PG-Curriculum
(Structure and Course Contents)
M.Tech- Electrical Engineering

With effect from July 2018

EXPLORE INNOVATE EXCEL

Electrical Engineering
Punjab Engineering College

(Deemed to be University)

Chandigarh

Index

M.Tech in Electrical Engineering (Specialization : Power Systems)

Sr. No	Course Stream	Course Code	Course Name	Segment {Fractal system (each section of 0.5 Credits and 7 contact hours)}						Credits
				1	2	3	4	5	6	
Semester I										
1.	Soft Computing	SCM5011	Internet of Things							1.5
		SCM5012	Machine Learning							1.5
2	Design of Experiments and Research Methodology	DRM5011	Design of Experiments & Research Methodology(DE)							3
2.	Program Core-I	EEM5011	Modern Control System							3
3.	Program Core-II	EEM5021	Advance Power System Analysis							2
		EEM5022	Emerging Trends in Power Industries							1
4.	Program Elective-I : E1	EEM5101 EEM5102 EEM5103	• EHVAC & HVDC transmission system • Renewable energy system • Power conditioning							1.5
	Program Elective-II : E2	EEM5201 EEM5202 EEM5203	• Modern Power System Protection • Power system planning • Power System Operation & Control							1.5
5.	Engineering Mathematics (EM)	EMM5011	EM1: Fourier Transforms							1
		EMM5013	EM2: Numerical Methods							1
		EMM5012	EM3: Optimization Techniques and Genetic Algorithms							1
Total Credits										**18**

Sr. No.	Course Stream	Course Code	Course Name	Segment {Fractal system (each section of 0.5 Credits and 7 contact hours)}						Credits
				1	2	3	4	5	6	
Semester II										
1.	Soft skills & Management	SSM5021	Communication Skills (CS)							1.5
		SSM5022	Management and Entrepreneurship (M) / IPR							1
		SSM5023	Professional Ethics(PE)							0.5
2.	Program Core-III	EEM5031	Smart Grid Technologies							
		EEM5032								1.5
			Advance Measurement & Control							1.5
3.	Program Core - IV	EEM5041	Power System Modeling and Dynamics							3
4.	Program Elective – III, E3	EEM5301 EEM5302 EEM5303	• Static reactive power control and FACTS • Fast transients in power system • Microcontroller & PLC							1.5
	Program Elective – IV, E4	EEM5401 EEM5402 EEM5403	• Power system reliability • Restructured and deregulated power system • Energy management & energy auditing							1.5
5.	Open Elective	EEO5002 EEO5003	• Digital Signal Processing and Applications • PLC &Automation							1.5
		EEO5004 EEO5005	• Intelligent control • Supervisory Control and Data Acquisition (SCADA) systems							1.5
6.	Mini Project / Pre Dissertation	EEP5001								3
Total Credits										18

M.Tech in Electrical Engineering (Specialization :Power Electronics)

Sr. No	Course Stream	Course Code	Course Name	Segment {Fractal system (each section of 0.5 Credits and 7 contact hours)}						Credits
				1	2	3	4	5	6	
Semester I										
1.	Soft Computing	SCM5011	Internet of Things							1.5
		SCM5012	Machine Learning							1.5
2.	Design of Experiments and Research Methodology	DRM5011	Design of Experiments & Research Methodology(DE)							3
3.	Program Core-I	EEM5011	Modern Control Systems							3
4.	Program Core-II	EEM5023	**1.** Power Electronic Devices and Controllers							3
5.	Program Elective-I : E1	EEM5111 EEM5112 EEM5103	1. DC Controllers 2. AC Controllers 3. Power Conditioning							1.5
	Program Elective-II : E2	EEM5211	1. Power Electronics Applications in Power System							1.5
6.	Engineering Mathematics (EM)	EMM5011	EM1: Fourier Transforms							1
		EMM5013	EM2: Numerical Methods							1
		EMM5012	EM3: Optimization Techniques - II							1
Total Credits										**18**

Sr. No.	Course Stream	Course Code	Course Name	Segment {Fractal system (each section of 0.5 Credits and 7 contact hours)}						Credits
				1	2	3	4	5	6	
Semester II										
1.	Soft skills & Management	SSM5021	Communication Skills (CS)							1.5
		SSM5022	Management and Entrepreneurship (M) / IPR							1
		SSM5023	Professional Ethics(PE)							0.5
2.	Program Core-III	EEM5033	• Power Electronics Controlled Electric Drive							3
3.	Program Core - IV	EEM5042	• Control Techniques in Power Electronics							3
4.	Program Elective – III, E3	EEM5311 EEM5312 EEM5313	• Smart Grid Technologies • Advanced Electric Drives • Advanced DC/AC Converters							1.5
	Program Elective – IV, E4	EEM5411 EEM5412	• Advanced DC/DC Converters • Advanced Control in Power Electronics & Drives							1.5
5.	Open Elective	EEO5002 EEO5003	• Digital Signal Processing and Applications • PLC &Automation							1.5
		EEO5004 EEO5005	• Intelligent control • Supervisory Control and Data Acquisition (SCADA) systems							1.5
6.	Mini Project/ Pre Dissertation	EEP5001								3
Total Credits										18

M.Tech in Electrical Engineering (Specialization : Control Systems)

Sr. No	Course Stream	Course Code	Course Name	Segment {Fractal system (each section of 0.5 Credits and 7 contact hours)}						Credits
				1	2	3	4	5	6	
Semester I										
1.	Soft Computing	SCM5011	Internet of Things							1.5
		SCM5012	Machine Learning							1.5
2.	Design of Experiments and Research Methodology	DRM5011	Design of Experiments & Research Methodology(DE)							3
3.	Program Core-I	EEM5011	Modern Control Systems							3
4.	Program Core II	EEM5024	Linear Optimal Control							3
5.	Program Elective-I : E1	EEM5121 EEM5122 EEM5123	• Neural Network Based Control • Introduction to Adaptive Control • System Dynamics							1.5
	Program Elective-II : E2	EEM5221 EEM5222 EEM5223	• Fuzzy Logic Based Control • Advanced Techniquesin Adaptive Control • Applications of System Dynamics							1.5
6.	Engineering Mathematics (EM)	EMM5011	EM1: Fourier Transform							1
		EMM5013	EM2: Numerical Methods							1
		EMM5012	EM3: Optimization Techniques – II							1
Total Credits										**18**

Sr. No.	Course Stream	Course Code	Course Name	Segment {Fractal system (each section of 0.5 Credits and 7 contact hours)}						Credits
				1	2	3	4	5	6	
Semester II										
1.	Soft skills & Management	SSM5021	Communication Skills (CS)							1.5
		SSM5022	Management and Entrepreneurship (M) / IPR							1
		SSM5023	Professional Ethics(PE)							0.5
2.	Program Core-III	EEM5034	Discrete Time Control Systems							3
3.	Program Core – IV	EEM5043	Non-linear Control Systems							3
4.	Program Elective – III, E3	EEM5321 EEM5322	• Introduction to Robust control • Introduction to System modeling & Identification							1.5
	Program Elective – IV, E4	EEM5421 EEM5422	• Advanced techniques in System Identification • H∞ Control							1.5
5.	Open Elective	EEO5002 EEO5003	• Digital Signal Processing and Applications • PLC &Automation							1.5
		EEO5004 EEO5005	• Intelligent control • Supervisory Control & Data Acquisition (SCADA) systems							1.5
6.	Mini Project / Pre Dissertation	EEP5001								3
Total Credits										18

Summer Term *

Sr. no.	Course Code	Course Name	Credits
1		Industrial Visit(3 days to 1 week of visit, Submission and presentation of visit report)	Satisfactory/ Non-satisfactory

*After Examination of second semester, in the first week of summer vacation industry visit can be undertaken.

Course No.	Course Name	Credits	When it runs in a semester					
			1	2	3	4	5	6
Semester-III								
1.	Dissertation/Industry Project	14						

Course No.	Course Name	Credits	When it runs in a semester					
			1	2	3	4	5	6
Semester-IV								
1.	Dissertation/Industry Project	18						

Total credits – 68

- ***20% courses/ semester can be offered in blended mode MOOC's/Industry.***
- ***MOOC's/Industry offered course is having fractional credits. Industry offering course content will be designed by industry will be as per expert availability. Industry person will deliver and evaluate this subject. As per the duration of MOOC's/industry offered course, credits of this course can be decided (fractional credits).***

Power Systems

Semester 1

Soft Computing

Course Name	**:**	**Internet of Things**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total no. of lectures: 14
Total no. of Lab hrs. : 14

Course Objectives:

The main objectives of this course are:	
1.	Understand core technology, applications, sensors used and IOT architecture along with the industry perspective.
2.	Principles and operations of different types of sensors commonly used on mobile platform will be taught in a manner that by the end of the course the students will be able to design and implement real time solutions using IOT.

Course Contents:

S.No.	**Course Contents**	**No. of Lectures**
1	**Introduction to IoT** What is IoT, how does it work? Difference between Embedded device and IoT device, Properties of IoT device, IoT Ecosystem, IoT Decision Framework, IoT Solution Architecture Models, Major IoT Boards in Market	**2**
2	**Setting Up Raspberry/Arduino to Create Solutions** Explore Raspberry Pi, Setting up Raspberry Pi, Showing working of Raspberry Pi using SSH Client and Team Viewer, Understand Sensing actions, Understand Actuators and MEMS	**3**
3	**Communication Protocols used in IoT** Types of wireless communication, MajorwirelessShort-rangecommunicationdevices,properties,comparisonofthesedevices (Bluetooth, WIFI, ZigBee, 6LoWPAN), Major wireless Long-range communication devices, properties, comparison of these devices (Cellular IoT,LPWAN)	**3**
4	**IoT Applications** Industrial Internet 4.0, Applications such as: Smart home, wearables, smart city, smart grid, , connected car, connected health(digital health, telehealth, telemedicine), smart retail	**3**
5	**Sensors:** Applications of various sensors: Google Maps, Waze, Whats App, Ola Positioningsensors: encoders and accelerometers, Image sensors: cameras, Global positioning sensors: GPS, GLONASS, IRNSS, Galileo and indoor localization systems, Motion&OrientationSensors:Accelerometer,Magnetometer,ProximitySensor, GyroscopeCalibration,noise modeling and characterization and-noisefiltering and sensor data processing. Privacy &Security	**3**

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Design and build systems that will use sensors, communication protocol and actuators.	14

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Understand concept of IOT and ability to implement in real time scenarios
2.	Design solutions based on IOT architecture and applications in various fields
3.	Critically analyze security and privacy issues in IOT
4.	Apply knowledge to Design and develop variousapplicationsofsensorsinIndustrial,healthcare,commercial,andbuildingautomation

Bibliography:

S.No.	Book Detail	Year of Publishing
1	Vijay Madisetti and ArshdeepBahga, Internet of Things (AHands-on Approach), 1st Edition, VPT	2014
2	Francis daCosta, Rethinking the Internet of Things: A ScalableApproach to Connecting Everything, 1stEdition, Apress Publications	2013
3	CunoPfister, Getting Started with the Internet of Things, OReillyMedia	2011
4	Kyung, C.-M., Yasuura, H., Liu, Y., Lin, Y.-L., Smart Sensorsand Systems, Springer International Publishing	2015

MOOCs on this course are available at:

1) Introduction to Internet of Things - https://www.edx.org/course/introduction-to-the-internet-of-things-iot
2) IoT Programming and Big Data -https://www.edx.org/course/iot-programming-big-data-curtinx-iot4x

Course Name	**:**	**Machine Learning**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total no. of lectures: 14
Total no. of lab hrs: 14

Course Objectives:

	The main objectives of this course are:
1.	To formulate machine learning problems corresponding to different applications.
2.	To understand a range of machine learning algorithms along with their strengths and weaknesses.
3.	To develop reasoning behind Model selection, model complexity, etc.

