability
6. Assess the system stability using frequency domain techniques to determine system stability.

Professional Core (Lab) Courses

Title of the Course: Power System Analysis and Stability Lab	L	T	P	Cr
Course Code: 4EL351	0	0	2	1

Pre-Requisite Courses: Power System Engineering, AC Machine

Textbooks:

1. I.J. Nagrath and D.P. Kothari, *"Power System Analysis", 2nd* Edition and TMH Publication 2015.

References:

1. Glover, Sharma, Overbye *Power Systems Analysis and Design*, Thompson, 5th Ed., 2012.
2. Hadi Saadat, *Power System Analysis*, TMH, 1st Edition, 2002.
3. Stevenson W.D., *Elements of Power System Analysis*, TMH, 4th Edition, 1994.

Course Objectives:

1. This laboratory course covers steady state analysis and fault studies for a power system.
2. It provides hand on skills to simulation of stability studies.
3. It lays the foundation for conducting higher level study in power system

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Simulate** the various load flow analysis methods.	2	Understanding
CO2	**Carry out** simulation for symmetrical components of network and analyze the power system under unbalanced fault.	3	Applying
CO3	**Evaluate** the equal Area criterion and swing curve.	5	Evaluating

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1				3									2	
CO2			2		3								2	
CO3			2	2									2	

Lab Assessment:

There are four components of lab assessment, LA1, LA2, LA3 and Lab ESE.
IMP: Lab ESE is a separate head of passing.

Assessment	Based on	Conducted by	Conduction and Marks Submission	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Lab activities, attendance, journal	Lab Course Faculty	During Week 10 to Week 14 Submission at the end of Week 14	25
Lab ESE	Lab Performance and related documentation	Lab Course faculty	During Week 15 to Week 18 Submission at the end of Week 18	25

Week 1 indicates starting week of Semester.
Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.

Course Contents: 2hrs for Each Session

1. Development of the MATLAB program of bus admittance matrix Y_{bus}.
2. Outline of MiPower for power system analysis and stability.
3. Analyze Load flow using MiPower.
4. Simulation of Short circuit analysis using MiPower.
5. Simulation of Transient analysis using MiPower.
6. Demonstration of unbalanced Fault Using TLS.
7. Outline of SIM Power Systems toolbox in MATLAB.
8. Analyze Symmetrical components of 3phase unbalanced system using MATLAB.
9. Development of the program for Equal Area Criteria analysis using MATLAB.
10. Examination of Swing Curve using power world/MiPower/MATLAB simulation

Computer Usage / Lab Tool: MATLAB/TLS/Power world/MiPower Simulator

Title of the Course: Control Systems Engineering Lab	L	T	P	Cr
Course Code: 4EL352	0	0	2	1

Pre-Requisite Courses: Engineering Mathematics III, Signals and Systems, Electrical Circuit Analysis

Textbooks:

1. Norman Nise, 'Control System Engineering', John Wiley, Sixth Edition, 2011.
2. I.J. Nagrath and M. Gopal,'Control System Engineering', Anshan Publishers, 5thEdition, 2008.

References:

1. M Gopal, 'Control System Principle and Design', T.M.H., Fourth Edition, 2012.
2. K Ogata, 'Modern Control Engg', P.H.I., Fourth Edition, 2002.
3. Dorf and Bishop, 'Modern Control System', Adison Wesley Longman, Eight Edition, 1998.

Course Objectives :

1. This course intends to provide practical knowledge regarding modelling of different physical systems.
2. It intends to impart skills to evaluate the performance of systems using transient analysis.
3. It aims to estimate the stability of linear systems.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Solve** and analyze physical systems using simulation tools	3	**Applying**
CO2	**Assess** the stability of systems using frequency domain techniques	4	**Analyzing**
CO3	**Study** transient analysis of physical systems	4	**Analyzing**

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1			3											
CO2				3										2
CO3				3										2

Lab Assessment:

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IMP: Lab ESE is a separate head of passing.

Assessment	Based on	Conducted by	Conduction and Marks Submission	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Lab activities, attendance, journal	Lab Course Faculty	During Week 10 to Week 14 Submission at the end of Week 14	25
Lab ESE	Lab Performance and related documentation	Lab Course faculty	During Week 15 to Week 18 Submission at the end of Week 18	25

Week 1 indicates starting week of Semester.

Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course.

The experimental lab shall have typically 8-10 experiments.

Course Contents:

1. Construct transfer function using software tools.
2. Analyze the effect of feedback using software and simulation tools.
3. Conversion of transfer functions to state space and vice versa using software tools
4. Calculate the transfer function of Electrical, Mechanical and Rotational systems using MATLAB
5. Calculate the state transition matrix, state and eigen values for Electrical Systems.
6. Evaluate the transient response of first and second order systems.
7. Compute the Controllability and Observability of physical systems
8. Stability analysis of control system using software tools.
9. Sketch root locus and design compensator using G.U.I. and software tools.
10. Sketch Nyquist, Bode Diagram and design compensator using G.U.I. and software tools.
11. Design a PID controller for speed control of electric machine.

Computer Usage / Lab Tool:

1. Use of software simulation tools like MATLAB/Simulink

Professional Elective (Theory) Courses

Title of the Course: Professional Elective I: Energy Audit and Management Course Code: 4EL311	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: NIL

Textbooks:

1. Amlan Chakrabarti, *"Energy Engineering and Management",* PHI, 2011.
2. Bureau of Energy Efficiency, *"General Aspects of Energy Management & Energy Audit1.1, 1.2 & 1.3",* BEE, e-books.

References:

Course Objectives :

1. To create awareness in the students about energy conservation and its importance.
2. To develop skills for energy auditing and energy management in industrial environment.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Identify** the energy conservation opportunities in thermal and electrical energy.	3	Analyzing
CO2	**Apply** various tools for energy audit and management.	4	Applying
CO3	**Evaluate** the financial analysis for energy efficiency importance	5	Evaluating

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1			2											2
CO2					2									
CO3											2			

Assessment:

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Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

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MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Energy Conservation and Management	Hrs.
Energy Conservation and its importance, Energy strategy for future, Energy Conservation Act-2001 and its features, Energy Pricing, Energy Sector Reforms, Energy And Environment, Energy Security, Objectives and Principles of Energy Management.	**6**

Module 2: Energy Audit	**Hrs.**
Energy audit Definition as per EC-act 2001, Need of Energy Audit, Types of Energy Audit, Energy Audit Reporting Format, Understanding Energy and Costs, Benchmarking, Energy Performance, Energy Audit Instruments, Duties and Responsibilities of Energy Auditor.	**6**
Module 3: Energy Action Planning, Monitoring And Targeting	**Hrs.**
.Energy action Planning Steps, Top Management Support, Energy Manager Duties & responsibilities, Evaluating Energy Performance, Energy monitoring & Targeting – Set up, Key Elements, Data & Information Analysis, Relating Energy Consumption & Production, CUSUM Technique, Case Study	**7**
Module 4: Energy Economics	**Hrs.**
Financial Analysis Techniques – Pay Back Period, Net Present Value, Return on Investment, Internal Rate Of Return, Time Value Of Money, Cash Flow, Risk & Sensitivity analysis.	**5**
Module 5: Energy Efficiency in Electrical Utilities	**Hrs.**
Electricity Billing, Electrical Load Management and Maximum Demand Control, Power Factor Improvement & Benefits, Assessment of Transmission and Distribution Losses, Estimation Of Technical Losses in Distribution System, Commercial Losses, Demand Side Management, Energy Saving Opportunities With Pumps and Fans.	**7**
Module 6: Energy Efficiency in Thermal Utilities	**Hrs.**
Energy Conservation in Boilers, Steam Turbine, Industrial Heating System, Heat Exchangers, Heat Pumps, Efficiency Improvement, Energy Conservation in Buildings, Climate responsive Buildings, Thermal load modeling in Building, Zero energy Buildings, Co-generation and Waste heat recovery.	**6**

Module wise Measurable Students Learning Outcomes :

After completion of the course students will be able to:

1. Identify the importance of energy conservation and energy management.
2. Write energy audit reports.
3. Assess best methodology in the energy management using CUSUM technique.
4. Evaluate payback period with different techniques.
5. Analyze the energy conservation opportunities in electrical systems.
6. Analyze the energy conservation opportunities in thermal utilities.

Title of the Course: Professional Elective I: Digital Signal Processing **Course Code: 4EL312**	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: Engineering Mathematics –III, Signals and Systems

Textbooks:

1. John G, Proakis*' Digital Signal Processing Principles, Algorithms and Applications',* Pearson Education, 2008.
2. Sanjeet Mitra, '*Digital Signal Processing'*, TMH Pub., 2006.

References:

1. Oppenheim and R. W. Schafer, '*Discrete Time Signal Processing'* PHI Pub., 2005.
2. Venkatramani, Bhaskar*, 'Digital Signal Processors*, TMH Pub., 2006.
3. Raghuveer Rao, Bopardikar, '*Wavelet Transform'*, Pearson Education, 2000.

Course Objectives :

1. To develop basic knowledge of DSP systems and signal processing.
2. To develop basic knowledge of FFT and filter design for applications in Electrical Engineering.
3. The course aims to enable students to learn different modern signal processing tools.

Course Learning Outcomes:

CO	**After the completion of the course the student will be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	**Explain** the signal processing tools and transforms.	2	Understanding
CO2	**Apply** different techniques for Filter design	3	Applying
CO3	**Explain** modern signal processing algorithms.	2	Understanding

CO-PO Mapping :

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1			3											
CO2					2									
CO3					2									2

Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion.[One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2]
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Digital Signals and Systems	**Hrs.**
DSP system concept. Interconnection of DSP systems, sampling theorem, Z Transforms review, Digital transfer function and response to different inputs.	**6**

Module 2: Discrete Fourier Transform	**Hrs.**
DFT, Relation between DFT & Z ¬transform, Circular convolution and DFT, FFT Algorithms, (DIT- FFT & DIF-FFT). Overlap save algorithm, overlap add algorithm	**7**
Module 3: IIR Filter Design	**Hrs.**
Filter design using impulse invariant technique, bilinear transformation and Analog filter approximation (Butterworth) and Realization issues.	**7**
Module 4: FIR Filter Design	**Hrs.**
FIR Filter Design, Fourier series method, Windowing method, Filter design using window, frequency sampling methods, quantization and realization issues.	**7**
Module 5: Modern Signal processing	**Hrs.**
Digital Signal Processors- Introduction, Architecture, important blocks, Programming Aspects, Multirate Signal Processing, time and frequency effects, filter design for aliasing and imaging effects.	**6**
Module 6: Wavelet and Applications of Digital Signal Processing	**Hrs.**
Wavelet Transform- Introduction, continuous and discrete wavelet, applications of wavelet transform, Noise cancellation and DSP based measurement techniques, Case studies in DSP - Power system and control system applications.	**6**

Module wise Measurable Students Learning Outcomes :

1. Grasp basic concepts of Digital Signal Processing.
2. Evaluate the Discrete Fourier Transform and Fast Fourier Transform of signals.
3. Analyze the IIR filter design using different methods.
4. Analyze the FIR filter design using different methods.
5. Grasp basic concepts of Modern Digital Signal Processing like DSP processors and Multirate.
6. Grasp basic concepts of Wavelet transform and applications.

Title of the Course: **Professional Elective I: Electromagnetic Field** **Course Code: 4EL313**	L	T	P	Cr
	3	0	0	3

Desirable Requisite: Electrical Circuits, DC Machines and Transformers

Textbooks:

1. W.H. Hayt, J A Buck, M J Akhtar "Engineering Electromagnetic", McGraw Hill, 8th Edition 2014.
2. M. Sadiku, "Elements of Electromagnetics", Oxford University Press, 4th Edition 2007.

References:

1. Joseph A. Edminster, "Electromagnetics", Tata Mc Graw Hill, 2nd Edition. 2010
2. John D. Kraus, "Electromagnetics", Tata Mc Graw Hill, 4th Edition 2006
3. Jorden and Balmen, "Electromagnetic Wave and Radiation System" Pearson Publication 2nd Edition 2015.

Course Objectives:

1. This course develops foundational concepts in electrostatic and electromagnetic fields.
2. It familiarizes the students with electrical field and scalar potential, magnetic field and vector potential, Maxwell's equations, Biot-Savart Law, electrostatic boundary conditions, time varying potential.
3. This course will help students in preparing for competitive examinations.

Course Learning Outcomes: (Write from student perspective)

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Catch** the concepts of electrostatic and electromagnetic fields.	2	Understanding
CO2	**Apply** various laws in electromagnetics to identify the nature and strength of electric and magnetic fields.	3	Applying
CO3	**Test** the boundary value conditions in electromagnetic fields.	4	Analyzing

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3													
CO2	3												2	
CO3		2											2	

Assessment:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

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MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Vector Analysis	Hrs.
Vector Algebra, Rectangular Coordinate System, Vector Component, Vector Field, Dot Product, Cross Product, Circular and Cylindrical Coordinate System, Vector Calculus, Del Operator, Gradient of Scalar, Divergence of Vector and Divergence Theorem, Curl of a Vector and Stroke's Theorem, Classification of Vector Fields.	**7**
Module 2: Electrostatic Fields	**Hrs.**
Coulombs Law and Field Intensity, Electric Fields due to Continuous Charge Distributions, Electric Flux Density, Gauss's Law- Maxwell's Equation, Electric Potential, Relationship between E and V-Maxwell's Equation, Electric Dipole and Flux Lines, Energy Density in Electrostatic Fields.	**7**
Module 3: Electric Fields in Material Space	**Hrs.**
Properties of Materials, Convection and Conduction Current, Conductors, Polarization in Dielectrics, Dielectric Constant and Strength, Linear , Isotropic and Homogenous Dielectrics, Continuity Equation and Relaxation Time, Boundary Conditions.	**7**
Module 4: Electrostatic Boundary-Value Problems	**Hrs.**
Introduction, Poisson's and Laplace's Equations, Uniqueness Theorem, General Procedures for Solving Poisson's and Laplace's Equations, Resistance and Capacitance, Method of Images.	**6**
Module 5: Magneto Static Fields and Magnetic Forces	**Hrs.**
Biot- Savart's Law, Ampere's Circuital Law-Maxwell's Equation, Application of Ampere's Law, Magnetic Flux Density-Maxwell's Equation, Maxwell's Equation for Static Fields, Magnetic Scalar and Vector Potentials. Introduction, Forces due to Magnetic Torque and Moment, Magnetic Dipole.	**7**
Module 6: Maxwell's Equations	**Hrs.**
Introduction, Faraday's Law, Transformer and Motional Electromotive Forces, Displacement Current, Maxwell's equations in Final Forms, Time-Varying Potentials, time Harmonic Fields.	**6**

Module wise Measurable Students Learning Outcomes:

After the completion of the course the students should be able to:

1. Understand the basic of vector and vector field.
2. Examine electrostatic field due to continuous charge distributions and measure energy density.
3. Estimate electric fields in material space to measure various properties in materials.
4. Interpret Poisson's and Laplace's Equations for Electrostatic Boundary-Value Problems.
5. Apply various laws of magneto static fields to find forces created by magnetic field on charged particles, current elements, loops and dipoles.
6. Interpret the Maxwell's equations for transformer and Time varying potentials.

Title of the Course: Professional Elective II: Microprocessor Course Code: 4EL314	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: Analog and Digital Circuits

Textbooks:

1. Gaonkar R.S., Microprocessor Architecture Prog. and Appl.with 8085, PENRAM, Fourth Edition, 2000.

References:

1. Ghosh P.K. & Sridhar P.R., 0000 to 8085 Introduction to Microprocessors for Engineers & Scientists, PHI, Second Edition, 2005.
2. Badri Ram, Fundamentals of Microprocessors &Microcomputers, Dhanpat Rai, First Edition, 1989.

Course Objectives :

1. This course aims to provide the foundation level knowledge of microprocessor to the student.
2. The course will enable student to develop basic skills of assembly language programming, necessary for microprocessor and microcontroller.
3. The course will also help in developing microprocessor based interfacing of peripheral devices.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Summarize** the basic philosophy of 8 bit microprocessor and write assembly language programs for simple tasks.	2	Understanding
CO2	**Apply** the assembly language programming knowledge for simple tasks.	3	Applying
CO3	**Analyze** the use of various peripheral chips for electrical engineering applications.	4	Analyzing

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1		3												
CO2			3											
CO3		3												

Assessment:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion.[One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2]

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Architecture and Instruction Set	**Hrs.**
8085 architecture, addressing modes, instruction set, simple programs.	**6**
Module 2: Interrupts of 8085	**Hrs.**
Interrupt structure of 8085, priority, and programming.	**6**
Module 3: Timing Diagrams	**Hrs.**
Concept of T-state, m/c cycle, instruction cycle, Timing Diagrams of various instructions.	**7**
Module 4: Memory & I/O interfacing	**Hrs.**
Types of memories, interfacing of memory, generation of chip select signal, I/O interfacing, memory mapped & I/O mapped I/O.	**5**
Module 5: Peripheral chips	**Hrs.**
8255 PPI, 8253 PTC, 8279 KBD & Display, 8257DMA, 8259 PIC Function block interfacing and programming, diagram study.	**10**
Module 6: Applications	**Hrs.**
DAC & ADC interfacing using 8255, Timers & counters using 8253, KBD and 7-segment display interface using 8279.	**6**

Module wise Measurable Students Learning Outcomes :

After completion of the course students will be able to:

1. Explain the architecture and instruction set of 8085.
2. Apply the knowledge of instruction set to write and execute simple assembly language programs.
3. Outline the timing diagram for an instruction and interpret the execution of that instruction.
4. Design the address decoding logic circuits for memory and I/O interfacing and evaluate their merits and demerits.
5. Explain and evaluate the applications of select peripheral chips in microprocessor based system.
6. Analyze the requirements and design a microprocessor based system for measurement and display of electrical quantities.

Title of the Course: Professional Elective II: Electrical Machine Design	L	T	P	Cr
Course Code: 4EL315	3	0	0	3

Pre-Requisite Courses.: Electrical Machine

Textbooks:

1. "A Course in Electrical Machine Design" - by A. K. Sawhney, Dhanpat Rai and Sons, Delhi, 6th Edition, 2006.
2. "Design of Electrical Machines", by V.N. Mittle and A. Mittle, Standard Publications & Distributors, Delhi, 2002.

References:

1. "Principles of Electrical Machine Design" , by R.K. Agarwal, S.K. Kataria and Sons, Delhi, 2002
2. "Principles of Electrical Machine Design with Computer Programmes" S.K. Sen, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 1987.

Course Objectives :

1. This course intends to provide basic knowledge of design process of Electrical machines.
2. It is aimed to impart skills to perform and apply basics of Electrical Engineering for design of Electrical machines.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Summarize** the design procedure for electrical machine.	2	Understanding
CO2	**Analyze** the performance of machine based on design details.	4	Analyzing
CO3	**Design** transformer, induction motor and synchronous machine.	6	Creating

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2													
CO2		3												
CO3			3											3

Assessment:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion.[One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2]

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Constructional Details And Design of Transformers	Hrs.
Output equation, EMF per turn. Ratio of iron loss to copper loss, Relation between core area and weights of iron and copper, optimum designs, Core design. Design of windings.	**6**
Module 2: Performance Evaluation of Transformer	**Hrs.**
Calculation of no-load current. Equivalent circuit and performance characteristics. Temperature rise. Design of tank and radiators.	**6**
Module 3: Constructional Details And Design of Three Phase Induction Motors	**Hrs.**
Output equation. Specific electric and magnetic loadings. Efficiency and power factor, main dimensions. Type of winding and connection .Turns per phase, shape of stator slots. Number of stator slots, design of stators.	**6**
Module 4: Operating Characteristics of Three Phase Induction Motors	**Hrs.**
No load current Magnetizing current, loss component short circuit current. Use of circle diagram to obtain performance figures. Calculation of static torque, maximum torque, maximum output, maximum power factor. Dispersion coefficient.	**6**
Module 5: Design of Synchronous Machines	**Hrs.**
Construction of water wheel and turbo alternators. Different parts and materials used for Synchronous machine, choice of electric and magnetic loadings, Output equation. Determination of diameter and length, effect of short circuit ratio on machine performance.	**6**
Module 6: Computer Aided Design of Electrical Machines	**Hrs.**
Benefits of computer in machine design, methods of approach, optimization and computer aided design of induction motor and three phase transformer, Testing as per IS.	**6**

Module wise Measurable Students Learning Outcomes:

After completion of the course students will be able to:

1. Design the transformer.
2. Calculate the radiators.
3. Design the Induction Motor stator.
4. Design the Induction Motor rotor.
5. Design the Synchronous Machine.
6. Design the machines with computer aided Methods.