Course Contents:

S.No.	Course Contents	No. of Lectures
1	**BASICS OF MACHINE LEARNING:** Applications of Machine Learning, processes involved in Machine Learning, Introduction to Machine Learning Techniques: Supervised Learning,Unsupervised LearningandReinforcementLearning,ReallifeexamplesofMachineLearning.	**3**
2	**SUPERVISED LEARNING:** Classification and Regression: K-Nearest Neighbour, Linear Regression,Logistic Regression, Support Vector Machine (SVM), Evaluation Measures: SSE, MME, R2,confusionmatrix,precision,recall,F-Score,ROC-Curve.	**6**
3	**UNSUPERVISED LEARNING:** Introductiontoclustering,TypesofClustering:Hierarchical-AgglomerativeClustering and Divisive clustering; Partitional Clustering - K-means clustering, Principal Component Analysis,ICA.	**5**

Lab Work:

S.No.	Lab Contents	No. of hours
1	Python Introduction: Loops and Conditions and other preliminarystuff, Functions, Classes and Modules, Exceptions, Database access, Mathematical computing with Python packages like: numpy, Mat- plotLib,pandas Tensor Flow, Keras	**8**
2	Application Oriented Project Work	**6**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Design and implement machine learning solutions to classification, regression and clustering problems
2.	Evaluate and interpret the results of the different ML techniques
3.	Design and implement various machine learning algorithms in a range ofReal-world applications.
4.	Use Python for various applications.

Bibliography:

S.No.	**Book Detail**	**Year of Publishing**
1.	Tom Mitchell, Machine Learning, McGraw Hill,	2017
2.	Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer,	2011.
3.	T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e,	2008.
4.	Yuxi (Hayden) Liu, "Python Machine Learning By Example", Packet Publishing Limited	2017

MOOCs on this course are available at:

1) Data Science: Machine Learning -https://www.edx.org/course/data-science-machine-learning
2) Machine Learning - https://www.coursera.org/learn/machine-learning

Design of Experiments and Research Methodology

Course Name	**:**	**Design of Experiments and Research Methodologies**
Course Code	**:**	
Credits	**:**	**3**
L T P	**:**	**2 0 2**
Segment	**:**	**1-6**

Total No. Lectures: 28

Total No. of Lab hrs. 28

Course Objectives:

The students should be able to develop an understanding of how to identify research topics, formulate research questions / hypotheses, select an appropriate research and, where applicable, experimental design. Provides a basis so the student can effectively develop a research proposal for either a capstone project, master's thesis, research project, or designed experiment.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Introduction**: Types of Research and Their Purposes, Locating, Analysing, stating and evaluating research problem, need for literature review, steps in conducting literature review, Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis, research questions and hypothesis, types of hypothesis, evaluation of hypothesis.	**3**
2.	**Research Design and Sampling Design:** Concept of research design, features of a good research design, concept of population and sample, characteristics of sample design, types of sampling techniques	**2**
3.	**Methods of data collection and measurement:** Primary data and Secondary data, data collection techniques: observation, interview, questionnaires, schedules, case-study, levels of measurement, problems in measurement in research – validity, reliability.	**3**
4.	**Statistical Methods of Analysis:** Descriptive statistics: mean, median, mode, range, mean deviation and standard deviation, regression and correlation analysis, inferential statistics: t-tests, Chi-square tests. Correlation (rank difference and product moment), Analysis of variance (ANOVA) (one way)	**4**
5.	**Procedure for writing a research report and manuscript:** Types of research reports, steps of writing a report, layout of report, layout of research paper, ethical issues related to publishing, Plagiarism and Self-Plagiarism.	**2**

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Select a problem from your area of interest, identifying the type of research problem it is and perform the SWOT analysis of the existing literature.	4
2.	Generate research questions and hypotheses for a problem from your area of interest.	4
3.	Identify the population and sample for the study (highlighting the technique used for sample selection) for a problem from your area of	4

	interest.	
4.	Design a questionnaire for the problem of interest.	4
5.	Utilizing software such as Statistical Package for the Social Sciences(SPSS), Mini Tab, etc. for the statistical analysis of the results obtained for the desired questionnaire.	6
6.	Preparing a research paper for the problem of interest	6

Course Outcomes:

At the end of the course, students will be able to:	
1.	Develope an understanding of how to identify research topics, formulate research questions and corresponding hypotheses, select an appropriate research and where applicable, experimental design.
2.	Perform required statistical analyses for any univariate application in a business / industrial setting, regardless of data form, and will be familiar with major indices for measuring correlation and association.
3.	Further, the underlying assumptions related to each statistical test and its interpretation will be thoroughly reviewed.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Probability and Statistics for Engineers and scientists by Anthony J. Hayter, Cencage Learning, 4th Edition	2016
2.	Probability and Statistics for Engineers and scientists by Walpole, Myers, Myers and Ye, 8th ed Pearson Education	2007
3.	Research Methodology - Methods and Techniques, C. K. Kothari, New Age International, 2nd Edition	2004
4.	English for writing research papers by Adrian Wallwork, 2nd Edition. Springer	2016
5.	Statistics: Concepts and Controversies by David S. Moore, William I. Notz, W. H. Freeman	2016

Available MOOCS:

1. https://www.coursera.org/learn/research-methods

2. https://www.lawctopus.com/certificate-course-on-research-methodology-online/

Program Core I

Course Name	**:**	**Modern Control Systems**
Course Code	**:**	
Credits	**:**	**3**
L T P	**:**	**2-0-2**
Segment	**:**	**1-6**

Total No. of Lectures – 28
Total No. of Lab hours – 28

Course Objectives:

	The main objectives of this course are:
1.	To learn the modeling concepts of system, modelling using state space.
2.	Tolearn and implement the optimal control techniques.
3.	To design the digital control system and nonlinear systems.

Course Contents:

Sr No.	Course Contents	No. of Lectures
1	**Introduction:** Control systems design requirements, classical versus modern approaches of design	**2**
2	**State Space Representation:** Concepts related to state space , state space representation, state transition matrix, solution of linear time invariant and linear time varying state equations, canonical forms	**3**
3	**Control System Design in State Space:** Controllability, pole placement design using full state feedback-regulator and tracking systems, observers, observability and compensators, full order and reduced order observers	**6**
4	**Linear Optimal Control :** Optimal control problem, infinite time linear optimal regulator design, optimal control of tracking systems (Riccati equation based designs).	**6**
5	**Digital Control Systems:** Basic concepts, z-transform, stability, performance, state space modeling and solution of linear digital equations, design using pole placement,: regulators and observers and compensators, linear optimal control of digital systems.	**7**
6	**Nonlinear Control Systems:** Sources of nonlinearities and characteristics of nonlinear systems, describing function method, phase plane analysis, Lyapunov stability theory.	**4**

Lab Work:

Sr. No.	Lab Contents	Lab Hours
1	State space modeling of continuous time system and study of stability and state and output responses	**02**
2	Pole placement design using state feedback for regulator and tracking systems	**02**

3	Full and reduced order observer design	**02**
4	State space modeling of discrete time system and study of responses	**02**
5	Pole placement design for regulator and tracking discrete time systems	**02**
6	Observer design for discrete time systems	**02**
7	Describing function analysis of nonlinear systems	**02**
8	Phase plane analysis of nonlinear systems	**02**
9	Project 1	**04**
10	Project 2	**04**
11	Project 3	**04**

Course Outcomes:

By the end of this course, the student will be:	
1	able to apply the modeling concepts of system modeling using state space and understand the design issues in the framework of modern control.
2	conversant with the optimal control techniques.
3	conversant with the concepts of digital control system and non-linear systems.

Bibliography:

Sr.No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	A.Tewari, *Modern Control Design with MATLAB and Simulink*. JohnWiley and Sons Ltd.	**2002**
2	K. Ogata, *Modern Control Engineering*.PHI.	**2014**
3	M. Gopal, *Modern Control System Theory*. New Age International (P) Ltd.	**2005**
4	M.Gopal, *Digital Control and State Variable Methods*. TMH.	**2003**
5	W. L. Brogan, *Modern Control Theory*. Pearson Education India.	**2011**

MOOCs on this course are available at:

1) Lecture Series On Control Engineering, Prof. Sd Agashe, IIT Bombay: nptel.iitm.ac.in.

2) **2)**Introduction to Control System Design - A First Look, Jacob White, Joe Steinmeyer, MIT,

https://www.edx.org/course/introduction-control-system-design-first-mitx-6-302-0x

3) Non-linear systems, Slotine, MIT, http://web.mit.edu/nsl/www/videos/lectures.html

Program Core II

Course Name	**:**	**Advance Power System Analysis**
Course Code	**:**	
Credits	**:**	**2**
L T P	**:**	**2-0-2**
Segment	**:**	**1-4**

Total No. Lectures:21
Total No. of Lab hours: 14

Course Objectives:

	The main objectives of this course are:
1.	To acquire knowledge of the fundamentals of network analysis using matrices.
2.	To get understanding of two-port and multi-port networks.
3.	To acquire knowledge of network synthesis and filter circuits.

Course Contents:

Sr.No	**Course Contents**	**No. of Lectures**
1.	**Review of Power Flow Studies:** Review of 1-phase load – Load flow studies using Y-bus, Gauss- Seidel, Newton-Raphson, Fast decoupled power flow. Comparison of various methods of load flow solution, AC-DC load flow.	**4**
2.	**Three phase networks:** Three phase network elements, three phase balanced network, Transformation matrices. Three phase unbalanced network elements. Algorithm for formation of three phase bus impedance matrix. Modification of three-phase bus impedance matrix for changes in the network, 3-φ load flow analysis.	**6**
3.	**Network fault, security and contingency analysis:** Fault computation using Z-bus. Short-circuit calculations for three phase networks using Z bus. Contingency analysis for Power systems.	**7**
4.	**State estimation from line measurements:** The line power flow state estimator. State estimation and noisy measurements. Monitoring the power system Determination of variance ÷Z2 – to normalize measurements, improving state estimates by adding measurements.	**4**

Lab Work:

Sr.No	**Lab contents**	**No. of Hours**
1.	Power Flow Studies with integration of Renewables	**6**
2.	Simulation of short circuit faults on 3-phase power system.	**8**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Model, analyze the power system in the study state.
2.	Apply the contingencies arising in the system under different conditions.
3.	Do the state estimation from line measurements

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Hadi Saadat, "*Power System Analysis*", McGraw Hill, 2nd edition.	**2004**
2	Grangier& Stevenson , "*Power System Analysis*", McGraw Hill International Students Edition.	**2003**
3	P.M. Anderson, "*Analysis of Faulted Power Systems*", IEEE Press Book.	**1995**

Classical Books:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Glonn N. Stagg and ahmed H. El-Abiad, "*Computer Methods in Power System Analysis*" McGraw Hill,International Edition	**1988**
2	George L.Kusic, "*Computer-aided Powersystem Analysis*", Prentice Hall.	**1986**
3	J.Arrillaga, C.P. Amold and B.J. Harker, "*Computer Modeling of Electrical Power Systems*", John willey&Sons	**1983**
4	M.A. Pai, "*Computer Techniques in Power System Analysis*", Tata McGraw Hill	**1979**
5	O.I. Elgard, "*Electric Energy Systems– An Introduction*", TataMcgraw Hill	**1971**

MOOCs on this course are available at:

1) Debapriya Das ,Indian Institute of Technology, Kaharagpur, h*ttps://swayam.gov.in/courses/4745-july-2018-power-system-analysis*

Course Name	**:**	**Emerging Trends In Power Industries**
Course Code	**:**	
Credits	**:**	**1**
L T P	**:**	**3-0-0**
Segment	**:**	**5-6**

Total No. of Lectures- 14

Course Objectives:

	The main objectives of this course are:
1.	To acquire knowledge of Indian power market, grid operation and its storage.
2.	To learn about non conventional energy sources and their coordination with industries.

Course Contents:

Sr No.	**Course Contents**	**No.of Lectures-14**
1.	**India Power Market:** Energy Needs of India, Energy policy, Generation mix, Opportunity and Challenges, Cost of Electricity, Future of India power market	**3**
2.	**Grid operation:** Basics of grid operations, Interconnection requirements for conventional technologies, Voltage and frequency control in grid, Role of excitation and governing control systems, Isochronous and droop control, Load shedding and islanding, Introduction to power system stabilizer	**4**
3.	**Renewable integration:** Renewable technologies, Challenges with high renewable penetration, Managing higher Solar and wind generation in grid, importance of forecasting, Interconnection requirements for renewables.	**4**
4.	**Grid scale Energy storage** Need for energy storage devices, types of energy storage solutions, their advantages, limitations and applications.	**3**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Understand recent trends in power industries
2.	About Indian power market, grid operation, renewable integration and grid scale energy storage.