Title of the Course: Professional Elective II: Energy Storage Systems for EV Course Code: 4EL316	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: Power Electronics

Textbooks:

1. Abu-Rub, Haitham, Mariusz Malinowski, and Kamal Al-Haddad. Power electronics for renewable energy systems, transportation and industrial applications. John Wiley & Sons, 2014.
2. Santhanagopalan, Shriram, et al. Design and analysis of large lithium-ion battery systems. Artech House, 2014.
3. Kiehne, H. A. "Battery Technology Handbook. Marcel Dekker Inc." (2003).

References:

1. Masters, Gilbert M. Renewable and efficient electric power systems. John Wiley & Sons, 2013.
2. Wakihara, Masataka, and Osamu Yamamoto, eds. Lithium ion batteries: fundamentals and performance. John Wiley & Sons, 2008.

Course Objectives :

1. This course aims to provide the foundation level knowledge of different energy storage systems.
2. The course will enable student to use various energy systems and study various components of battery management system.
3. The course will help the students to examine the power converters for electric vehicles.
4. The course will also help the students to analyze the performance of fuel cells and supercapacitors.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Examine** the operation of various energy storage systems used for engineering applications	3	Applying
CO2	**Analyze** the components and working of battery management system, fuel cells and supercapacitors to meet the performance criteria	4	Analyzing
CO3	**Investigate** the performance of different power electronic converters used in electric vehicles	4	Analyzing

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1		**3**												
CO2				**3**										
CO3				**2**										

Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion. [One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2]

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Introduction to Energy Storage Systems	**Hrs.**
Introduction and need for storage for EV, traditional energy storage systems, global market and scenario, battery, fuel cell, supercapacitors, compressed air, hydrogen storage, fly-wheels.	**4**
Module 2: Batteries	**Hrs.**
Battery introduction, parameters of battery, battery cell electrical equivalent models, types of batteries, coulomb efficiency, electrode, battery manufacturing process, building block cells, battery modules and packs, working principle, operation, modeling and components- lithium polymer and lithium ion batteries, lead acid batteries, applications of batteries, future developments.	**8**
Module 3: Converters for Batteries	**Hrs.**
Concept of vehicle to grid and grid to vehicle, DC-DC converters, SEPIC converters- topology and operation, interleaved converters- topology and operation, power flow between converters.	**6**
Module 4: Battery Management System	**Hrs.**
Objectives and functions of the BMS, SOC and DOD, charge controller, sensors in BMS, protection of batteries, CCCV, charging topologies, cell equalization, pulse power capability, dynamic power limits.	**6**
Module 5: Fuel Cells and its Classification	**Hrs.**
Basic structure and functions of fuel cell, its characteristics and working, fuel cell power conversion, classification of fuel cells, PEM and alkaline fuel cells, molten carbonate fuel cells, phosphoric acid, solid oxide fuel cells.	**6**
Module 6: Supercapacitors and Hydrogen Storage Systems	**Hrs.**
Supercapacitor: characteristics, components, schematic, classification, advantages, disadvantages Hydrogen storage systems: Basics, working and applications.	**6**

Module wise Measurable Students Learning Outcomes :

After completion of the course students will be able to:

1. Illustrate the need and classification of energy storage systems
2. Analyze the operation, modeling and components of various batteries.
3. Study topology and operation of different power electronics converters.
4. Investigate the working and components of battery management system
5. Illustrate different types and working of fuel cells.
6. Study working principle, operation and components of super capacitors and hydrogen storage systems.

Professional Elective (Lab) Courses

Title of the Course: Professional Elective II: Microprocessor Lab Course Code: 4EL364	L	T	P	Cr
	0	0	2	1

Pre-Requisite Courses: Analog and Digital Circuits

Textbooks:

1. Gaonkar R.S., *Microprocessor Architecture Prog. And Apply With 8085*, PENRAM, Fourth Edition, 2000

References:

1. Ghosh P.K. & Sridhar P.R., *0000 to 8085 Introduction to Microprocessors for Engineers & Scientists*, PHI, Second Edition, 2005.
2. Badri Ram, *Fundamentals Of Microprocessors &Microcomputers*, Dhanpat Rai, First Edition, 1989.

Course Objectives :

1. This course will give hands on experience to use and program the INTEL 8085 microprocessor.
2. It would help in developing and executing programs on an 8085 based trainer system.
3. This knowledge will enable the student to execute programs for interfacing peripheral chips with 8085.

Course Learning Outcomes:

CO	**After the completion of the course the student will be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	**Develop** and execute assembly language programs for simple tasks.	3	Applying
CO2	**Demonstrate and analyze** the use of various peripheral chips for practical applications.	3 & 4	Applying & analyzing
CO3	**Demonstrate** the use of microprocessor based system for simple engineering applications.	3	Applying

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1			3											
CO2				3										
CO3			3											

Lab Assessment:

There are four components of lab assessment, LA1, LA2, LA3 and Lab ESE.

IMP: Lab ESE is a separate head of passing.

Assessment	Based on	Conducted by	Conduction and Marks Submission	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Lab activities, attendance, journal	Lab Course Faculty	During Week 10 to Week 14 Submission at the end of Week 14	25
Lab ESE	Lab Performance and related documentation	Lab Course faculty	During Week 15 to Week 18 Submission at the end of Week 18	25

Week 1 indicates starting week of Semester.

Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.

Course Contents:

1.	Develop & execute programs for addition & subtraction of Hex & BCD numbers	**4 hrs.**
2.	Develop & execute programs for arranging series of numbers in ascending/ descending order	**2 hrs.**
3.	Develop & execute programs for Up / down counters	**2 hrs.**
4.	Develop & execute programs for Interrupt Service Routines	**2 hrs.**
5.	Develop & execute programs for interfacing 8255 in Mode 0, BSR mode	**2 hrs.**
6.	Develop & execute programs for interfacing 8255 in Mode 1 & Mode 2	**4 hrs.**
7.	Develop & execute programs for interfacing 8253 in all Modes	**4 hrs.**
8.	Develop & execute programs for interfacing 8279 for keyboard & display	**4 hrs.**
9.	Develop & execute programs to design a voltage/ current measurement system using ADC interfaced through 8255.	**2 hrs.**
10.	Develop & execute programs to generate various waveforms on CRO using DAC interfaced through 8255.	**2 hrs.**

Title of the Course: Professional Elective II: Electrical Machines Design Lab Course Code: 4EL365	L	T	P	Cr
	0	0	2	1

Pre-Requisite Courses: Electrical Machine.

Textbooks:

1. "A Course in Electrical Machine Design" - by A. K. Sawhney, Dhanpat Rai and Sons, Delhi, 6th Edition, 2006.
2. "Design of Electrical Machines", by V.N. Mittle and A. Mittle, Standard Publications & Distributors, Delhi, 2002.

References:

1. "Principles of Electrical Machine Design" , by R.K. Agarwal, S.K. Kataria and Sons, Delhi, 2002
2. "Principles of Electrical Machine Design with Computer Programmes" S. K. Sen, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 1987.

Course Objectives :

1. This course intends to provide basic knowledge of draw and design process of simple Electrical machines.
2. It is aimed to impart skills to perform and apply basics of Electrical Engineering for draw and design of Electrical machines.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Summarize** the design procedure for electrical machine.	2	Understanding
CO2	**Analyze** the performance of machine based on design details.	4	Analyzing
CO3	**Design** and formulate transformer, induction motor and synchronous machine.	6	Creating

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1			3											
CO2				3										
CO3					2									3

Lab Assessment:

There are four components of lab assessment, LA1, LA2, LA3 and Lab ESE.

IMP: Lab ESE is a separate head of passing.

Assessment	Based on	Conducted by	Conduction and Marks Submission	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Lab activities, attendance, journal	Lab Course Faculty	During Week 10 to Week 14 Submission at the end of Week 14	25
Lab ESE	Lab Performance and related documentation	Lab Course faculty	During Week 15 to Week 18 Submission at the end of Week 18	25

Week 1 indicates starting week of Semester.

Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course.

The experimental lab shall have typically 8-10 experiments.

Course Contents: 2hrs for Each Session.

After completion of the course students will be able to:

1. Design the transformer with given suitable data.
2. Calculate the radiators for transformer.
3. Design the Induction Motor stator parts with provided input data.
4. Design the Induction Motor rotor with applications.
5. Design the Synchronous Machine parts.
6. Drawing sheets on Transformer parts, Transformer Design.
7. Drawing sheets on Induction motor parts, Induction Motor design.
8. Design the machines with computer aided Methods.
9. Assignments using software or problem solving, Seminars, and any other work based on syllabus.
10. Use Software for design of Electrical Machine parts.

Computer Usage / Lab Tool: MATLAB software

Title of the Course: Professional Elective II: Energy Storage Systems for EV Lab Course Code: 4EL366	L	T	P	Cr
	0	0	2	1

Pre-Requisite Courses: Power Electronics

Textbooks:

1. Abu-Rub, Haitham, Mariusz Malinowski, and Kamal Al-Haddad. Power electronics for renewable energy systems, transportation and industrial applications. John Wiley & Sons, 2014.
2. Santhanagopalan, Shriram, et al. Design and analysis of large lithium-ion battery systems. Artech House, 2014.
3. Kiehne, H. A. "Battery Technology Handbook. Marcel Dekker Inc." (2003).

References:

1. Masters, Gilbert M. Renewable and efficient electric power systems. John Wiley & Sons, 2013.
2. Wakihara, Masataka, and Osamu Yamamoto, eds. Lithium ion batteries: fundamentals and performance. John Wiley & Sons, 2008.

Course Objectives:

1. This course will help students to model and test different battery models using in Electric Vehicles.
2. It would help in developing and executing programs on Matlab/Simulink environment.
3. This knowledge will enable the student to execute programs for investigating the performance of power converters in Electric Vehicles.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Develop** and test battery models using software tools	3	Applying
CO2	**Construct** the simulation models of power converters for electric vehicles	3	Applying
CO3	**Analyze** the performance of batteries and power converters used in Electric Vehicles.	3	Applying

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1			3											
CO2			3											
CO3				2										

Lab Assessment:

There are four components of lab assessment, LA1, LA2, LA3 and Lab ESE.

IMP: Lab ESE is a separate head of passing.

Assessment	Based on	Conducted by	Conduction and Marks Submission	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Lab activities, attendance, journal	Lab Course Faculty	During Week 10 to Week 14 Submission at the end of Week 14	25
Lab ESE	Lab Performance and related documentation	Lab Course faculty	During Week 15 to Week 18 Submission at the end of Week 18	25

Week 1 indicates starting week of Semester.
Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.

Course Contents: (Experiments)

1. Study the performance of various types of the batteries.
2. Demonstrate modeling of lead acid battery and observe various characteristics.
3. Execute modeling and characteristics of Lithium Battery.
4. Examine Super-capacitor charging and discharging characteristics.
5. Implement the electrical system of a vehicle.
6. Simulate and model different types of fuel cells.
7. Construct interleaved DC to DC converter for designing EV.
8. Implement SEPIC converter for designing EV.

Computer Usage / Lab Tool: MATLAB

Open Elective- I Courses

Title of the Course: Open Elective I: Electrical Machine Technology Course Code: 4OE343	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: Basic Electrical Engineering, Basic Electronics Engineering.

Textbooks:

1. S. J. Chapman, "Electric Machinery Fundamentals", Tata Mc Graw Hill publication, 4th Edition, 2011
2. M. G. Say. "Performance Design of AC Machines", CBS Publishers, 3rd Edition, 2017

References:

1. SK Bhattacharya, *"Electrical Machines"*, Tata Mc Graw Hill, 3rd Edition, 2010.
2. J. B. Gupta, *"Electrical Machines"*, SK Kataria and Sons, 2013.

Course Objectives :

1. To make students understand operation and performance of ac and dc machines.
2. To make students learn characteristics of ac and dc machines.
3. To develop skills to choose ratings of ac and dc machines for various applications.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Explain** the construction and working principle of A.C. and D.C. Machines.	2	Understanding
CO2	**Examine** the various characteristics of A.C. and D.C. machines.	3	Applying
CO3	**Analyze** the performance of A.C. and D.C. machines for various applications.	4	Analyzing

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3													
CO2		2												
CO3		2												

Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion.[One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2]

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: DC Motors	**Hrs.**
Construction, Working, Types, Back emf, Speed equation, Armature Reaction, Torque equation, Speed torque characteristics, Applications, Power losses in d.c. motors. Need of starter, 3 point starter, 4 point starter, speed control of D.C. shunt and series motor (numerical treatment), Thyristor based speed control for D.C. motor. Reversal of rotation, Electric braking of shunt and series motor.	**6**
Module 2: Single Phase Transformer	**Hrs.**
Construction and type, EMF equation phasor diagram, equivalent circuit, efficiency, losses, regulation, Experimental determination of equivalent circuit parameters and calculation of efficiency and regulation, parallel operation, Introduction to three Phase Transformer, Connection of three Phase Transformer, Applications of Transformers.	**7**
Module 3: Three Phase Induction Motor	**Hrs.**
Construction, Types, Working, Speed equation, Torque equation, Starting torque, Concept of full load torque, torque speed characteristics, Power stages in motor, (numerical treatment). Induction Generator.	**7**
Module 4: Three Phase Induction Motor Control	**Hrs.**
Need of starter, Star delta starter, DOL starter, Autotransformer starter, Rotor resistance starter. Speed control methods- Pole changing, Voltage control, VFD (V/f) control, Block schematic of electronic VFD control, Rotor resistance speed control, Reversal of rotation.	**5**
Module 5: Synchronous Machines	**Hrs.**
Alternator, Construction of Alternator, Alternator Operation, Armature Winding of Alternator, Winding Factors, E.M.F. equation of an alternator, Armature Reaction in Alternator, Alternator on Load, Synchronous Reactance, Phasor Diagram of a Loaded Alternator, Voltage Regulation, Effect of Salient Poles, Power developed in Salient Pole Synchronous Generator. Synchronous Motor, Equivalent Circuit, Motor on load, Pull-Out Torque, Motor Phasor Diagram, Mechanical Power Developed by Motor, Power Factor of Synchronous Motor, Application of Synchronous Motor, Comparison of Synchronous Motor with Induction Motor.	**8**
Module 6: Special-Purpose Electric Machines	**Hrs.**
Stepper motor-Variable-Reluctance Motor, Permanent Magnet Motor, Hybrid Stepper Motor, Servomechanism, D.C. Servomotors, A.C. Servomotors, Switched Reluctance Motor, Permanent Magnet D.C. Motor, Brushless D.C. Motor. Selection and Sizing of Motors based on applications.	**6**

Module wise Measurable Students Learning Outcomes:

After completion of the course students will be able to:

1. Evaluate performance of dc motor.
2. Evaluate performance of transformer.
3. Understand operation, working and characteristics of the three-phase induction motor.
4. Understand the control concepts of three phase induction motor.
5. Evaluate performance of Synchronous Machines.
6. Understand applications of Special Electrical Machines.

Title of the Course: Honors Specialization Course: Energy Storage Systems for EV	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: Power Electronics

Textbooks:

4. Abu-Rub, Haitham, Mariusz Malinowski, and Kamal Al-Haddad. Power electronics for renewable energy systems, transportation and industrial applications. John Wiley & Sons, 2014.
5. Santhanagopalan, Shriram, et al. Design and analysis of large lithium-ion battery systems. Artech House, 2014.
6. Kiehne, H. A. "Battery Technology Handbook. Marcel Dekker Inc." (2003).

References:

3. Masters, Gilbert M. Renewable and efficient electric power systems. John Wiley & Sons, 2013.
4. Wakihara, Masataka, and Osamu Yamamoto, eds. Lithium ion batteries: fundamentals and performance. John Wiley & Sons, 2008.

Course Objectives :

5. This course aims to provide the foundation level knowledge of different energy storage systems.
6. The course will enable student to use various energy systems and study various components of battery management system.
7. The course will help the students to examine the power converters for electric vehicles.
8. The course will also help the students to analyze the performance of fuel cells and supercapacitors.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Examine** the operation of various energy storage systems used for engineering applications	3	Applying
CO2	**Analyze** the components and working of battery management system, fuel cells and supercapacitors to meet the performance criteria	4	Analyzing
CO3	**Investigate** the performance of different power electronic converters used in electric vehicles	4	Analyzing

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1		3												
CO2				3										
CO3				2										

Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
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MSE	30
ISE 2	10
ESE	50

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MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Introduction to Energy Storage Systems	**Hrs.**
Introduction and need for storage for EV, traditional energy storage systems, global market and scenario, battery, fuel cell, supercapacitors, compressed air, hydrogen storage, fly-wheels.	**4**
Module 2: Batteries	**Hrs.**
Battery introduction, parameters of battery, battery cell electrical equivalent models, types of batteries, coulomb efficiency, electrode, battery manufacturing process, building block cells, battery modules and packs, working principle, operation, modeling and components- lithium polymer and lithium ion batteries, lead acid batteries, applications of batteries, future developments.	**8**
Module 3: Converters for Batteries	**Hrs.**
Concept of vehicle to grid and grid to vehicle, DC-DC converters, SEPIC converters- topology and operation, interleaved converters- topology and operation, power flow between converters.	**6**
Module 4: Battery Management System	**Hrs.**
Objectives and functions of the BMS, SOC and DOD, charge controller, sensors in BMS, protection of batteries, CCCV, charging topologies, cell equalization, pulse power capability, dynamic power limits.	**6**
Module 5: Fuel Cells and its Classification	**Hrs.**
Basic structure and functions of fuel cell, its characteristics and working, fuel cell power conversion, classification of fuel cells, PEM and alkaline fuel cells, molten carbonate fuel cells, phosphoric acid, solid oxide fuel cells.	**6**
Module 6: Supercapacitors and Hydrogen Storage Systems	**Hrs.**
Supercapacitor: characteristics, components, schematic, classification, advantages, disadvantages Hydrogen storage systems: Basics, working and applications.	**6**

Module wise Measurable Students Learning Outcomes :

After completion of the course students will be able to:

1. Illustrate the need and classification of energy storage systems
2. Analyze the operation, modeling and components of various batteries.
3. Study topology and operation of different power electronics converters.
4. Investigate the working and components of battery management system
5. Illustrate different types and working of fuel cells.
6. Study working principle, operation and components of super capacitors and hydrogen storage systems.

EVEN Semester

Professional Core (Theory) Courses

Title of the Course: Fundamentals of Management for Engineers Course Code: 4HS308	L	T	P	Cr
	3	0	0	3

Desirable Courses: Fundamentals of Management for Engineers

Textbooks:

1. Koontz and O'Donnell, Principles of Management
2. Joseph Messie, Essentials of Management
3. R. Paneerselvam, Engineering Economics, PHI Learning Pvt. Ltd.
4. Datta, Sundaram, Indian Economy, S. Chand
5. Mishra, Puri, Business Economics, Himalaya Publishing House

References:

1. Heinz Weiharich, Management, 12th Edition
2. Julie Nelson, Economics for Humans
3. Matthew Bishop, Essential Economics

Course Objectives:

1. To introduce concepts involved in management and economics.
2. To impart knowledge about practicing aspects of management and economics.
3. To develop students towards identifying rational solutions for managerial and economic problems.
4. To prepare students for working as team member and team leader.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
CO1	**Perceive** and describe management theories and approaches as well as economics terminologies.	2	Understanding
CO2	**Solve** industrial and business problems by grasping market scenario and using skills related to operations, financial and human resource management.	3	Apply
CO3	**Design** strategic plans to overcome managerial and economic difficulties faced by management of business and industrial organizations.	4	Analyze

CO-PO Mapping :

PO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2
CO1						3					3			
CO2										2	3			
CO3											3			

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Introduction to Management	**Hrs.**
Definition, objectives, nature and importance of management. Managerial roles and skills, Challenges for management in global scenario.	**6**
Module 2: Functions and Principles of Management	**Hrs.**
Functions of Management: Planning, Organising, Staffing, Directing, Controlling (Meaning, need and scope of each function) Mission, Vision and goals, Decision making process. Leadership styles, characteristics of good leader, Types of organisation structures. Communication-Process and barriers.	**8**
Module 3: Principles of Management and Motivation	**Hrs.**
Fayol's fourteen principles of management and their application in organisations. Motivation: Concept, Need and theories (Maslow's hierarchy of needs, Theory X and Theory Y, Herzberg's Two Factor Theory)	**6**
Module 4: Functional Areas and Recent Trends in Management	**Hrs.**
Sources of funds, financial statements (Types and contents) Functions of HRM, recruitment, selection, Training-types, performance appraisal Operations management-Plant layout, production systems, site selection, productivity, inventory control and TQ	**7**
Module 5: Recent Trends in Management	**Hrs.**
Recent Trends: Change management, supply chain management, digital marketing, management in Post-Covid scenario, Business ethics.	**5**
Module 6: Introduction to Economics	**Hrs.**
Economics: Meaning, nature, scope, types, Basic concepts-Demand, Supply, Law of demand, Types of market structures, Pricing methods, Types of costs. Elasticity of demand, Giffen goods Indian economics: Features, sectors of economy, economic planning, GST	**7**

Title of the Course: Power System Protection **Course Code: 4EL321**	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: Power System Engineering

Textbooks:

1. S.S. Rao, Switchgear & Protection, Khanna Pub., XI edition, 2005.
2. B.Ram & Vishwakarma, Power System Protection & Switchgear, TMH Pub., III edition, 2008.