Bibliography:

Sr.No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Dong, Z., Zhang, P., "*Emerging Techniques in Power System*	**2010**

	Analysis", Springer	
2	Bent Sørensen , "*Renewable Energy*", Elsevier,4th Edition	**2010**

MOOCs on this course are available at:

1)N.P Padhy, IIT Roorkee, *https://swayam.gov.in/courses/4778-july-2018-introduction-to-smart-grid*

2)Laura Ramirez, Pavol Bauer & Seyedmahdi Izadkhast, "Solar Energy: Integration of Photovoltaic Systems in Microgrids", Delf University of Technology,*https://www.edx.org/course/solar-energy-integration-photovoltaic-delftx-pv4x-0*

Program Elective I – E1

Course Name	**:**	**EHVAC And HVDC Transmission System**
Course Code	**:**	**.**
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**
Segment	**:**	**1-3**

Total No. Lectures:-14
Total No. Lab Hours:-14

Course Objectives:

	The main objectives of this course are:
1.	To differentiate between HVDC Transmission and EHVAC transmission network.
2.	To have understanding of reactive power planning for EHV lines.
3.	To model and analyse EHVAC and HVDC network.

Course Contents:

Sr.No	**Course Contents**	**No. of Lectures**
1	Comparison of EHVAC and DC transmission, description of DC transmission systems, modern trends in AC and DC transmission.	**2**
2	Voltage profile and voltage gradient of conductor, electrostatic field of transmission line	**2**
3	Travelling and standing waves, EHV cable transmission system, Limitations of extra-long AC transmission,	**2**
4	Converter configurations and their characteristics, DC link control, converter control characteristics; Monopolar operation, converter with and without overlap,	**2**
5	Smoothing reactors, transients in DC line, converter faults and protection, HVDC Breakers.	**2**
6	Component models, solution of DC load flow, per unit system for DC quantities, solution techniques of AC-DC power flow equations	**2**
7	Parallel operation of HVDC/AC systems, Multi terminal systems.	**2**

Lab Work:

Sr No.	**Lab Contents**	**No. of Hours**
1	Mathematical modeling of EHV lines	**4**
2	Simulation and time domain analysis of EHV network during prefault and post fault conditions using soft computational method (PSCAD & MATLAB)	**5**
3	Simulation, time domain analysis and FFT analysis of two terminal HVDC network during prefault and post fault conditions using PSCAD.	**5**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Compare the HVDC Transmission and EHVAC transmission network and idea of modern power system
2.	Realize the characteristics of EHV lines
3.	Understand the role of impedance control, phase angle control and voltage control in controlling real and reactive power in transmission systems
4.	Identify and analyze converter configurations used in HVDC and list the performance metrics.
5.	Understand controllers for controlling the power flow through a dc link and multiterminal operation of HVDC system

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Padiyar K.R., "*HVDC Power Transmission Systems*", Wiley Eastern Ltd.	**2015**
2	Begamudre R.D., *"EHV AC Transmission Engineering",* Wiley Eastern Press.	**2011**
3	Arrillaga J. and Smith B.C., *"AC-DC Power System Analysis*", IEE Press.	**1998**
4	Arrillaga J., "*HVDC Transmission",* IEE Press.	**1998**

Classical Books:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	Kimbark E., Direct Current Transmission, Vol-I, John-Wiley and sons, NY	**1971**

MOOCs on this course are available at:

1) Subba reddy,Indian Institute of Science , *https://swayam.gov.in/courses/3756-advances-in-uhv-transmission-and-distribution*

Course Name	**:**	**Renewable Energy Systems**
Course Code	**:**	**.**
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**
Segment	**:**	**1-3**

Total No. Lectures - 14
Total No. of Lab hours – 14

Course Objective:

	The main objectives of this course are:
1.	To make students familiar with working and operation of non-conventional energy systems.
2.	To make students capable to design different renewable systems.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1.	**Introduction** Introduction to Energy Sources: Energy sources and their availability, Non-renewable reserves and resources; renewable resources.	**2**
2.	**Solar Energy** Solar processes and spectral composition of solar radiation; Radiation flux at the Earth s surface. Solar collectors. Types and performance characteristics. solar energy storage. b)Application of solar energy: Solar thermal electric conversion, Thermal electric conversion systems, solar electric power generation, Design of photovoltaic system for power generation solar cells.	**3**
3.	**Wind Energy** Wind energy conversion; efficiency limit for wind energy conversion, types of converters, aerodynamics of wind rotors, power ~ speed and torque ~ speed characteristics of wind turbines, wind turbine control systems; conversion to electrical power: induction and synchronous generators, grid connected and self-excited induction generator operation, constant voltage and constant frequency generation with power electronic control, reactive power compensation;	**5**
4.	**Tidal Energy:** Wave characteristics, Conversion systems and their performance features application	**1**
5.	**Geothermal Energy:** Introduction to Geothermal Energy Conversion	**1**
6.	**Biomass Energy:** Introduction to Biomass Energy Conversion	**1**
7.	**Hydro Energy:** Electricity generation and Water pumping, Micro/Mini hydropower systems	**1**

Lab Work:

Sr.No	Lab contents	No. of Hours
1	To determine various characteristics of solar modules of a standalone PV system.	**4**
2	Evaluation of heating/cooling and performance of parabolic solar concentrator.	**2**
3	Case study on effect of change of solar PV tilt angle on power output	**4**
4	Power analysis at different branches of wind turbine energy system (at high frequency) with AC/DC load.	**4**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Acquire the knowledge of working of non conventional energy sources as solar energy, wind energy, energy from biomass, hydro energy (micro/mini hydro plants).
2.	Design and analyze renewable energy system.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	S. A. Abbasi and N. Abbasi, "*Renewable Energy Sources: Their Impact on Global Warming and Pollution*", Prentice Hall of India	**2010**
2	D. P. Kothari, K. C. Singal, R. Ranjan, "*Renewable Energy Sources and Emerging Technologies*", Prentice Hall of India	**2008**
3	S. N. Bhadra, D. Kastha, S. Banerjee, "*Wind Electrical Systems*", Oxford Univ. Press, New Delhi	**2005**

Classical Books:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	G.Boyle, "Renewable Energy: Power for a Sustainable Future", Oxford, 3rd edition	**1996**

MOOCs on this course are available at:

1) Technical University of Denmark, *https://www.coursera.org/learn/wind-energy*
2) P.Haridos, IIT Madras, *https://swayam.gov.in/courses/4894-july-2018-non-conventional-energy-resources*

Course Name	**:**	**Power Conditioning**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segment	**:**	**1-3**

Total No. of Lectures-21

Course Objectives:

	The main objectives of this course are:
1.	Tounderstand and apply various concepts of harmonic generation and mitigation.
2.	To provide knowledge of transformation from 3 phase to single phase using two axis theory, active power line conditioners.

Course Contents:

Sr No.	Course Contents	No. of Lectures
1.	**Harmonic Producing Loads, Mitigation and Power Supplies** Compensation of arc furnace and traction loads. Microwave ovens, light and temperature controllers, power supplies for appliances such as camera, X-Ray equipments. Power supplies in Telecommunication systems, High frequency induction heating, Dielectric heating, Power supplies in automobiles.	**4**
2.	**Power Definitions and Instantaneous Reactive Power Theory** Concepts and Evolution of Electric Power Theory, Electric Power Definitions, Instantaneous Power Theory: Basis of the pq Theory, Clarke Transformation, pq theory application to 3φ-3 wire and 3φ-4 wire systems, Modified pq theory, Instantaneous abc theory. Comparison of pq theory and Instantaneous abc theory. Synchronous Reference Frame Theory and applications.	**8**
3.	**Active Power Line Conditioners** Passive filters and limitations, active filters for harmonic and reactive power compensation in two wire, three wire and four wire ac systems, Shunt Active Filter, Hybrid and Series Active Filters, Combined Series and Shunt Power Conditioners. Case studies on microcomputer and DSP control in active filters and power supplies.	**9**

Course outcome:

At the completion of this course, students will be able to:	
1.	Apply various concepts of power conditioning.
2.	Design converters for harmonic mitigation
3.	Acquire knowledge of three phase to single phase transformation.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Patricio SalmeronRevuelta, Salvador Pérez Litrán, Jaime Prieto Thomas "*Active Power Line Conditioners: Design, Simulation and Implementation"* Elsevier publications.	**2016**
2	A.E.Emanuel, "*Power Definitions and the Physical Mechanism of Power Flow*", IEEE Press, John Wiley and sons Ltd.	**2010**
3	H Akagi, E.H. Watanabe and M Aredes, "*Instantaneous power Theory and applications to Power Conditioning*", IEEE Press, John Wiley and sons Incorporate.	**2007**
4	J Arrilaga and N.R Watson, "*Power System Harmonics*", John Wiley and Sons Ltd.	**2003**

Classical Books:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	J Arrilaga, D.A Bradley and P.S Bodger, "Power System Harmonics", John Wiley and Sons Ltd, 1995.	**1995**

MOOCs on this course are available at:

1) Power quality in power distribution systems,NPTEL *http://nptel.ac.in/courses/108106025/*

Program Elective II – E2

Course Name	**:**	**Modern Power System Protection**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total No. Lectures:14
Total No. of Lab Hours:14

Course Objectives:

	The main objectives of this course are:
1.	To make students aware about the need and importance of power system protection.
2.	To provide understanding of the protection algorithm for static and microprocessor based relays for different type of setups.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1	The need for electrical protection. The principles behind the protection of the power system and its components. The relay/circuit-breaker combination.	**02**
2	Differential protection, Voltage regulation protection, Frequency regulation protection. Distance protection. Negative sequence protection.	**03**
3	Introduction to Computer Relaying. Remote substation access and local intelligence. PLCs. SCADA Systems. Microprocessor and PLC based protection schemes.	**03**
4	Integrated approach to power system protection using the existing electromechanical relays, the static electronic relays, and the microprocessor based digital relays.	**03**
5	Adaptive relaying, EHV System Protection**,** Protection System failures. Case studies of Blackouts: Causes and Countermeasures	**02**
6	Protection of Wind and Solar Plants.	**01**

Lab Work:

Sr.No	Lab contents	No. of Hours
1	Relay coordination in radial distribution system.	**2**
2	Algorithm design for over current protection and other relays	**3**
3	Fault detection using sample to sample difference,	**3**
4	Time domain and FFT analysis during pre and post fault conditions	**3**
5	Understanding the realization of overcurrent and distance protection using comparator ckt.	**3**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Obtain the realization of need and importance of power system protection .
2.	Acquire the knowledge of different protection schemes and will be able to realize, simulate and analyse protection algorithm .
3.	Understand protection system for Wind and Solar Plants.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Stanley H. Horowitz and Arun G. Phadke,"*Power System Relaying*", John Wiley& Sons, Third Edition	**2014**
2	Arun G. Phadke, James S. Thorp,*"Computer Relaying for Power Systems"*, John Wiley & Sons.	**2009**
3	Badri Ram, D. N. Vishwakarma, "*Power System Protection and Switchgear"*, Tata McGraw-Hill Education.	**2007**
4	L.P.Singh, "*Digital Protection:Protective Relaying from Electromechanical to Microprocessor*", New Age International.	**2004**
5	T S MadhavRao,*"Power System Protection,Static Relays with Microprocessor applications"* ,TataMcGRAW Hill.	**2001**

Classical Books:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	A. Allan T Johns and S.K. Salman, "*Digital Protection for Power Systems"* ,IEE Power.	**1995**

MOOCs on this course are available at:

1)Power System Protection,NPTEL,*http://nptel.ac.in/downloads/108101039/*

Course Name	**:**	**Power System Planning**
Course Code	**:**	**.**
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segment	**:**	**4-6**

Total No. of Lectures-21

Course Objectives:

	The main objectives of this course are:
1.	To learn the fundamentals of power system planning reliability
2.	To learn short term load forecasting and planning in deregulated environment
3.	To learn power system planning with hybrid sources.