References:

1. Oza, Nair, Mehta & Makwana, Power System Protection & Switchgear, MGH pub., 2011.
2. C.R. Mason, Art & Science of Protective Relaying, GE e-book.
3. Y.G. Paithankar & S.R. Bhide, Fundamentals of Power System Protection, PHI pub., I edition, 2004.

Course Objectives :

1. The need for power system protection and basic principles of circuit breakers and relays would be taught.
2. Protection of feeders, transmission lines, transformers, generators and their implementation using electromagnetic & microprocessor based relays would be covered.
3. Causes of over voltages in power system and protection against these over voltages would be discussed.

Course Learning Outcomes:

CO	**After the completion of the course the student will be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	**Describe** basic principles & working of circuit breakers & fuses and select proper CB/fuse for a particular application.	1	Remembering
CO2	**Classify** the requirements of protection for different parts of a power system and select proper relay scheme.	2	Understanding
CO3	**Analyze** the performance of various protection devices and discuss digital relaying techniques.	4	Analyzing

CO-PO Mapping :

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2													
CO2		3												
CO3			3										3	

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Over Current Relays	**Hrs.**
Need of protection, Brief theory and construction of electromagnetic relays. Different time current characteristics of over current relay, Directional relay, Microprocessor based over current relay, Directional over current relay, drawbacks of over current schemes.	**6**
Module 2: Arc Interruption Process	**Hrs.**
Voltage - current characteristics of arc, Principles of DC and AC arc interruption, high resistance and current zero interruption, arc voltage, Transient Restriking Voltage (TRV), Recovery voltage, RRRV, current chopping, resistance switching, capacitive current interruption.	**6**
Module 3: Circuit Breakers & Fuses	**Hrs.**
Classification of circuit breakers, brief study of construction and working of Air break and Air Blast CB, SF6 and Vacuum CB, HVDC breakers, ratings of CB and testing of CB, Fuse – Rewirable and HRC fuse, fuse characteristics, application and selection of fuse.	**7**
Module 4: Protection of Transformer, Generator and Bus Bar	**Hrs.**
Circulating current differential protection, percentage differential protection of power transformers, through fault stability, effect of magnetizing inrush, effect of over voltage inrush, Buchholz relay, Differential protection of generator, stator and rotor protection schemes of generator, loss of excitation, prime mover failure protection, bus bar protection.	**6**
Module 5: Protection of Transmission Line	**Hrs.**
Principles of distance relays, Effect of arc resistance, and power swing on relay operation, Microprocessor based impedance, reactance and admittance relays, Quadrilateral characteristics, carrier aided protection of transmission line. Protection Against Over Voltages.	**8**
Module 6: Recent Developments in Protection	**Hrs.**
Introduction to numerical/digital relay techniques. New numerical /digital relaying algorithms, introduction of various transform techniques - Discrete Fourier Transform, Haar Transform etc.	**6**

Module wise Measurable Students Learning Outcomes :

Module 1: CO1- Student will be able to explain & justify the overcurrent relay principle and application.
Module 2: CO1 - Student will be able to understand & describe the DC and AC arc interruption processes.
Module 3: CO2 - Student will be able to identify various types of circuit breakers, fuses & select proper device for protection.
Module 4: CO2 - Student will be able to summarize protection schemes for transformer, generator and bus bars.
Module 5: CO3 - Student will be able to analyze the importance of distance relays analyze their performance.
Module 6: CO3 - Student will be able to differentiate between the electromagnetic & digital relaying techniques.

Title of the Course: Industrial Drives and Control	L	T	P	Cr
Course Code: 4EL322	3	0	0	3

Pre-Requisite Courses: DC Machines and Transformer, AC Machines and Power Electronics

Textbooks:

1. "Fundamentals *of Electrical Drives*", G. K. Dubey, Narosa publication, 2nd edition.

References:

1. "Fundamentals *of Electrical Drives*", NPTEL video lecture series by Prof. Shyama Prasad Das, Department of Electrical Engineering, IIT Kanpur.
2. "*Power Electronics* - Converter Application" By N. Mohan T.M. undel and W. P. Robbins, John Wiely and sons.
3. "*Electrical Drives* - Concept and application" Vedam Subramanyam.

Course Objectives :

The course aims at giving a fundamental knowledge in dynamics and control of Electric Drives. The control principles of various DC and AC motors using solid state converters are discussed. Principles of selection of Electric Motors are introduced. Some of the applications of Electrical Drives are also highlighted.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Explain** the various concepts used in Electric drives.	2	Understanding
CO2	**Apply** the control techniques for Electric drives for speed control.	3	Applying
CO3	**Analyze** the performance of various control techniques used in speed control of electric drives and **select** a drive for particular application.	4,5	Applying , Evaluating

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3													2
CO2		2												2
CO3		2												2

Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion. [One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2]

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Basics of drives	**Hrs.**
Types & parts of the Electrical drives, Selection criteria of drives, motor rating, selection based on duty cycle, selection of converter rating, fundamental torque equation, speed torques characteristics DC motor & Induction motor, multi quadrant operation of the drive, classification of mechanical load torques, steady state stability of the drive, constant torque and constant HP operation of the drive, closed loop speed control.	**6**
Module 2: DC motor drives	**Hrs.**
Methods of speed control, starting and breaking operation, single phase and three phase full controlled and half controlled converter fed DC drives, Multi quadrant operation of separately excited DC shunt motor, dual converter fed DC drives, circulating and non – circulating mode of operation, converter fed DC series motor drive, chopper control of DC shunt and series motor drives, four quadrant operation of chopper fed DC shunt motor drive.	**6**
Module 3: Induction motor drives	**Hrs.**
Speed control methods for three phase cage induction motor, stator voltage control, three phase AC voltage controller, closed loop speed control of induction motor by stator voltage control, multi quadrant operation of drive with AC voltage controller, phase angle and integral cycle control of stator voltage controlled induction motor drive VSI fed induction motor drive, constant torque (constant E/F and constant V/F), constant HP operation, closed loop speed control block diagram., CSI fed induction motor drive, speed torque characteristics of CSI fed drive, closed loop speed control block diagram, comparison of CSI fed and VSI fed induction motor drive. Analysis of inverter fed induction motor drive using harmonic equivalent circuit, harmonic slip, harmonic torques and losses with inverter fed induction motor. Introduction to field oriented control and direct torque control.	**8**
Module 4: Slip Ring Induction Motor Drives	**Hrs.**
Chopper controlled resistance in rotor circuit, slip power recovery using converter cascade in rotor circuit, sub synchronous and super synchronous speed control, Kramer speed control, cyclo - converter in rotor circuit.	**6**
Module 5: Synchronous motor drives and Brushless DC drives	**Hrs.**
VSI fed synchronous motor drives, true synchronous and self-control mode, open loop and closed loop speed control of Permanent magnet synchronous machine, brushless DC motor drives.	**5**
Module 6: Special Drives	**Hrs.**
Construction and operating principle, Current / Voltage control of switched reluctance motors, torque equation, converter circuits, operating modes and applications of switched reluctance motors. Solar panel VI characteristics, solar powered pump, maximum power point tracking and battery operated vehicles.	**5**

Module wise Measurable Students Learning Outcomes :

After completion of the course students will be able to:

1. Explain the dynamics of motor load combination and dynamic response of the drive.
2. Classify DC drives and investigate the performance of DC drives.
3. Apply and analyze various control techniques for speed control of Squirrel Cage Induction motor.
4. Apply and analyze various control techniques for speed control of Slip Ring Induction motor.

5. Explain the high efficiency PM synchronous drives.
6. Describe SRM drives, solar and battery powered drives.

Title of the Course: Microcontroller and Applications	L	T	P	Cr
Course Code: 4EL323	3	0	0	3

Pre-Requisite Courses: Analog and Digital Circuits

Textbooks:

1. Muhammad Mazidi, Janice Mazidi and Rolin McKinlay, 'The 8051 Microcontroller and Embedded systems using Assembly and C', Pearson Education, 2nd Edition, 2007
2. Kenneth Ayala ,'8051 Architecture, Programming and Applications', 3rd Edition, 2007
3. Massimo Banzi and Michael Shiloh, Make: Getting Started With Arduino - The Open Source Electronics Prototyping Platform, Shroff/Maker Media; 3rd edition, 2014
4. Raj Kamal ,"Embedded System", 2nd Edition, TATA McGraw Hill, 2009

References:

1. Subrata Ghoshal, 'Embedded Systems and Robots- Projects using the 8051 Microcontroller', Cengage Learning, 1st Edition, 2009
2. Michael Margolis, 'Arduino Cookbook', Shroff/ O'Reilly,2nd Edition,2012
3. Texas Instruments MSP 430/C2000 microcontrollers, Guide and Datasheet
4. Mazidi, RolinMc Kinlay and Danny Causey, 'PIC Microcontroller and Embedded Systems using Assembly and C for PIC18', Pearson Education.

Course Objectives :

1. To develop basic knowledge of microcontrollers and their features.
2. To provide skills for programming microcontroller for applications in Electrical Engineering.
3. The course aims to enable students to interface and program different peripherals to microcontrollers.