Course Contents:

Sr No.	**Course Contents**	**No. of Lectures**
1.	**Introduction** Background: Power industry restructuring Electricity Act 2003; Electricity market models; Electricity market fundamentals for planning purpose	**6**
2.	**Power System Planning Fundamentals** Planning criteria; Uncertainties, Planning Process, Generation planning, Transmission planning, Least-cost planning, Risks and making choices in planning; short term and long term load and price forecasting	**8**
3.	**New Challenges of Power System Planning in Deregulated Environment** Deterministic vs.probabilistic approaches; Probabilistic power system planning, Combining conventional and nonconventional sources for optimal power system planning in deregulated environment.	**7**

Course outcome:

At the completion of this course, students will be able to:	
1.	Understand electricity market fundamentals for planning purpose
2.	Apply short term and long term load and price forecasting
3.	Implement optimal power system planning in deregulated environment

References:

Bibliography:

Sr.No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Lo lei Lai, "*Power System Restructuring and Deregulation: Trading, Performance and Information Technology*" Wiley	**2002**

2	M.llic, F.Frliana, L.Fink*, "Power System Restructuring",*Kluwer Academic Publishers	**1998**
3	R.L.Sullivan,"*Power System Planning",*McGraw Hill	**1997**

Classical Books:

Sr.No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	X.F. Wang and James Mcdonald, *"Modern Power System Planning",*McGraw-Hill Publishing Co.	**1993**
2	R.Billinton, R.N.Allan,*"Reliability Assessment of Large Electric Power Systems"* ,Springer, 2nd edition	**1988**

MOOCs on this course are available at:

1)Restructured Power Systems,NPTEL, *http://nptel.ac.in/courses/108101005/*

Course Name	**:**	**Power System Operation And Control**
Course Code	**:**	**.**
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**
Segment	**:**	**4-6**

Total No. Lectures:- 14
Total No. Lab Hours:- 14

Course Objectives:

	The main objectives of this course are:
1.	To learn the concepts of power systems operation, security and dispatch.
2.	To acquire knowledge of single area, multi area and interconnected system and their operation
3.	To learn Optimal Power Flow Techniques and Optimal Power Flow Calculations.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1	**Power Systems Operational Security and Dispatch** Review of security concept and state of operation, generation dispatch; dynamic security, economic load dispatch, unit commitment.	3
2	**Frequency Control and AGC** Review of theory of frequency dynamics. Multi-area frequency dynamics, Load-frequency and tie-line power flow control. Theory of Automatic Generation control, AGC implementation methods.	3
3	**Interconnected Systems Operation** Need of system interconnection. Operating policies, Economic interchange, Optimal multi-area Operation.	4
4	**Optimal Power Flow** Introduction to Optimal Power Flow Techniques and Optimal Power Flow Calculations.	4

Lab Work:

Sr.No	Lab contents	No. of Hours
1	Optimal power flow,economic dispatch, AGC solutions with the help of MATLAB and software for different standard test systems.	14

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Gain the knowledge of the concepts of power systems operation, security and dispatch.
2.	Develop the frequency control and AGC in single area and Interconnected Systems Operation.
3.	Attain understanding of Unit commitment, Real-Time Control and Optimal Power Flow.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Dr. K Uma Rao, "*Power System Operation & Control"*, Wiley	**2012**
2	B.R. Gupta and Vandhana Singhal, "*Power System Operation & Control"*, S.Chand	**2010**
3	S.Sivanagaraju, *"Power System Operation & Control"*, Pearson	**2009**
4	Mahalanabis et al., *"Computer-aided power system analysis"* Tata McGraw-Hill	**1988**

Classical Books:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Wood and Wollenberg "Power Generation Operation and Control", John Wiley, 1984.	**1984**
2	OI Elgerd "Electric Energy Systems, Theory", McGraw Hill, 1983	**1983**
3	IEEE Power Engineering Society, *"Fundamentals of supervisory systems"* IEEE Tutorial Course	**1981**
4	Anderson &Fouand "Power system control and stability" Lowa State University Press, 1977.	**1977**

MOOCs on this course are available at:

1) Power system generation, transmission and distribution, NPTEL, *http://nptel.ac.in/courses/108102047/*

Engineering Mathematics

Course Name	**:**	**FOURIER TRANSFORMS**
Course Code	**:**	
Credits	**:**	**01**
L T P	**:**	**2-1-0**
Segment	**:**	**1-2**

Total No. of Lectures– 10
Tutorials -5

Course Objectives:

The main Objectives of this course are:

1	To make the students understand the concept of Fourier transform and be able to compute it for standard examples.
2	To make the students able to apply Fourier transforms to solve differential equations and partial differential equations.

Course contents:

Sr.No	Course Contents	No. of Lectures
1	**Fourier Transforms:** Fourier Integral formulas, Definition and examples, Basic properties, Fourier cosine and sine transforms and examples, Basic properties of Fourier cosine and sine transforms, Multiple Fourier transforms.	05
2	**Fast Fourier Transforms and Short Term Fourier Transforms:** Definition and examples, Basic properties, Applications.	05

Course Outcomes:

At the end of the course, students will be able to:	
1	Solve differential equations by using Fourier transforms
2	Solve partial differential equations by using Fourier transforms
3	Apply FFT and STFT to engineering problems

Bibliography:

Sr.No.	Name of Book / Authors / Publishers	Year of Publication/ Edition
1	"Integral Transforms and Their Applications", Loknath Debnath, CRC Press, Inc.,	1995.
2	"Integral Transforms and their Applications", Brian Davies, 3rd Edition, Springer-Verlag, New York,Inc,	2001
3	"Fourier Transform and Its Applications", Ronald N. Bracewell, 2nd Edition, McGraw-Hill Inc.,US,	1986

Course Name	**:**	**NUMERICAL METHODS**
Course Code	**:**	
Credits	**:**	**01**
L T P	**:**	**2-0-2**
Segment	**:**	**3-4**

Total No. of Lectures – 10
Practicals -10

Course Objectives:
The main Objectives of this course are:

1	To make the students understand the basics of numerical methods.
2	To make the students able to solve problems on system of linear equations and Interpolation by numerical methods.

Course contents:

Sr.No	Course Contents	No. of Lectures
1	**Error Analysis:** Definition and sources of errors, Propagation of errors, Floating-point arithmetic and rounding errors.	02
2	**Interpolation:** Interpolation using Finite differences, Numerical Differentiation and Numerical integration, Trapezoidal and Simpson's rules.	04
3	**Numerical Solution of Differential Equations:** Picard's method, Taylor series method, Euler and modified Euler methods, Runge-Kutta methods, Predictor-Corrector method.	04

Lab Work:

Sr.No	Lab. Contents	No. of Hours
1.	Solving Interpolation, Numerical Differentiation and Numerical integration problems using Mathematica.	04
2.	Solving Differential equations numerically using Mathematica.	06

Course Outcomes:

By the end of the course, the students will be able to solve the following by numerical methods:
1. Problems on Interpolation 2. Problems on Differentiation, Integration. 3. Solve differential equations.

Bibliography:

Sr.No.	Name of Book / Authors / Publishers	**Year of Publication/ Edition**
1	"Introduction to Numerical Analysis",Atkinson K. E., John Wiley.	1989
2	"Applied Numerical Analysis", Gerald C. F. and Wheatley P. O., Pearson	2004
3	"Numerical Methods for Scientific and Engineering Computation", Jain M. K., Iyengar S.R.K. and Jain R. K., New Age International Publisher.	2004
4	"Elements of Numerical Analysis", Gupta R.S., Macmillan India Ltd .	2008

Course Name	**:**	**OPTIMIZATION TECHNIQUES AND GENETIC ALGORITHMS**
Course Code	**:**	
Credits	**:**	**01**
L T P	**:**	**2-0-2**

Total No. of Lectures – 10,

Practicals -10

Course Objectives:

The main Objectives of this course are:

1	To make the students understand the need of Optimization Techniques and develop the ability to form mathematical model of optimization problems.
2	To make the students able to identify and solve linear and non-linear models of optimization problemsusing Genetic Algorirhms.

Course contents:

Sr.No	Course Contents	No. of Lectures
1	Introduction to optimization problem, local and global optimum, conversion of a constrained problem to unconstrained problem.	04
2	Genetic Algorithms, Binary and Real coded Genetic Algorithms, Coding and decoding of variables, Key steps in a GA, starting population, fitness evaluation, reproduction, crossover, mutation, evaluation.	06

Lab Work:

Sr.No	Lab. Contents	No. of Hours
1.	Using Genetic Algorithms in various optimization Problems	10

Course Outcomes:

1	The students are able to form mathematical model of optimization problems .
2	The students are able to distinguish between linear and nonlinear models .
3	The students are able to solve simple problems using Mathematica/MATLAB

Bibliography:

Sr.No.	Name of Book / Authors / Publishers	Year of Publication/ Edition
1	"Practical Genetic Algorithms", Haupt, R. L. and Haupt, S.E., John Wiley &Sons	1998
2	"Genetic Algorithm in Search, Optimization and Machine Learning" , Goldberg, D.E., Addison Wesley.	1989
3	"Engineering Optimization", Ranjan, Ganguli,University Press.	2011

Semester 2

Soft Skills & Management

Course Name	**:**	**Communication Skills**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**1-0-4**
Segment	**:**	**1-3**

Total No. Tutorials-7
Total No. of Lab hours – 28

Course Objectives:

	The main objectives of this course are:
4.	To enhance competence in communication skills: verbal and nonverbal.
5.	To provide orientation in technical communication skills: spoken and written.
6.	To sensitize students to attitude formation and behavioural skills.

Course Contents:

Sr.No	Course contents	No. of Tutorials
1.	**Introduction to Communication Skills, Soft Skills and Interpersonal Communication**	**1**
2.	**Speech:** Structure, Elements, Content, Organization and Delivery, J-a-M	**1**
3.	**Writing Skills:** Letters, Minutes of Meeting	**1**
4.	**Technical Report Writing:** Concept and Structure	**1**
5.	**Research Writing:** Concept and Structural Framework	**1**
6.	**Power Point Presentation:** Project Presentation	**1**
7.	**Interviews**	**1**

Lab Work:

Sr.No	Lab contents	No. of Hours
1.	Self- Introduction	**2**
2.	Negotiation Skills & Role Play	**2**
3.	J-a-M Session	**2**
4.	Building Word Power through Reading	**2**
5.	Group Discussion and Case Study	**4**
6.	Writing Skills: Letters, Minutes of Meeting	**2**
7.	Technical Report Writing: Concept & Structure	**4**
8.	Research Writing: Concept and Structural Framework	**4**
9.	Power Point Presentation: Project Presentation	**4**
10.	Interviews	**2**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Show enhanced competence in communication skills and technical communication.
2.	Develop awareness of attitude formation and behavioural appropriateness
3.	Gain self-confidence and perform better in their academic and professional life.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	"Technical Communication", RamanMeenakshiand SharmaSangeeta, Oxford University Press.	2015
2.	"English for Research Paper Writing", WallworkAdrian, Springer, London.	2011
3.	"English Vocabulary In Use: Advanced+ CD", MichaelMcCarthy, CUP, Cambridge.	2004
4.	"Advanced English Grammar", HewingsMartin, CUP, Cambridge.	2003
5.	"Study Listening", TonyLynch, CUP, Cambridge.	2004
6.	"Study Speaking", KennethAnderson, CUP, Cambridge.	2010
7.	"Study Reading", Glendenning H. Eric, CUP, Cambridge.	2004
8.	"Study Writing", HampLyons Liz & HeasleyBen, CUP, Cambridge.	2004
9.	"Study Skills in English", WallaceMichael J., CUP, Cambridge.	2004

MOOCs on this course are available at:

1) "Take Your English Communication Skills to the Next Level". Available at Coursera (Offered by Georgia Institute of Technology), 4 weeks, Starts on September 10, 2018. https://www.coursera.org/learn/english-communication-capstone

2) "Effective Communication in Globalised Workplace- The Capstone". Available at Coursera (Offered by National University of Singapore), 3 weeks, Starts on August 06, 2018. https://www.coursera.org/specializations/effective-communication

Course Name	**:**	**Management Entrepreneurship and IPR**
Course Code	**:**	
Credits	**:**	**1**
L T P	**:**	**0-2-0**
Segment	**:**	**4-5**

Total No. Tutorials – 14

Course Objectives:

The main objectives of this course are:	
1.	To make students familiar with the concepts of Management, Entrepreneurship and Intellectual Property Rights (IPRs).
2.	To make students understand how to initiate a new Start-up and manage it effectively.
3.	To enable students to convert their innovative ideas into different forms of IPRs.