Course Learning Outcomes:

CO	**After the completion of the course the student will be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	**Explain** the architecture and features of microcontrollers.	2	Understanding
CO2	**Apply** programming techniques to implement counters, timers, interrupts and other peripherals.	3	Applying
CO3	**Implement** the applications related to interface microcontroller with electrical and electronics systems.	3	Applying
CO4	**Construct** a microcontroller based application.	3	Applying

CO-PO Mapping :

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1			3											
CO2					3									
CO3					3									
CO4			3											2

Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion.[One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2]
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Microcontroller Basics	**Hrs.**
Difference between Microprocessor and Microcontroller, Harvard and Von-Neumann architectures, Advantage of microcontrollers, Overview of 8051/Arduino/DSP family, features, internal architecture, Pin out and pin functions, program memory, data memory, SFR area, PSW, Code memory space, (Internal/External), Port structure, clock circuit.	**5**
Module 2: Programming ports and timers	**Hrs.**
Instruction set, Introduction to C programming, , data types using pointers I/O programming, Assembler directives, Development tools for 8051 programs, Programming Timers and counters Timer block diagram and function, Timer modes 0, 1, 2 and their Applications, Timer and Counter Programming	**7**
Module 3: Interrupts and Serial Communication	**Hrs.**
Interrupt structure, Writing ISR, interrupt blocking conditions, Interrupt priorities, Programming for external interrupt. Programming timer interrupts. Serial Communication :Serial communication modes, RS232 signals of PC, Programming through Serial communication	**6**
Module 4:Peripheral Interfacing- I	**Hrs.**
Interfacing of microcontrollers to external peripherals and programming, LCD interfacing, Interfacing of Analog to Digital Converters and Digital to Analog Converters, Stepper motor interfacing , RTC interfacing, RS232 interfacing,	**6**
Module 5: Peripheral Interfacing- II	**Hrs.**
DC motor interfacing, PWM programming using microcontrollers, Interfacing of Wifi module, Use of Arduino in Power Electronics Applications, Introduction to CAN protocol and its interfacing	**6**
Module 6: Introduction to Advanced microcontrollers	**Hrs.**
Introduction of MSP430 microcontrollers, PIC microcontrollers, overview, Features, concepts of brown out reset, watch dog timers, configurations registers, concept of hardware-in-loop simulation, programming examples	**6**

Module wise Measurable Students Learning Outcomes :

After completion of the course students will be able to:

1. Describe the architecture and features of microcontrollers.
2. Use the instruction set and develop different I/O, timer and counter programs.
3. Implement the programs related to interrupts and serial communication
4. Construct programs for peripherals interfaced to 8051.
5. Design and implement programs for applications like motor speed control, etc.
6. Compare different microcontrollers and understand their strengths and limitations.

Professional Core (Lab) Courses

Title of the Course: **Power System Protection Lab**	L	T	P	Cr
Course Code: 4EL371	0	0	2	1

Pre-Requisite Courses: Power System Engineering.

Textbooks:

1. S.S. Rao, Switchgear & Protection, Khanna Pub., XI edition, 2005.
2. B.Ram and Vishwakarma, Power System Protection & Switchgear, TMH Pub., III edition, 2008.

References:

1. Oza, Nair, Mehta and Makwana, Power System Protection and Switchgear, MGH pub., 2011.
2. C.R. Mason, Art and Science of Protective Relaying, GE e-book.
3. Y.G. Paithankar and S.R. Bhide, Fundamentals of Power System Protection, PHI pub., I edition, 2004.

Course Objectives :

This course is designed to develop hands on skills to test and verify protective relay operation, used in power system protection. A mix of electromagnetic and digital relays will be used to demonstrate their operating characteristics. Students will also gain experience to use power system analysis software for developing protection schemes for simple electrical systems.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Demonstrate** the working of over current, earth fault relays and plot the I-t characteristics.	3	Applying
CO2	**Execute** experimental study of a microcontroller based relays.	3	Applying
CO3	**Devise** a scheme for over current relay co-ordination using simulation software/hardware.	6	Creating

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1				3										
CO2					3									
CO3			2										3	

Lab Assessment:

There are four components of lab assessment, LA1, LA2, LA3 and Lab ESE.

IMP: Lab ESE is a separate head of passing.

Assessment	Based on	Conducted by	Conduction and Marks Submission	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Lab activities, attendance, journal	Lab Course Faculty	During Week 10 to Week 14 Submission at the end of Week 14	25
Lab ESE	Lab Performance and related documentation	Lab Course faculty	During Week 15 to Week 18 Submission at the end of Week 18	25

Week 1 indicates starting week of Semester.
Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.

Course Contents: (Experiments)

1. Arrange the set-up & perform an experiment to verify the Current-Time characteristics of a shaded pole type over current relay.
2. Arrange the set-up & perform an experiment to verify the Current-Time characteristics of a shaded pole type earth fault relay.
3. Arrange the set-up & perform an experiment to demonstrate the operation & use of Directional over Current relay.
4. Assemble a circuit to obtain & verify various Current-Time curves for Digital over Current Relay.
5. Demonstrate the application of Quadrilateral Distance relay for detection of fault on transmission lines.
6. Conduct a simulation study to develop relay co-ordination scheme of over current relays for a simple radial feeder system.
7. Conduct an experiment to illustrate the over current relay co-ordination on the Transmission Line Simulator.
8. Conduct a simulation study to explain the Circuit Breaker operation under fault condition.

Computer Usage / Lab Tool: MiPOWER/ MATLAB/ NRDE

Title of the Course: Industrial Drives and Control Lab	L	T	P	Cr
Course Code: 4EL372	0	0	2	1

Pre-Requisite Courses: DC Machines and Transformer, AC Machines and Power Electronics

Textbooks:

1. "Fundamentals *of Electrical Drives*", G. K. Dubey, Narosa publication, 2nd edition.

References:

1. "*Modern Power Electronics and AC drives*" by B. K. Bose, Prentice Hall of India Pvt. India
2. "*Power Electronics* - Converter application" By N. Mohan T.M. undeland and W. P. Robbins, John Wiely and sons
3. "*Electrical Drives* - Concept and application" Vedam Subramanyam.

Course Objectives :

The course aims at imparting knowledge on performance of the fundamental control practices associated with AC and DC machines (starting, reversing, braking, plugging, etc.) using solid state converters. It intends to hone the skills for the use of computer-based analysis tools to review the major classes of machines and their physical basis for operation and suitability for a particular operation.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Demonstrate** experiments on basics of DC and AC drives.	3	Applying
CO2	**Analyze** the performance of drives using hardware circuits and simulation.	4	Analyzing
CO3	**Evaluate** performance of drives using hardware circuits and simulation.	5	Evaluating

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1		3												
CO2		2												2
CO3			2											2

Lab Assessment:

There are four components of lab assessment, LA1, LA2, LA3 and Lab ESE.

IMP: Lab ESE is a separate head of passing.

Assessment	Based on	Conducted by	Conduction and Marks Submission	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Lab activities, attendance, journal	Lab Course Faculty	During Week 10 to Week 14 Submission at the end of Week 14	25
Lab ESE	Lab Performance and related documentation	Lab Course faculty	During Week 15 to Week 18 Submission at the end of Week 18	25

Week 1 indicates starting week of Semester.

Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course.

The experimental lab shall have typically 8-10 experiments.

Course Contents:

1. To verify Speed – Torque characteristics of chopper fed D. C. series motor.(Hardware)
2. To analyze the performance of chopper fed D. C. drive for closed – loop speed control (simulation).
3. To demonstrate operation and application of single phase full wave, half controlled converter for open loop speed control of D. C. shunt motor.(Hardware)
4. To demonstrate operation and application of single phase full wave, full controlled converter for open loop speed control of D. C. shunt motor.(Hardware)
5. To analyze the performance of converter fed D. C. drive for closed loop speed control.(Simulation)
6. To study the operation of two quadrant single phase converter fed 5 HP DC drive (Simulation).
7. To study the four quadrant operation of 5 HP DC motor using single phase converter.(Simulation).
8. To study the operation of four quadrant chopper fed DC drive (simulation).
9. To assess the performance of rotor resistance control method for speed control of Slip – Ring Induction motor.(Simulation)
10. To demonstrate speed control of Induction motor using V/f method.(Hardware)
11. To analyze the operation of Induction motor drive with Six – step VSI control (Simulation).
12. To demonstrate the operation of brushless DC motor drive with software Simulation.(Simulation)
13. To demonstrate speed control of Induction motor using Kramer speed control method.(Hardware)

Computer Usage / Lab Tool:

Simulation on Matlab/ Scilab.

Title of the Course: Microcontroller and Applications Lab	L	T	P	Cr
Course Code: 4EL373	0	0	2	1

Pre-Requisite Courses: Analog and Digital Circuits

Textbooks:

1. Muhammad Mazidi, Janice Mazidi and Rolin McKinlay, 'The 8051 Microcontroller and Embedded systems using Assembly and C', Pearson Education, 2^{nd} Edition, 2007
2. Kenneth Ayala ,'8051 Architecture, Programming and Applications', 3^{rd} Edition, 2007
3. Massimo Banzi and Michael Shiloh, Make: Getting Started With Arduino - The Open Source Electronics Prototyping Platform, Shroff/Maker Media; 3^{rd} edition, 2014
4. Raj Kamal ,"Embedded System", 2nd Edition, TATA McGraw Hill, 2009

References:

1. Subrata Ghoshal, 'Embedded Systems and Robots- Projects using the 8051 Microcontroller', Cengage Learning, 1^{st} Edition, 2009
2. Michael Margolis, 'Arduino Cookbook', Shroff/ O'Reilly,2^{nd} Edition,2012
3. Texas Instruments MSP 430/C2000 microcontrollers, Guide and Datasheet
4. Mazidi, RolinMc Kinlay and Danny Causey, 'PIC Microcontroller and Embedded Systems using Assembly and C for PIC18', Pearson Education.

Course Objectives :

1. This course is designed to develop the necessary skills required for programming 8051 and Arduino microcontroller to implement real world applications.
2. The course aims at understanding the practical problems in electrical systems and implementing programs for same.
3. This course introduces various programming software's to implement microcontroller based applications.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Use** simulation tools to analyze microcontroller based systems.	3	Applying
CO2	**Apply** programming techniques to implement counters, timers, interrupts and other peripherals.	3	Applying
CO3	**Execute** programs to interface microcontrollers with electrical and electronics systems.	3	Applying
CO4	**Construct** programs for electrical applications using microcontrollers.	3	Applying

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1			3											
CO2					3									
CO3					3									
CO4			3											

Lab Assessment:

There are four components of lab assessment, LA1, LA2, LA3 and Lab ESE.

IMP: Lab ESE is a separate head of passing.

Assessment	Based on	Conducted by	Conduction and Marks Submission	Marks

LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Lab activities, attendance, journal	Lab Course Faculty	During Week 10 to Week 14 Submission at the end of Week 14	25
Lab ESE	Lab Performance and related documentation	Lab Course faculty	During Week 15 to Week 18 Submission at the end of Week 18	25

Week 1 indicates starting week of Semester.
Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.

Course Contents:

1. Introduction to Keil/Arduino IDE, Using Keil/Arduino IDE to assemble a program, Hex file format, Downloading and running the program
2. Demonstrate the flashing of GPIO ports of using delay.
3. Implement a 8-bit up and down counter using microcontroller.
4. Devise a running light scheme using GPIO pins of microcontroller.
5. Demonstrate the process of serial communication using 8051 and Arduino microcontroller
6. Construct a C program using 8051 to generate pulses using various timer modes
7. Execute programs to demonstrate interrupts for 8051.
8. Construct a C program to interface LCD with 8051 LCD.
9. Devise a Arduino based system interfaced with relay to control a single phase ac load.
10. Construct a C program to interfacing stepper motor with Arduino.
11. Implement digital sensor based control using TI Launchpad.
12. Demonstrate the operation of analog to digital converters using TI launchpads.

Computer Usage / Lab Tool:

C programming of 8051 using KEIL IDE. Introduction to C programming for 8051, Proteus and ISIS, Arduino IDE

Title of the Course: Mini Project Course Code: 4EL341	L	T	P	Cr
	0	0	2	1

Pre-Requisite Courses:

Textbooks:

References:

Course Objectives:

1. To acquire the skills related to electrical and electronic circuit designing and assembly.
2. To develop the skills related to programming, analysis and fault diagnosis of the electrical and electronic circuit.
3. To implement the electrical and electronic circuit assembly to meet desired specifications.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Analyze** the reference literature critically and efficiently.	4	Analyzing
CO2	**Evaluate** the performance of the project	5	Evaluating
CO3	**Construct** the project model to meet desired specifications using suitable hardware	6	Creating
CO4	**Develop** the report for the complete project.	6	Creating

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1							2		3				2	2
CO2			2						3		2			
CO3					3							3		
CO4								3		3				

Assessment:

There are four components of mini-project assessment, LA1, LA2, LA3 and Project ISE.

Assessment	Based on	Conducted by	Conduction and Marks Submission	Marks
LA1	Project Topic Selection and Literature Review	Mini project panel	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Simulation / Basic Project design	Mini project panel	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Software /Hardware Implementation	Mini project panel	During Week 10 to Week 14 Submission at the end of Week 14	25
Project ISE	Presentation, Project report submission	Mini project panel	During Week 15 to Week 18 Submission at the end of Week 18	25

Week 1 indicates starting week of Semester.ISE is based on performance of student in project reports, demonstration, presentation, oral, etc. The mini-project guide/panel shall use at least two assessment tools as mentioned above for ISE.

Course Contents:

1. Students may visit to nearby industry for the study of problems.
2. Prepare the problem statement and design the hardware.
3. Analyze the performance of project and results to meet desired specifications.

4. Prepare a report on the same.

Module wise Measurable Students Learning Outcomes:

1. Students will be able to do literature review efficiently.
2. It is expected that the students will be able to analyze the problem, work on hardware circuits/software and evaluate the project performance.
3. Students will be able to prepare the project report and develop presentation skills.

Computer Usage / Lab Tool: MATLAB/Simulink, Mipower, LabView, Proteus, Keil, PSpice, etc

Professional Elective (Theory) Courses

Title of the Course: Professional Elective III: Artificial Neural Network	L	T	P	Cr
Course Code: 4EL331	3	0	0	3

Pre-Requisite Courses: Nil

Textbooks:

1. Simon Haykin, ”Neural Network, Pearson Publications, 2005
2. Bishop, C. M. Neural Networks for Pattern Recognition. Oxford University Press. 1995.
3. Neural Networks, Fuzzy Logic and Genetic Algorithms, by S.Rajasekaran and G.A. Vijayalakshmi Pai., 2012.

References:

1. Neuro-Fuzzy Systems, Chin Teng Lin, C. S. George Lee, PHI.pub. 2007.

Course Objectives :

1. To develop basic knowledge of neural networks and their features.
2. To provide skills for programming ANN for applications in Electrical Engineering.
3. The course aims to enable students to understand and program different neural network algorithms.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Explain** the architecture and features of neural networks	2	Understanding
CO2	**Explain** programming techniques to implement of neural networks	2	Understanding
CO3	**Implement** the applications related to electrical and electronics systems using of neural networks.	3	Applying

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1			2											
CO2			2											
CO3					3									2

Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion.[One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2]
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Neural Networks and Architecture	**Hrs.**
Fundamentals of Neural Networks: What is Neural Network, Model of Artificial Neuron, Learning rules and various activation functions, Single layer Feed-forward networks, Perceptron learning, MLP structures.	**6**
Module 2: Back propagation Networks	**Hrs.**
Delta and LMS rules, Back propagation Networks, Architecture of Back-propagation (BPN) Networks, Back-propagation Learning, Variation of Standard Back propagation algorithms.	**7**
Module 3: Unsupervised networks	**Hrs.**
Associative Memory: Auto correlators, Heterocorrelators, Multiple Training Encoding Strategy, Exponential BAM, and Associative Memory for Real coded pattern pairs, Applications.	**7**
Module 4: Adaptive Resonance Networks	**Hrs.**
Adaptive Resonance Theory: Cluster Structure, Vector Quantization, Classical ART Network, Simplified ART Architecture,ART1 and ART2 Architecture and algorithms, Applications, Sensitivities of ordering of data.	**7**
Module 5: Radial and Convolution Networks	**Hrs.**
Convolution networks, pooling, working and design , radial basis function network, working	**6**
Module 6:Application to Electrical	**Hrs.**
Control system design with neural network- controller design , tuning and learning, power system applications, load forecasting and fault analysis	**6**

Module wise Measurable Students Learning Outcomes :

After completion of the course students will be able to:

1. Describe the architecture and features of Neural Networks
2. Use the BPN algorithm and develop different application programs.
3. Implement the programs related to unsupervised learning.
4. Construct programs using ART network.
5. Describe the architecture and features of convolution and RBF networks.
6. Construct programs for applications in control and power system area

Title of the Course: Professional Elective III: Nonlinear and Digital Control System **Course Code: 4EL332**	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: Control System Engineering

Textbooks:

1. K. Ogata, "*Discrete Time Control Systems",* Pearson Education, Second Edition, 2015
2. C.L. Phillips, J.M. Parr, "*Feedback ControlSystems",*Pearson,2010

References:

1. I.J. Nagrath, M.Gopal "*Control Systems Engineering"*, New Age International, Sixth Edition, 2018.
2. B.C. Kuo, "*Digital Control Systems"*, Oxford University Press, Second Edition, 2012.

Course Objectives :

1. To make students identify various characteristics of nonlinear systems.
2. To develop skills for analyzing nonlinear systems.
3. To make students familiar with digital control system.

Course Learning Outcomes:

CO	**After the completion of the course the student will be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	**Calculate** mathematical models of digital control system.	3	Applying
CO2	**Identify** the properties of nonlinear systems using appropriate methods.	4	Analyzing
CO3	**Calculate** the compensators and controllers for digital control system.	5	Evaluating

CO-PO Mapping :

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3													
CO2		2												
CO3			2											

Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion.[One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2] MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Nonlinear System	**Hrs.**
Properties of nonlinear system, Multiple Equilibrium States, Chaos, Sensitive to input amplitude, Limit Cycle, Bifurcation, Jump Phenomenon, Common Physical Nonlinearities, Dead Zone, Saturation, Hysteresis, Backlash, Classification of Nonlinearities.	**4**

Module 2: Analysis of Nonlinear System	Hrs.
Linearization, Phase Plane Analysis, Classification of Equilibrium States, Node, Focus, Saddle Point, Centre, Prediction of Limit Cycle using Phase Plane, Describing Function Method, Lyapunov Stability for Non-linear and Linear Systems.	**8**
Module 3: Digital Control System	**Hrs.**
Review of Z transforms, Z transform method for solving difference equation, Impulse Sampling and Data Hold, Pulse Transfer Function, Sampling Theorem, Mapping between S Plane and Z Plane, Stability Analysis, Transient and Steady State Analysis.	**8**
Module 4: Design of Digital Control System	**Hrs.**
Construction of Root Locus, Design based on Root Locus, P,PI,PD,PID Controllers, Lead, Lag, Lead-Lag Compensators, Frequency Response Analysis, Bode Diagram.	**7**
Module 5: State Space Analysis of Digital Control System	**Hrs.**
State Space representation of Digital System, Controllable Canonical form, Observable Canonical form, Diagonal form, Jordan form, Solving State Space Equations, State Transition Matrix, Properties of State Transition Matrix, Pulse Transfer Function Matrix. Discretization of Continuous Time State Space Equation.	**7**
Module 6: State Space Design of Digital Control System	**Hrs.**
Controllability, Controller Design in State Space, Design via Pole Placement for Controller Design, Ackermann's Formula for Controller Design, Observability, Observer Design, Design via Pole Placement for Observer Design, Ackermann's Formula for Observer Design, Deadbeat Design, Design for Deadbeat Response.	**5**

Module wise Measurable Students Learning Outcomes :

After completion of the course students will be able to:

1. Identify the properties of nonlinear systems.
2. Analyze the nonlinear system using various techniques.
3. Inspect the stability, transient and steady state response of digital control system.
4. Assess the Compensators for digital control system using Root locus and Bode plot.
5. Employ State Space model for digital control system.
6. Estimate the controllers for digital control system in State Space domain.

Title of the Course: Professional Elective III: Introduction to Electric Vehicle Course Code: 4EL333	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: Electrical Machines, Power Electronics

Textbooks:

1. Iqbal Husain ,‘ Electric and Hybrid Vehicles: Design Fundamentals ’, CRC Press, 2003
2. James Larminie, John Lowry, “ Electric Vehicle Technology Explained”, Wiley , 2nd edition, 2012

References:

1. Sheldon Williamson, ‘ Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles ’, Springer-Verlag, 2012
2. M. Ehsani, Y. Gao, S. Gay and A. Emadi , Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, CRC Press, 2005.