Course Contents:

Sr.No	Course contents	No. of Tutorials
1.	**Introduction to Management:** Concepts and Principles of Management	**1**
2.	**Functions of Management:** Planning Process - Hypothetical Planning of an Event/Activity, Form of Organization Structure - Case Study, Human Resource Planning and Process, Elements of Directing and Effective Control Mechanism, Activity: Role Playing/Management Game	**4**
3.	**Introduction to Entrepreneurship:** Concepts of Entrepreneurship and Characteristics of Entrepreneurs	**1**
4.	**Development Phases of Entrepreneurship:** Innovation and Idea Generation, Project Formulation and Validation (Feasibility Analysis), Business plan	**2**
5.	**Ecosystem for Entrepreneurship Development:** Government Schemes and Initiatives, Financial and Non-Financial Institutional Support, Legal Framework, Role of Incubator, Venture Capitalist, Angel Investor, Crowd Funding Accelerator etc.	**2**
6.	**Intellectual Property Rights (IPRs):** Concept and Relevance of IPRs, Process for filing IPR	**2**
7.	**Different Forms of IPRs:**Patents, Copyright, Trademarks, Industrial Designs and Geographic Indicator	**2**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Developand manage new project/Start-up.
2.	Apply managerial skills for success of entrepreneurial/business venture.
3.	Make effective use of IPR practicesin their ventures.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	"Management Principles and Practice", Srinivasan R. and Chunawalla S.A., Himalaya Publishing House.	**2017**
2.	"Introduction to Management", Schermerhorn John R. Jr. And Bachrach Daniel G., 13th Edition, Wiley Publications	**2016**
3.	"Principles & Practice of Management", Prasad L.M., 8th Edition, Sultan Chand & Sons.	**2015**
4.	"The New Era of Management", Daft R.L., 11th Edition, Pubs: Cengage Learning.	**2014**
5.	"Case Studies in Management", Pandey Chandra Akhilesh, 2nd Edition, I.K. International Publishing House Pvt. Ltd.	**2015**
6.	"Harvard Business Review: Manager's Handbook", Harvard Business School Press.	**2018**
7.	"Entrepreneurship", Trehan Alpana, Dreamtech Press.	**2016**
8.	"Entrepreneurship and Small Business" Schaper Michael, Volery Thierry, Weber Paull and Lewis Kate, 3rd Asia-Pacific Edition, Wiley Publications	**2018**
9.	"Harvard Business Review: Entrepreneur's Handbook", 1st Edition, Harvard Business Review Press	**2018**
10.	"Take Me Home", Bansal Rashmi, 1st Edition, Westland.	**2014**
11.	"Intellectual Property Law", Narayanan P., 3rd Edition, Eastern Law House	**2017**
12.	"Intellectual Property Rights", Pandey Neeraj and Dharni Khushdeep, PHI Learning	**2014**
13.	"Intellectual Property Rights", Rosedar S.R.A., LexisNexis (Quick Reference Guide – Q&A Series)	**2016**
14.	MSME Annual Publications (www.msme.gov.in)	**Annual**
15.	WIPO Annual Publications (www.wipo.int)	**Annual**

MOOCs on this course are available at:

1) "Entrepreneurship: Do Your Venture", Available at edx (Offered by IIM Bangalore), Self-Paced (6 weeks).
   https://www.edx.org/course/entrepreneurship-do-your-venture
2) "Becoming an Entrepreneur", Available at edx (Offered by MIT), Self-Paced (6 weeks).
   https://www.edx.org/course/becoming-entrepreneur-mitx-launch-x-4
3) "How to Build a Start-up", Available at Udacity, Self-Paced (One Month).
   https://in.udacity.com/course/how-to-build-a-startup--ep245
4) "Intellectual Property Rights: A Management Perspective, Available at edx (Offered by IIM Bangalore), Starts on 1 August 2018 (6 weeks).
   https://www.edx.org/intellectual-property-rights-a-management-perspective

Course Name	**:**	**Professional Ethics**
Course Code	**:**	
Credits	**:**	**0.5**
L T P	**:**	**0-1-0**
Segment	**:**	**6-6**

Total No. Tutorials -7

Course Objectives:

	The main objectives of this course are:
1.	To imbibe ethical values and understanding.
2.	To develop moral thinking that will help students to recognize their potential.
3.	To engage and motivate the students to perform ethically in their professional life.

Course Contents:

Sr.No	Course contents	No. of Tutorials
1.	**Introduction to Ethics:** Concept of Ethics – Nature, Scope, Sources, Types, Functions and Factors influencing Ethics, Ethics in Engineering	**2**
2.	**Ethics in Profession:** Concepts of Honesty, Integrity, Reliability, Risk, Safety and Liability, Responsibilities and Rights of Professionals, Professional accountability.	**2**
3.	**Ethics and Business:** Concept of Business Ethics – Nature and Objectives, Ethical dilemmas in business ethics.	**1**
4.	**Self-Development:** Concept of Self-Assessment – SWOT Analysis, Self-Concepts, Self-Confidence, Self-Esteem, Managing Time and Stress, Human values.	**2**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Demonstrate knowledge and better understanding of self and to manage time and stress effectively.
2.	Have subjective well-being.
3.	Have ethical decision making ability in their personal and professional life.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	"Professional Ethics", Subramaniam R., 2nd Edition, Oxford University Press.	**2017**
2.	"Introduction to Psychology", Kalat James W., 11th Edition, Cengage Learning.	**2017**

3.	"Business Ethics – Text and Cases", Murthy C.S.V., 1st Edition, Himalaya Publishing House.	**2014**
4.	"A Foundation Course in Human Values and Professional Ethics", Gaur R.R., Sangal R. and Bagaria G.P., Excel Books.	**2010**
5.	"Issues and Ethics in the Helping Professions", Corey G., Corey M.S. and Callanan P., 8th Edition, Brooks/Cole, Cengage Learning.	**2010**
6.	"The Curse of Self: Self-awareness, Egotism and the Quality of Human Life", Leary M.R., 1st Edition, Oxford University Press.	**2007**
7.	"Business Ethics", Hartman L.P. and Chatterjee A., 3rd Edition, Tata McGraw Hill.	**2006**
8.	"Business Ethics and Professional Values", Rao A.B., Excel Books.	**2006**
9.	"Business Ethics – Concepts and Cases", Velasquez M.G., 5th Edition, Prentice Hall.	**2001**
10.	"Theories of Personality", Hall C.S., Lindzey D. and Cambell J.B., 4th Edition, Hamilton Printing Company.	**1997**

MOOCs on this course are available at:

1) "Ethics in Engineering Practice". Available at SWAYAM(Offered by IIT Kharagpur), 8 weeks, Starts on August 27, 2018.
https://swayam.gov.in/courses/4799-july-2018-ethics-in-engineering-practice

2) "Ethics, Technology and Engineering". Available at Coursera (Offered by EindhovenUniversity of Technology), 8 weeks, Starts on July 16, 2018.
https://www.coursera.org/learn/ethics-technology-engineering

Program Core III

Course Name	**:**	**Smart Grid Technologies**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segment	**:**	**1-3**

Total No. of Lectures-21

Course Objectives:

The main objectives of this course are :	
1.	To understand the fundamentals of smart grid technologies such as smart measurements, smart technology for smart substations.
2.	To understand micro grid and distributed energy sources, power quality management in smart grid, information and communication technology for smart grid.

Course Contents:

Sr No.	Course Contents	No. of Lectures
1.	**Introduction to Smart Grid:** Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference betw. conventional & smart grid, Concept of Resilient & Self-Healing Grid, Present development & International policies in Smart Grid. Case study of Smart Grid. CDM opportunities in Smart Grid.	**4**
2.	**Smart Grid Technologies:** Part 1:Introduction to Smart Meters, Real Time Pricing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid.	**4**
3.	**Smart Grid Technologies**: Part 2: Smart Substations, Substation Automation, Feeder Automation. Geographic Information System(GIS), Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU).	**4**
4.	**Micro grids and Distributed Energy Resources**: Concept of micro grid, need & applications of micro-grid, formation of micro grid, Issues of Inter-connection, protection & control of micro grid. Plastic & Organic solar cells, Thin film solar cells, Variable speed wind generators, fuel cells, micro turbines, Captive power plants, Integration of renewable energy sources, power quality issues in renewable energy integration.	**5**
5.	**Information and Communication Technology for Smart Grid:** Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN). Bluetooth, Zig-Bee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Basics of CLOUD Computing & Cyber Security for Smart Grid.	**4**

Course outcome:

At the completion of this course, students will be able to:

1.	Understand and analyze smart grid technologies such as smart measurements.
2.	Understand smart substations, micro grid and distributed energy sources, information and communication technology for smart grid.

Bibliography:

Sr. No		Year of Publication
1.	Clark W. Gellings, "*The Smart Grid: Enabling Energy Efficiency and Demand Response*",CRC Press JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu	**2012**
2.	Akihiko Yokoyama," *Smart Grid: Technology and Applications*", Wiley	**2012**
3.	Jean Claude Sabonnadière, NouredineHadjsaïd, "*Smart Grids*", Wiley Blackwell	**2012**
4.	Peter S. Fox-Penner, "*Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities*"	**2010**
5.	Ali Keyhani, Mohammad N. Marwali, Min Dai "*Integration of Gr. and Renewable Energy in Electric Power Systems*", Wiley	**2009**
6.	Tony Flick and Justin Morehouse, "*Securing the Smart Grid*", Elsevier Inc. (ISBN: 978-1-59749-570-7)	**2006**
7.	James A. momoh, "*Smart Grid: Fundamentals of Design and Analysis*," Wiley	**2012**
8.	Stephen F. Bush, "*Smart Grid: Communication-Enabled Intelligence for the Electric Power System*," Wiley	**2014**

MOOCs and online contents on this course are available at:

1)N.P. Pandey, "Introduction to smart grid", IIT Roorkee (*https://swayam.gov.in/courses/4778-july-2018-introduction-to-smart-grid*)

2) Narayana Prasad Padhy, Premalata Jena, "Introduction to Smart Grid," NPTEL*(https://onlinecourses.nptel.ac.in/noc18_ee42/preview)*

3)M. Vadari, M. Balasubramanyan, *Distributed Energy – Smart Grid Resources for the Future*, IEEE, Coursera

4)P.S. Prat, *Smart Grids for Smart Cities: Towards Zero Emissions*, FutureLearn, InnoEbergy, *homuork*

5)Dr. M. Vadari and M. Balasubramanyan, *Smart Grids: Electricity for the Future*, IEEE & EDX

Course Name	**:**	**Advance Measurement & Control**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segment	**:**	**4-6**

Total No. of Lectures- 21

Course Objectives:

The main objectives of this course are:	
1	The students undergoing this course are expected to learn the concepts of data acquisition, signal conditioningand analysis.
2	Learning basics of smart measurement, power system operation and control.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1	**Signal Analysis Instruments** Basic Wave Analyzer, Frequency Selective Wave Analyzer, Heterodyne Wave Analyzer, Harmonic Distortion Analyzer, Spectrum Analyzer	**5**
2	**Smart Measurement** Introduction to Smart meters, Smart appliances, Automatic meter reading, smart sensors. Wide area measurement systems, phase measurement unit. Advance metering infrastructure, home area network, neighborhood area network, wide area network.	**5**
3	**Power System Control and Instrumentation** Optimal, sub-optimal and decentralized controllers. Discrete mode AGC. Time-error and inadvertent interchange correction techniques. Online computer control. Distributed digital control. Data acquisition systems. Emergency control, preventive control, system wide optimization.	**6**
4	**SCADA:** Introduction to Supervisory Control and Data Acquisition, SCADA Functional requirements and Components, General features, Functions and Applications, Benefits, Configuration of SCADA, RTU (Remote Terminal Units) Connections, Power Systems SCADA and SCADA in Power System Automation, SCADA Communication requirements, SCADA Communication protocols: Past Present and Future, Structure of a SCADA Communications Protocol.	**5**

Industrial Visit

Sr.No	Lab contents	No. of Days
1.	Visit To Tata Power Delhi Distribution Ltd.(TPDDL)	**3**

Course Outcomes

At the end of the course, students will have:	
1	Knowledge of the concepts of data acquisition, signal conditioning and analysis.
2	Basic understandings of smart measurement for power system operation and control and other applications.

Bibliography:

Sr.No		Year of Publication/Reprint
1	W.D.Cooper& A.D. Helfrick, "*Electronic Instrumentation & Measurement Techniques*,"	**2008**
2	Alan S. Moris "*Principals of Measurements & Instrumentation*,"	**2011**
3	Joseph J. Carr, "*Elements of Electronics Instrumentation And Measurements*,"	**1995**
4	Fundamentals of supervisory systems, IEEE Tutorial Course Text, 91EH0337-6PWR.	**1991**

Classical books:

1	Wood and Wollenberg "*Power Generation Operation and Control 2nd edition*", John Wiley.	**1996**
2	C S Rangan, G.R. Sharma, V.S.V.Mani, "*Instrumentation Devices & Systems*,"	**1983**
3	Ernest O. Doebelin, "*Measurement Systems: Application & Design*,"	**1989**

MOOCs and online contents on this course are available at:

1) Power system operation and control, coordinated by IIT Kanpur, NPTEL, "*http://nptel.ac.in/courses/108104052,"*

2) Energy Management and SCADA, coordinated by IIT Madras, NPTEL, "*http://www.nptel.ac.in/courses/108106022/8*,"

Program Core IV

Course Name	**:**	**Power System Modeling And Dynamics**
Course Code	**:**	
Credits	**:**	**3**
L T P	**:**	**2-0-2**
Segment	**:**	**1-6**

Total No. Lectures -28
Total No. Lab Hours - 28

Course Objectives:

The main objectives of this course are:	
1	To learn the basic conceptsof power system components, modeling for linear and non linear system
2	To learn the methods of system analysis in steady state and transient state operating conditions using eigen value, direct energy conversion
3	To investigate the set of FACTS devices for improvement of power system stability.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1	**SystemModelingReview:** Modern power system operation and control, static and dynamic modeling, Load flow studies, transient stability and small signal stability of large power systems, voltage stability: P-V and Q-V curves, static analysis, sensitivity and continuation power flow method, Wide area real-time monitoring systems.	**4**
2	**Introduction to Power System Stability and Preliminary Fundamentals** Definition and classification of power system stability, The Swing Equation, The equal area criterion, Synchronizing power and natural frequencies of oscillations, Numerical integration techniques, fundamentals to system identification.	**3**
3	**Modeling of a Synchronous Machine:** Synchronous machine model dynamical equations, Park's transformation, Development of the complete d and q - axes equation in per unit, Effect of saturation on Modeling, Synchronous machine parameters, Steady state analysis of synchronous machine, Synchronous machine connected to infinite bus.	**4**
4	**Modeling of Exciter, Turbine and Load:** Types of excitation system-AC, DC, Static, Modeling of DC excitation system, introduction to AVR, Modeling and development of Hydraulic turbine transfer function, development of steam turbine transfer function, power system loads-static, synchronous motor, induction motor, ZIP.	**6**
1.	**Small Signal Stability Analysis:** Eigen properties of state matrix, linearizing a nonlinear power system model, Small-Signal stability analysis of single machine connected to	**7**

	infinite bus, Power system stabilizer, effects of excitation system, small signal stability of multi-machine systems.	
2.	**Control of Active and Reactive Power:** Speed governing system, Primary control, secondary control, Tertiary control, Automatic Generation Control (AGC), Capabilities and Constraints of Generators/Exciters/Turbines/, Analysis of Uncompensated AC Line, shunt and series compensation, Introduction to FACTS and HVDC controllers.	**4**

Lab Work:

Sr.No	Lab contents	No. of Hours
1	Modeling of synchronous machines, exciter and turbines.	**10**
2	Simulation studies of Small Signal Stability of 3- Power system	**10**
3	Control of three phase active and reactive power simulation studies .	**8**

Course Outcomes:

At the end of the course, students will have:	
1	From this course the students shall be able to apply the basic concepts of power system components, modeling for linear and non linear system.
2	The students shall be able to apply the methods of system analysis in steady state and transient state operating conditions using eigen value, direct energy conversion.
3	The students shall be able to investigate the set of FACTS devices for improvement of power system stability.

Bibliography:

Sr.No		Year of Publication/Reprint
1	L. P. Singh, "*Advanced Power System Analysis and Dynamics*," New Age International Publishers, NewDelhi, 6th Edition.	**2012**
2	D.P. Kothari, I.J. Nagrath, " *Modern Power System Analysis*," 3rd edition, Tata Mcgraw Hill Education Private Limited	**2003**
3	K.R.Padiyar, "*Power System Dynamics Stability and Control*," B.S. Publisher.	**2002**
4	NarainHingorani, et al, "*Understanding FACTS: Concepts And Technology Of Flexible AC TransmissionSystems*," IEEE Press Standard Publisher Distributors, Delhi-110006.	**1999**
5	'P.Sauer & M.A. Pai, "*Power System Dynamics & Stability*," Prentice Hall.	**1997**

Classical books:

1	'V.A. Venikov, "*Transient Phenomena in power system*" Mir Publications.	**1964**
2	A.A. Fouad and P.M.Anderson, "*Power system stability and control*" Iowa University Press, Ames, Iowa.	**1977**
3	E.W. Kimbark, John Wiley and Sons, "*Power system Stability, Vol.I and III*," Inc., New York.	**1948**
4	'P. Kundur, "*Power System Stability and Control*,"	**1994**

MOOCs& online contents on this course are available at:

1) Power System Dynamics and Control, coordinated by IIT Bombay, NPTEL, "*http://nptel.ac.in/downloads/108101004/#,"*

2) Power System Stability and Control, coordinated by IIT Madras, NPTEL, "*http://nptel.ac.in/courses/108106026/,"*

Program Elective III – E3

Course Name	**:**	**Static Reactive Power Control And FACTS**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**
Segment	**:**	**1-3**

Total No. Lectures:- 14
Total No. Lab Hours:- 14

Course Objectives:

The main objectives of this course are:	
1.	To learn the basic concepts of reactive power transmission, FACTS, voltage sourced converters
2.	To understand self and line commutated current sourced converters, UPFC, Shunt Compensation, Series compensation.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1.	Introduction: Principles of reactive power control in load and transmission line compensation, series and shunt reactive power compensation. Concepts of Flexible AC Transmission System (FACTS).	**3**
2.	Voltage-sourced converters, Self and line-Commutated Current-Sourced Converters.	**3**
3.	Static shunt compensators, Static series compensators, Static Voltage and phase angle regulators, Unified Power Flow Controller and interline Power Flow Controller.	**8**

Lab Work:

Sr.No	Lab contents	No. of Hours
1.	Power flow, voltage control, transient stability control with FACTS	**14**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Understand and apply the basic concepts of reactive power transmission, FACTS, voltage sourced converters
2.	Understand self and line commutated current sourced converters, UPFC, TCBR, Sen Transformer etc., in electrical power system.

Bibliography:

Sr.No		Year of Publication/ Reprint
1	R. Mohan Mathur, Rajiv K. Varma, "Thyrister based FACTS controllers for electrical transmission system," Wiley	**2011**
2	R.K.Varma and R.M.Mathur, "*Thyristor Controlled Flexible AC Transmission System*," IEEE Press.	**2002**
3	N.G. Hingorani and L.Gyugyi, "*Understanding FACTS: Concepts and Technology of Flexible ACTransmission Systems*," Standard Publishers-Distributors.	**2000**

Classical books:

1	Miller T.J.E., "*Reactive Power Control in Electric Systems*", John Wiley.	**1982**

MOOCs and online contents on this course are available at:

1) Avik Bhattacharya, "Facts Devices," IIT Roorkee, NPTEL *(https://onlinecourses.nptel.ac.in/noc18_ee44/preview)*

2) Avik Bhattacharya, "Facts Devices,"Swayam (*https://swayam.gov.in/courses/4784-july-2018-facts-devices*)

Course Name	**:**	**Fast Transients In Power Systems**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**3 0 0**
Segment	**:**	**1-3**

Total No. Lectures:-21

Course Objectives:

The main objectives of this course are:	
1.	To describe the concepts, origin and the effect of fast transients, lightning phenomenon.
2.	To learn the theory of ground wires, switching surges, insulation coordination, transients in integrated power systems.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1.	**INTRODUCTION TO FAST TRANSIENTS** Origin and nature of power system Transients, traveling waves on transmission system, the line equation, the shape attenuation and distortion of waves, reflection of traveling waves, successive reflections, traveling waves on multi conductor systems.	**7**
2.	**THEORY OF GROUNDS WIRES & SWITCHING SURGES:** Mathematical model of lightning stroke. Direct stoke to a tower, effect of reflection up and down the tower, the counterpoise. Normal frequency effects, high charging currents, cancellation waves, recovery voltage, restricting phenomena. Protection of transmission systems against surge	**7**
3.	**TRANSIENTS IN INTEGRATED POWER SYSTEMS** Introduction, the short line or kilometric fault, line dropping and load rejection, voltage transients on closing and re-closing lines, over voltages induced by faults, switching high-voltage direct current lines, switching surges on an integrated system, transients in the industrial power network, transients due to capacitor switching.	**7**

Course Outcomes:

At the completion of this course, students will be able to:	
1	To apply the concepts, origin and the effect of fast transients, lightning phenomenon, theory of ground wires.
2	To understand switching surges, insulation coordination, transients in integrated power systems and computer aided calculation of electrical transients.

Bibliography:

S.No		Year of Publication/Reprint
1	Akihiro Ametani, Naoto Nagaoka, Yoshihiro baba, Teruo ohno, "*Power Sytem Transients*," CRC press	**2013**
2	C.S. Indulkar, D.P. Kothari, K. Ramalingam, "*Power System Transients*," 2nd edition PHI	**2010**
3	Lou van der Sluis, " *Transients in Power Systems*" Wiley	**2001**
4	Transmission Line Reference Book, EPRI, USA.	**2006**

Classical books:

1	Allan Gr.wood, "*Electrical Transients in power Systems*," Wiley Iterscience.	**1991**
2	R Rudenterg, "*Electric Stroke waves in power systems*," Harvard University press, Cambridge, Massachusetts.	**1968**
3	L.V Bewley, "*Travelling waves on transmission system*," power publications Inc. New York.	**1993**
4	Gonen, T., "*Electric Power Transmission System Engineering: Analysis and Design*", Wiley.	**1988**

MOOCs and online contents on this course are available at:

1) Transients on transmission line, coordinated by IIT Kanpur, NPTEL *(http://nptel.ac.in/courses/108104087/65)*

2) Transients stability analysis, coordinated by IIT Madras, NPTEL (*http://nptel.ac.in/courses/108106026/7*)

Course Name	**:**	**Microcontroller And PLC**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**
Segment	**:**	**1-3**

Total No. Lectures:-14
Total No. Lab Hours:-14

Course Objectives:

The main objectives of this course are:	
1.	To deliver knowledge of various types of controllers used in design and development of intelligent system.
2.	To learn the development of microcontrollers based hardware system.

Course Contents:

Sr.No	Course Contents	No. of Lectures
A. MICROCONTROLLER		
1	**Introduction :** 8051 microcontroller, The 8051 Pin Diagram,8051 Architecture, Functional Aspect of 8051 Architecture.	**2**
2	**Software Concept of Microcontroller:** Microcontroller programming, Data Transfer Operation, Arithmetic operations, Logical Operations, Jump and Branching Operations, Assembly and C language.	**2**
3	**Integration of Hardware & Software**: Interfacing Concept of 8051, Analog Interfacing, Digital Interfacing , ADC Interfacing , DAC Interfacing	**2**
4	**Case Studies:** Voltage Measurement , LED Glowing , Fluid Tank level Control ,Intelligent Project Design &Development	**2**
B. PLC		
1	**Introduction:** Programmable Logic Controller, Difference betw. Computer and PLC, Basic Structure of PLC	**1**
2	**Assembly Languages Program Instructions :** Ladder Logic Program, PLC Ladder Program Symbols, PLC Ladder Programming, Conventions of PLC Ladder Diagram, Programming Equipment, Programming Formats	**2**
3	**Implementation of PLC Logic functions:** Latching , Timers & Time Delay using PLC , Shift registers, Internal relays &Counters, Master and Jump Control , Data Handling.	**2**
4	**Integration of Hardware and Software:** Selection of PLC, SCADA System, HMI System, Case studies, WiperMotion Control.	**1**

Lab Work:

Sr.No	Lab contents	No. of Hours
1	Design and prepare algorithm for microcontroller based application using sensors and other interfacing peripheral and implement on hardware	**8**
2	Design and simulate experiment using any PLC simulation software and implement on hardware	**6**

Course Outcomes:

At the end of the course, students will have:	
1	After going through this course students will be able to apply their knowledge to design and develop intelligent systems.
2.	An in-depth knowledge of applying the concepts on real-time applications

Bibliography:

S.No		Year of Publication/Reprint
1	Tilak Thakur, "*Microcontroller and PLC (Chapter 8 & 9) of Mechatronics*," Oxford University Press	**2015**
3	Ali Mazidi, "*The 8051 Microcontroller and Embedded Systems*," Pearson.	**2011**
5	W.Bolton Programmable Logic Controller	**2006**

Classical books:

1	Ayala, "*The 8051 Microcontroller Architecture, Programming & Application*," Themson Publications.	**1996**
2	John W. Web Programmable Logic Controller	**1995**

MOOCs and online contents on this course are available at:

1) Programmable logic controller, Coordinated by IIT Guwahati, NPTEL (*http://nptel.ac.in/courses/112103174/13*)

2) Shrikrishna N. Joshi, "Mechatronics and Manufacturing Automation," IIT Guwahati, NPTEL (*http://nptel.ac.in/courses/112103174/*)

Program Elective IV – E4

Course Name	**:**	**Power System Reliability**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segment	**:**	**4-6**

Total No. of Lectures-21

Course Objectives:

The main objectives of this course are:	
1.	To understand the fundamentals of reliability and its application to transmission system, distribution system, substation, HVDC systems.
2.	To exercise the reliability concepts/methods for various power system problems.