Course Objectives :

1. To develop basic knowledge related to architecture of Electric Vehicles
2. To provide knowledge related to design aspects and dynamics of Electric vehicles
3. The course aims at enabling students to understand the motor specifications and charging standards for Electric vehicles.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Explain** the architecture and features of Electric Vehicles	2	Understanding
CO2	**Interpret** the topologies and various design considerations for Electric vehicles	2	Understanding
CO3	**Calculate** the vehicle dynamics for Electric propulsion systems	3	Applying

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3													
CO2		3												
CO3		3												

Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment, oral, seminar, test (surprise/declared/quiz), and group discussion.[One assessment tool per ISE. The assessment tool used for ISE 1 shall not be used for ISE 2]

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Introduction to Electric Vehicles	**Hrs.**
Background of Electric Vehicles, Electric Vehicle System, Components of Electric Vehicles, Advantages of Electric Vehicles, Efficiency, Pollution Comparison with conventional vehicles, Fundamentals of Electric Vehicles	**5**
Module 2: Types of Electric Vehicles and Architecture of EVs	**Hrs.**
Concept of Electric, Hybrid and Plug-in Electric Vehicles, Typical configuration of Hybrid Electric Vehicle, Topologies of HEVs: Series, Parallel and Series-Parallel Configuration, Topologies of Plug-in Hybrid Electric Vehicles, Fuel Cell Electric Vehicles, Solar Powered Electric Vehicles	**7**
Module 3: Design Considerations for Electric Vehicles	**Hrs.**
Introduction to EV design fundamentals, Aerodynamic Consideration, Rolling resistance, Transmission efficiency, Consideration of vehicle mass, Basics of Electric vehicle chassis and body design, general issues in Electric vehicle design	**6**
Module 4: Vehicle Dynamics	**Hrs.**
Roadway fundamentals, Vehicle Kinetics, Dynamics of Vehicle Motion, Propulsion power: Force velocity characteristics, Vehicle gradability, Velocity and Acceleration: Velocity Profile, Distance traversed, tractive power, Energy Required, Propulsion System Design for EV systems	**6**
Module 5: Electric Machines in EV systems	**Hrs.**
Motor and Engine ratings, EV and HEV motor requirements, Three phase AC machines for Electric vehicles: Induction Machines, SRM machines, PMSM machines, Design aspects for EV systems, Numericals	**6**
Module 6: Electric Vehicle Chargers and Charging Standards	**Hrs.**
EV charging: requirements and Classification, Charging standards for Electric vehicles, Introduction to AC and DC chargers for EV systems, Working of Electric Vehicle Supply Equipment (EVSE), Fast Chargers for EV systems	**6**

Module wise Measurable Students Learning Outcomes :

After completion of the course students will be able to:

1. Describe the types and features of Electric Vehicles.
2. Interpret the different topologies and configuration of Electric Vehicles.
3. Calculate the vehicle dynamics for Electric propulsion systems.
4. Identify and select appropriate machines for Electric vehicles.
5. Summarize the power electronics converters used in Electric vehicles.
6. Determine the performance of electric vehicle chargers and explain the charging standards.

Professional Elective (Lab) Courses

Open Elective -II

Courses

Title of the Course: Open Elective II: Renewable Energy Course Code: 4OE350	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: Basic Mechanical Engineering & Basic Electrical Engineering.

Textbooks:

1. Boyle, Godfrey, "Renewable Energy", (2nd edition), Oxford University Press, 2004.
2. Masters, Gilbert M. Renewable and efficient electric power systems. John Wiley & Sons, 2013.
3. Solanki, Chetan Singh. Solar Photovoltaics: fundamentals, technologies and applications. PHI Learning Pvt. Ltd., 2015.

References:

1. G.S.Sawhney, "Non-Conventional Resources of Energy", PHI Publication 2012. Gary-L. Johnson Wind Energy Systems Tata Mc-Graw-Hill Book Company.
2. S. P. Sukhatme, J. K. Nayak Solar Energy- Principles of Thermal Collection and Storage (3rd edition), Tata McGraw-Hill Publication.

Course Objectives:

1. To create awareness about the importance of renewable resources and their classification for sustainable future.
2. To impart the knowledge of solar power generation and wind power generation.
3. To introduce other renewable resources and their technologies.
4. To study energy storage systems in renewable generation.

Course Learning Outcomes:

CO	After the completion of the course the student will be able to	Bloom's Cognitive	
		level	Descriptor
CO1	**Describe** need and types of renewable energy resources with sustainability.	2	Understanding
CO2	**Interpret** working of solar and wind power generation and its utilization.	3	Applying
CO3	**Distinguish** various renewable energy sources like biogas, geothermal and MHD.	4	Analyzing
CO4	**Explain** need and operation of various energy storage technologies.	3	Applying

CO-PO Mapping :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1						3							
CO2	3													
CO3			3											
CO4	3													

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Introduction to Renewable Energy Sources	**Hrs.**
Energy sources: classification of energy sources, introduction to renewable energy, renewable energy trends, and key factors affecting renewable energy supply, global and Indian scenario of renewable energy sources, policies of the government, sustainable development, challenges, advantages and disadvantages of renewable energy sources and their uses.	**4**
Module 2: Solar Energy	**Hrs.**
solar earth geometry, solar radiations and measurement, fundamentals of semi-conductors, absorption of light, solar thermal power generation, heat transfer, solar thermal conversion: basics, solar concentrator and tracking system, flat plate and concentrating collectors, single axis and two axes axis tracking collectors, selective coatings.	**6**
Module 3: PV System Design	**Hrs.**
PV power generation, basic principle of power generation in PV cell, solar cell and its parameters, module and array, efficiency of PV cell, characteristics curves of PV cell, effects of different electrical parameters on I-V & P-V curves, manufacturing of Si, solar cell production, configuration of PV power generation system - off-grid system & grid-connected PV system, design methodology, stand-alone PV system, grid-connected PV systems.	**8**
Module 4: Wind Energy	**Hrs.**
Power available in wind, wind turbine power & torque characteristics, types of rotors, characteristics of wind rotor, components of wind turbine, local effects, wind shear, turbulence & acceleration effects, measurement of wind, wind speed statistics, wind power calculations and Betz limit, capacity factor, aerodynamics of wind turbines, airfoil, lift & drag characteristics, power coefficient & tip speed ratio characteristics, electrical generator machines in wind energy systems, wind energy conversion system.	**7**
Module 5: Biomass Energy and other renewable energy systems	**Hrs.**
Overview of biomass as energy source, physicochemical and thermal characteristics of biomass as fuel, biochemical conversion of biomass for energy production, gasification, bio-refinery and bio-diesel, geothermal energy generation, magneto hydro dynamic power generation- working, layout, different components, advantages, limitations,	**6**
Module 6: Energy Storage Technologies	**Hrs.**
Introduction, need for storage for renewable energy sources, basic thermodynamic and electrochemical principles, classification, traditional energy storage system- battery, fuel cell, principle of operation, types, applications for power generation, battery management system.	**5**

Module wise Measurable Students Learning Outcomes :

After completion of the course students will be able to:

1. Explain the need and types of renewable energy sources.
2. Explain solar radiations and solar thermal power generation
3. Explain solar cell and the designing of on-grid & stand-alone PV systems
4. Explain the wind energy and its conversion systems
5. Explain other renewable energy sources like biomass, geothermal and MHD
6. Compare the operation of different energy storage technologies.

Mandatory Life-skill Courses

Value Added Professional Courses

Value Added Life-Skill Courses

Minor Specialization Courses

Walchand College of Engineering, Sangli
(An Autonomous Institute)
Minor in Electrical Engineering Structure

Semester	Course Name	Credits	Faculty and its Address	Available on
Semester- VI	Industrial Drives - Power Electronics	3	Prof. K. Gopakumar IISc, Bangalore.	NPTEL

Semester	**VI**
Credits	**3**

Honors Specialization Courses

Walchand College of Engineering, Sangli
(An Autonomous Institute)
Teaching and Evaluation Scheme effective from 2020-21
B. Tech in Electrical Engineering with Specialization Electrical Vehicle Technology

Semester VI

<table>
<tr><th colspan="3">Course</th><th colspan="4">Teaching Scheme</th><th colspan="4">Evaluation Scheme</th></tr>
<tr><th rowspan="2">Semester</th><th rowspan="2">Code</th><th rowspan="2">Name</th><th rowspan="2">L</th><th rowspan="2">T</th><th rowspan="2">P</th><th rowspan="2">Credits</th><th rowspan="2">Component</th><th colspan="3">Marks</th></tr>
<tr><th>Max</th><th colspan="2">Min for Passing</th></tr>
<tr><td rowspan="5">6th</td><td rowspan="5"></td><td rowspan="5">Core 2: Introduction to Electrical Vehicles</td><td rowspan="5">4</td><td rowspan="5">--</td><td rowspan="5">--</td><td rowspan="5">4</td><td>ISE 1</td><td>10</td><td rowspan="3"></td><td rowspan="5">40</td></tr>
<tr><td>MSE</td><td>30</td></tr>
<tr><td>ISE 2</td><td>10</td></tr>
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<tr><td>ESE</td><td>50</td><td>20</td></tr>
</table>

Title of the Course: Introduction to Electric Vehicle	L	T	P	Cr
	3	0	0	3

Pre-Requisite Courses: Electrical Machines, Power Electronics

Textbooks:

1. Iqbal Husain ,' Electric and Hybrid Vehicles: Design Fundamentals ', CRC Press, 2003
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1. Sheldon Williamson, ' Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles ', Springer-Verlag, 2012
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Course Objectives :

1. To develop basic knowledge related to architecture of Electric Vehicles
2. To provide knowledge related to design aspects and dynamics of Electric vehicles
3. The course aims at enabling students to understand the motor specifications and charging standards for Electric vehicles.

Course Learning Outcomes:

CO	**After the completion of the course the student will be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	**Explain** the architecture and features of Electric Vehicles	2	Understanding
CO2	**Interpret** the topologies and various design considerations for Electric vehicles	2	Understanding
CO3	**Calculate** the vehicle dynamics for Electric propulsion systems	3	Applying

CO-PO Mapping :

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3													
CO2		3												
CO3		3												

Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weightage respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

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MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Introduction to Electric Vehicles	**Hrs.**
Background of Electric Vehicles, Electric Vehicle System, Components of Electric Vehicles, Advantages of Electric Vehicles, Efficiency, Pollution Comparison with conventional vehicles, Fundamentals of Electric Vehicles	**5**
Module 2: Types of Electric Vehicles and Architecture of EVs	**Hrs.**
Concept of Electric, Hybrid and Plug-in Electric Vehicles, Typical configuration of Hybrid Electric Vehicle, Topologies of HEVs: Series, Parallel and Series-Parallel Configuration, Topologies of Plug-in Hybrid Electric Vehicles, Fuel Cell Electric Vehicles, Solar Powered Electric Vehicles	**7**
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Module 5: Electric Machines in EV systems	**Hrs.**
Motor and Engine ratings, EV and HEV motor requirements, Three phase AC machines for Electric vehicles: Induction Machines, SRM machines, PMSM machines, Design aspects for EV systems, Numericals	**6**
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EV charging: requirements and Classification, Charging standards for Electric vehicles, Introduction to AC and DC chargers for EV systems, Working of Electric Vehicle Supply Equipment (EVSE), Fast Chargers for EV systems	**6**

Module wise Measurable Students Learning Outcomes :

After completion of the course students will be able to:

1. Describe the types and features of Electric Vehicles.
2. Interpret the different topologies and configuration of Electric Vehicles.
3. Calculate the vehicle dynamics for Electric propulsion systems.
4. Identify and select appropriate machines for Electric vehicles.
5. Summarize the power electronics converters used in Electric vehicles.
6. Determine the performance of electric vehicle chargers and explain the charging standards.

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