Course Contents:

Sr No.	Course Contents	No. of Lectures
1.	**Basic Reliability Theory:** Reliability concepts – exponential distributions – meantime to failure – series and parallel system – MARKOV model – recursive technique. Generator system reliability analysis – probability models for generators unit and loads – reliability analysis of isolated and interconnected system – generator system cost analysis – corporate model – energy transfer and off peak loading.	**7**
2.	**Transmission System reliability analysis:** Composite generation and transmission systems, introduction, radial configurations, conditional probability approach, network configurations, state selection, system and load point indices, application to practical systems, data requirements for composite system reliability evaluation.	**6**
3.	**Distribution System reliability analysis (radial, parallel and meshed)**: Distribution systems – basic techniques and radial networks, introduction, evaluation techniques, additional interruption indices, application to radial systems, effect of lateral distributor protection, effect of disconnects, effect of protection failures, effect of transferring loads, probability distributions of reliability indices, distribution systems-parallel and meshed networks, introduction, basic evaluation techniques, inclusion of busbar failures, inclusion of scheduled maintenance, temporary and transient failures, inclusion of weather effects, common mode failures, common mode failures and weather effects, inclusion of breaker failures.	**8**

Course outcome:

At the completion of this course, students will be able to:	
1.	Apply the fundamentals of reliability to generation, transmission and distribution system
2.	Exercise the reliability concepts/methods for various power system problems

Bibliography:

Sr. No		Year of Publication/Reprint
1	Ali Chowdhury and D. Kova, "*Power Distribution System Reliability: Practical Methods and Applications*," Wiley IEEE	**2011**

Classical books:

1.	Roy Billinton Ronald N Allan, "*Reliability Evaluation of Power Systems*," 2nd edition	**1992**
2.	, J. Endrenyi, "*Reliability Modeling in Electrical Power System*,"	**1979**
3.	RoyBillinton, Ronald N Allan, "*Reliability evaluation of engineering system*,"	**1983**

MOOCs and online contents on this course are available at:

1) Introduction to Reliability, coordinated by IIT Madras, NPTEL (*http://nptel.ac.in/courses/114106037/40*)

2) System Reliability, coordinated by IIT Madras, NPTEL (*http://nptel.ac.in/courses/114106041/25*)

Course Name	**:**	**Restructured And Deregulated Power Systems**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**
Segment	**:**	**4-6**

Total No. Lectures:- 14
Total No. Lab Hours:- 14

Course Objectives:

The main objectives of this course are:	
1.	The student should be able to acquire knowledge of various issues in Indian Power Sector, power system de-regulation.
2.	To understand restructuring, market reforms, transmission planning and pricing issues.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1.	**Deregulation of Electricity Supply Industries** Introduction to deregulation, different entities in deregulated electricity markets, background of deregulation around the world, benefits from competitive electricity markets, different key issues of competitive electricity markets, market Clearing Price(MCP) - Market operations: Day-ahead and Hour-Ahead Markets, Elastic and Inelastic demand, technical challenges, Power System Restructuring and electricity reforms in India, key features of electricity act 2003, introduction to various institutions in Indian power sector such as CEA, CERC.	**3**
2.	**Market Models** Market Models based on energy trading, contractual agreement: Pool & Bilateral models, different independent models, role of ISO, market power, Bidding and auction mechanisms, market models in Indian market context and power trading in India, restructuring models of different countries – UK, California, New Jersey, Australia	**3**
3.	**Transmission Open Access and pricing issues** Power wheeling, transmission open access, cost component in transmission pricing, basic objectives, different methods of transmission pricing, principles of ATC determination, factors affecting ATC, static and dynamic ATC, static ATC determination using DC power transfer distribution factors, AC power transfer distribution factors, ATC with line outage contingencies.	**4**
4.	**Transmission congestion management** Transmission congestion, impact of transmission congestion, different methods of congestion management, financial transmission right, flow gate rights, market power and congestion issues, numerical examples, international experiences of transmission congestion management.	**4**

Lab Work:

S.No	Lab contents	No. of Hours
1	Load flow analysis using NR method in MATLAB, LMP calculations using Optimal power flow for congestion management & Transmission Pricing using power flow by different methods	**14**

Course Outcomes:

At the end of the course, students will have:	
1	Knowledge of various issues in Indian Power Sector.
2	Power system de-regulation, restructuring, market reforms.
3	Transmission planning and pricing issues.

Bibliography:

S.No		Year of Publication/Reprint
1	LaiLio Lee, "*Power System restructuring and deregulation*," John Wiley and Sons, UK	**2001**
2	BhattacharyaK, Bollen MHT and DoolderJC, "*Operation of Restructured Power Systems*," Kluwer Academic Publishers, USA	**2012**
3	ShahidehpourM et al, "*Market Operations in Electric Power Systems*," John Wiley and Sons	**2002**
4	PhilipsonLorrin, WillisHLee, "*Understanding electric utilities and de-regulation*," Marcel Dekker Pub	**2006**

Classical books:

1	IlicM, "*Power Systems Restructuring-Engineering and Economics*," Kluwer Int. Series	**1998**

MOOCs and online contents on this course are available at:

1) Restructured power systems, coordinated by IIT Delhi, NPTEL (*http://nptel.ac.in/courses/108101005/)*

Course Name	**:**	**Energy Management and Energy Auditing**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segment	**:**	**4-6**

Total No. of Lectures-21

Course Objectives:

The main objectives of this course are:	
1.	To learn the fundamentals of energy management, strategies and planning.
2.	To learn energy conservation and recycling, energy monitoring and targeting, material and energy balance.

Course Contents:

Sr No.	Course Contents	No. of Lectures
1.	Energy Management Centers and Their Functions, Architectures, recent Developments	**2**
2.	Characteristics of Power Generating Units and Economic Dispatch	**3**
3.	Unit Commitment (Spinning Reserve, Thermal, Hydro and Fuel Constraints); Solution techniques of Unit Commitment	**2**
4.	Generation Scheduling with Limited Energy	**2**
5.	Energy Production Cost – Cost Models, Budgeting and Planning	**3**
6.	Interchange Evaluation for Regional Operations, Types of Interchanges Exchange Costing Techniques.	**3**
7.	Demand side management	**2**
8.	Power Quality, Measurement, Energy Efficiency Audit and Analysis	**4**

Course outcome:

At the completion of this course, students will be able to:	
1.	Apply the fundamentals of energy management, strategies and planning, energy conservation and recycling.
2.	Apply the fundamentals of Energy monitoring and targeting, material and energy balance and can also be capable of performing energy audit in the various types of systems.

Bibliography:

Sr. No		Year of Publication/Reprint
1.	Gr., J. N, Wilson, R, "*Control and Automation of Electric Power Distribution Systems*", Taylor and Francis.	**2007**
2.	Turner, W. C, " *Energy Management Handbook*", 5 th Edition, 2004	**2004**
3.	John D Mc Donald, "*Electric Power Substation Engineering*", CRC press, 2001.	**2001**

4.	Wood, A. J and Wollenberg, B. F, "*Power Generation Operation and Control*", 2 nd Edition John Wiley and Sons, 2003.	**2003**
5.	S.C.Tripathy, "*Electrical Energy utilization and energy conversion*," Tata Mc-GrawHill	**2003**
6.	S.B.Pandya, "*Conventional energy technology*," Tata Mc-GrawHill	**2003**

Classical books:

1.	Handschin, E. "*Real Time Control of Electric Power Systems*", Elsevier.	**1972**
2.	Handschin, E. "*Energy Management Systems*", Springer Verlag.	**1990**

MOOCs and online contents on this course are available at:

1) Energy Management Systems and SCADA, Coordinated by IIT Madras, NPTEL (*http://www.nptel.ac.in/courses/108106022/)*

2) Power system Generation, Transmission and Distribution (Optimal Unit Commitment), coordinated by IIT Delhi, NPTEL (*http://nptel.ac.in/courses/108102047/33*)

Power Electronics

Semester I

Soft Computing

Course Name	**:**	**Internet of Things**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total no. of lectures: 14
Total no. of Lab hrs. : 14

Course Objectives:

The main objectives of this course are:	
1.	Understand core technology, applications, sensors used and IOT architecture along with the industry perspective.
2.	Principles and operations of different types of sensors commonly used on mobile platform will be taught in a manner that by the end of the course the students will be able to design and implement real time solutions using IOT.

Course Contents:

S.No.	**Course Contents**	**No. of Lectures**
1	**Introduction to IoT** What is IoT, how does it work? Difference between Embedded device and IoT device, Properties of IoT device, IoT Ecosystem, IoT Decision Framework, IoT Solution Architecture Models, Major IoT Boards in Market	**2**
2	**Setting Up Raspberry/Arduino to Create Solutions** Explore Raspberry Pi, Setting up Raspberry Pi, Showing working of Raspberry Pi using SSH Client and Team Viewer, Understand Sensing actions, Understand Actuators and MEMS	**3**
3	**Communication Protocols used in IoT** Types of wireless communication, MajorwirelessShort-rangecommunicationdevices,properties,comparisonofthesedevices (Bluetooth, WIFI, ZigBee, 6LoWPAN), Major wireless Long-range communication devices, properties, comparison of these devices (Cellular IoT,LPWAN)	**3**
4	**IoT Applications** Industrial Internet 4.0, Applications such as: Smart home, wearables, smart city, smart grid, , connected car, connected health(digital health, telehealth, telemedicine), smart retail	**3**
5	**Sensors:** Applications of various sensors: Google Maps, Waze, Whats App, Ola Positioningsensors: encoders and accelerometers, Image sensors: cameras, Global positioning sensors: GPS, GLONASS, IRNSS, Galileo and indoor localization systems, Motion&OrientationSensors:Accelerometer,Magnetometer,ProximitySensor, GyroscopeCalibration,noise modeling and characterization and-noisefiltering and sensor data processing. Privacy &Security	**3**

Lab Work:

Sr. No.	Lab contents	No. of Hours
2.	Design and build systems that will use sensors, communication protocol and actuators.	14

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Understand concept of IOT and ability to implement in real time scenarios
2.	Design solutions based on IOT architecture and applications in various fields
3.	Critically analyze security and privacy issues in IOT
4.	Apply knowledge to Design and develop variousapplicationsofsensorsinIndustrial,healthcare,commercial,andbuildingautomation

Bibliography:

S.No.	Book Detail	Year of Publishing
1	Vijay Madisetti and ArshdeepBahga, Internet of Things (AHands-on Approach), 1st Edition, VPT	2014
2	Francis daCosta, Rethinking the Internet of Things: A ScalableApproach to Connecting Everything, 1stEdition, Apress Publications	2013
3	CunoPfister, Getting Started with the Internet of Things, OReillyMedia	2011
4	Kyung, C.-M., Yasuura, H., Liu, Y., Lin, Y.-L., Smart Sensorsand Systems, Springer International Publishing	2015

MOOCs on this course are available at:

1) Introduction to Internet of Things - https://www.edx.org/course/introduction-to-the-internet-of-things-iot
2) IoT Programming and Big Data -https://www.edx.org/course/iot-programming-big-data-curtinx-iot4x

Course Name	**:**	**Machine Learning**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total no. of lectures: 14
Total no. of lab hrs: 14

Course Objectives:

	The main objectives of this course are:
4.	To formulate machine learning problems corresponding to different applications.
5.	To understand a range of machine learning algorithms along with their strengths and weaknesses.
6.	To develop reasoning behind Model selection, model complexity, etc.

Course Contents:

S.No.	Course Contents	No. of Lectures
1	**BASICS OF MACHINE LEARNING:** Applications of Machine Learning, processes involved in Machine Learning, Introduction to Machine Learning Techniques: Supervised Learning,Unsupervised LearningandReinforcementLearning,ReallifeexamplesofMachineLearning.	**3**
2	**SUPERVISED LEARNING:** Classification and Regression: K-Nearest Neighbour, Linear Regression,Logistic Regression, Support Vector Machine (SVM), Evaluation Measures: SSE, MME, R2,confusionmatrix,precision,recall,F-Score,ROC-Curve.	**6**
3	**UNSUPERVISED LEARNING:** Introductiontoclustering,TypesofClustering:Hierarchical-AgglomerativeClustering and Divisive clustering; Partitional Clustering - K-means clustering, Principal Component Analysis,ICA.	**5**

Lab Work:

S.No.	Lab Contents	No. of hours
1	Python Introduction: Loops and Conditions and other preliminarystuff, Functions, Classes and Modules, Exceptions, Database access, Mathematical computing with Python packages like: numpy, Mat- plotLib,pandas Tensor Flow, Keras	**8**
2	Application Oriented Project Work	**6**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Design and implement machine learning solutions to classification, regression and clustering problems
2.	Evaluate and interpret the results of the different ML techniques
3.	Design and implement various machine learning algorithms in a range ofReal-world applications.
4.	Use Python for various applications.

Bibliography:

S.No.	**Book Detail**	**Year of Publishing**
1.	Tom Mitchell, Machine Learning, McGraw Hill,	2017
2.	Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer,	2011.
3.	T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e,	2008.
4.	Yuxi (Hayden) Liu, "Python Machine Learning By Example", Packet Publishing Limited	2017

MOOCs on this course are available at:

1) Data Science: Machine Learning -https://www.edx.org/course/data-science-machine-learning
2) Machine Learning - https://www.coursera.org/learn/machine-learning

Design of Experiments and Research Methodology

Course Name	**:**	**Design of Experiments and Research Methodologies**
Course Code	**:**	
Credits	**:**	**3**
L T P	**:**	**2 0 2**
Segment	**:**	**1-6**

Total No. Lectures: 28

Total No. of Lab hrs. 28

Course Objectives:

The students should be able to develop an understanding of how to identify research topics, formulate research questions / hypotheses, select an appropriate research and, where applicable, experimental design. Provides a basis so the student can effectively develop a research proposal for either a capstone project, master's thesis, research project, or designed experiment.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Introduction**: Types of Research and Their Purposes, Locating, Analysing, stating and evaluating research problem, need for literature review, steps in conducting literature review, Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis, research questions and hypothesis, types of hypothesis, evaluation of hypothesis.	**3**
2.	**Research Design and Sampling Design:** Concept of research design, features of a good research design, concept of population and sample, characteristics of sample design, types of sampling techniques	**2**
3.	**Methods of data collection and measurement:** Primary data and Secondary data, data collection techniques: observation, interview, questionnaires, schedules, case-study, levels of measurement, problems in measurement in research – validity, reliability.	**3**
4.	**Statistical Methods of Analysis:** Descriptive statistics: mean, median, mode, range, mean deviation and standard deviation, regression and correlation analysis, inferential statistics: t-tests, Chi-square tests. Correlation (rank difference and product moment), Analysis of variance (ANOVA) (one way)	**4**
5.	**Procedure for writing a research report and manuscript:** Types of research reports, steps of writing a report, layout of report, layout of research paper, ethical issues related to publishing, Plagiarism and Self-Plagiarism.	**2**

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Select a problem from your area of interest, identifying the type of research problem it is and perform the SWOT analysis of the existing literature.	4
2.	Generate research questions and hypotheses for a problem from your area of interest.	4
3.	Identify the population and sample for the study (highlighting the technique used for sample selection) for a problem from your area of	4

	interest.	
4.	Design a questionnaire for the problem of interest.	4
5.	Utilizing software such as Statistical Package for the Social Sciences(SPSS), Mini Tab, etc. for the statistical analysis of the results obtained for the desired questionnaire.	6
6.	Preparing a research paper for the problem of interest	6

Course Outcomes:

At the end of the course, students will be able to:	
1.	Develope an understanding of how to identify research topics, formulate research questions and corresponding hypotheses, select an appropriate research and where applicable, experimental design.
2.	Perform required statistical analyses for any univariate application in a business / industrial setting, regardless of data form, and will be familiar with major indices for measuring correlation and association.
3.	Further, the underlying assumptions related to each statistical test and its interpretation will be thoroughly reviewed.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Probability and Statistics for Engineers and scientists by Anthony J. Hayter, Cencage Learning, 4th Edition	2016
2.	Probability and Statistics for Engineers and scientists by Walpole, Myers, Myers and Ye, 8th ed Pearson Education	2007
3.	Research Methodology - Methods and Techniques, C. K. Kothari, New Age International, 2nd Edition	2004
4.	English for writing research papers by Adrian Wallwork, 2nd Edition. Springer	2016
5.	Statistics: Concepts and Controversies by David S. Moore, William I. Notz, W. H. Freeman	2016

Available MOOCS:

1. https://www.coursera.org/learn/research-methods

2. https://www.lawctopus.com/certificate-course-on-research-methodology-online/

Program Core I

Course Name	**:**	**Modern Control Systems**
Course Code	**:**	
Credits	**:**	**3**
L T P	**:**	**2-0-2**
Segment	**:**	**1-6**

Total No. of Lectures – 28
Total No. of Lab hours – 28

Course Objectives:

	The main objectives of this course are:
1.	To learn the modeling concepts of system, modelling using state space.
2.	Tolearn and implement the optimal control techniques.
3.	To design the digital control system and nonlinear systems.

Course Contents:

Sr No.	Course Contents	No. of Lectures
1	**Introduction:** Control systems design requirements, classical versus modern approaches of design	**2**
2	**State Space Representation:** Concepts related to state space , state space representation, state transition matrix, solution of linear time invariant and linear time varying state equations, canonical forms	**3**
3	**Control System Design in State Space:** Controllability, pole placement design using full state feedback-regulator and tracking systems, observers, observability and compensators, full order and reduced order observers	**6**
4	**Linear Optimal Control :** Optimal control problem, infinite time linear optimal regulator design, optimal control of tracking systems (Riccati equation based designs).	**6**
5	**Digital Control Systems:** Basic concepts, z-transform, stability, performance, state space modeling and solution of linear digital equations, design using pole placement,: regulators and observers and compensators, linear optimal control of digital systems.	**7**
6	**Nonlinear Control Systems:** Sources of nonlinearities and characteristics of nonlinear systems, describing function method, phase plane analysis, Lyapunov stability theory.	**4**

Lab Work:

Sr. No.	Lab Contents	Lab Hours
1	State space modeling of continuous time system and study of stability and state and output responses	**2**
2	Pole placement design using state feedback for regulator and tracking systems	**2**
3	Full and reduced order observer design	**2**

4	State space modeling of discrete time system and study of responses	**2**
5	Pole placement design for regulator and tracking discrete time systems	**2**
6	Observer design for discrete time systems	**2**
7	Describing function analysis of nonlinear systems	**2**
8	Phase plane analysis of nonlinear systems	**2**
9	Project 1	**4**
10	Project 2	**4**
11	Project 3	**4**

Course Outcomes:

By the end of this course, the student will be:	
1	able to apply the modeling concepts of system modeling using state space and understand the design issues in the framework of modern control.
2	conversant with the optimal control techniques.
3	conversant with the concepts of digital control system and non-linear systems.

Bibliography:

Sr.No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	A.Tewari, *Modern Control Design with MATLAB and Simulink*. JohnWiley and Sons Ltd.	**2002**
2	K. Ogata, *Modern Control Engineering*.PHI.	**2014**
3	M. Gopal, *Modern Control System Theory*. New Age International (P) Ltd.	**2005**
4	M.Gopal, *Digital Control and State Variable Methods*. TMH.	**2003**
5	W. L. Brogan, *Modern Control Theory*. Pearson Education India.	**2011**

MOOCs on this course are available at:

1) Lecture Series On Control Engineering, Prof. Sd Agashe, IIT Bombay: nptel.iitm.ac.in.

2) **2)**Introduction to Control System Design - A First Look, Jacob White, Joe Steinmeyer, MIT,

https://www.edx.org/course/introduction-control-system-design-first-mitx-6-302-0x

3) Non-linear systems, Slotine, MIT, http://web.mit.edu/nsl/www/videos/lectures.htm

4) **J. White and J. Steinmeyer, *Introduction to State Space Control*, MIT, EDX**

Program Core II

Course Name	**:**	**Power Electronic Devices And Controllers**
Course Code	**:**	
Credits	**:**	**3**
L T P	**:**	**2-0-2**
Segment	**:**	**1-6**

Total No. Lectures:-28
Total No. of Lab hours – 28

Course Objectives:

	The main objectives of this course are:
1.	To learn and apply the concepts of power electronic converters (AC-DC, DC-AC, DC-DC and AC-AC) using power electronic devices.
2.	Utilize the concepts power processing and their applications.
3.	Apply theacquired knowledge in contemporary research areas

Course Contents:

Sr.No	Course Contents	No. of Lectures
1.	**Power Electronic Devices** Review of power switching devices, switching and I-V characteristics. Triggering and Protection circuits	**3**
2.	**AC- DC Conversion circuits** Review of AC-DC Power Converters. Output Voltage and Source Current Analysis (THD, DPF, PF). Definitions of Fundamental Real Power (P) and Reactive Power (Q) of converters and associated VAR Diagrams. Effect of Source Inductance on output voltage.	**6**
3.	**DC- AC Conversion circuits** **1-** Ø and 3- Ø bridge inverters, Voltage Control of Three Phase Inverters: Review of PWM Techniques. Space Vector Modulation (SVM). Relationship between PWM and SVM. Comparison of Various PWM Techniques. Multilevel Inverters: Introduction and Basic Concept, Types of Multilevel Inverters (Diode Clamp, Flying Capacitor, Cascaded), Switching Device Currents, DC- Link Capacitor Voltage Balancing. Features of Multilevel Converters.	**8**
4.	**DC-DC Switch Mode Converters** Introduction to DC-DC Converters, Control of DC-DC Converters, Buck Converter, Boost Converter, Buck-Boost Converter, Cuk Converter, Full Bridge DC-DC Converter. Forward, Push-Pull and Fly back converters. Comparison of DC-DC Converters.	**6**
5.	**AC- AC Conversion circuits** Single and three phase Fully and Half controlled Regulator: Analysis of operation for R and RL Load. Load and Supply Current Characteristics. Variants, Analysis and Characteristics of 3Ø Regulators: Delta Connected Arrangement of three 1Ø Regulators (half and fully controlled), Delta and Star Connected Load,Comparison of 3Ø Regulators.	**5**

	Static Power Frequency Changers: Operational features and Operating Principles. Mathematical Representation (output voltage and Input Current) of Static Frequency Changers. Synthesis of the Output Voltage Waveform, Control of the Output Voltage.	

Lab Work:

Sr.No	Lab contents	No. of Hours
Performance Evaluation and Analysis of following power electronic converters through Simulation/ Experimentation		
1.	Half and full-wave 1-phase controlled rectifier.	**2**
2.	Half and full-wave 3-phase controlled rectifier.	**2**
3.	Twelve-pulse converter.	**2**
4.	24-pulse converter.	**2**
5.	48-pulse converter.	**2**
6.	Buck, boost, buck-boost converters.	**4**
7.	Single-phase and 3-phase ac voltage controllers.	**2**
8.	Single-phase inverter with different modulation techniques.	**2**
9.	Three-phase inverter with different modulation techniques.	**4**
10.	SVM 3-phase inverter.	**2**
11.	Multilevel Inverters	**4**

Course Outcomes:

	At the completion of this course, students will be able to:
1.	Apply the concepts of power electronic converters (AC-DC, DC-AC, DC-DC and AC-AC) using power electronic devices.
2.	Apply the concepts power processing and work on their applications.
3.	Carry-out contemporary research areas by theacquired knowledge of convertors

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/Reprint
1.	M. H. Rashid,*Power Electronics: Circuits, Devices and Applications*, PHI.	**2014 / 4E**
2.	N. Mohan, T.M. Undeland and W.P.Robbins, *Power Electronics: Converters Applications and Design*, John Wiley & Sons.	**2006**
3.	R.S. Ramshaw, *Power Electronic Semiconductor Switches*, Chapman and Hall.	**1994**
4.	Marian K Kazimierczuk, *Pulse-width Modulated DC–DC Power Converters*, John Wiley & Sons.	**2008**
5.	R.W. Erickson and D. Maksimovic, *Fundamentals of Power Electronics*, KLUWER Academic Publishers.	**2004**
6.	I. Batarseh and A. Harb. *Power Electronics: Circuit Analysis and Design*. Springer.	**2017**
7.	D.W. Hart, *Power Electronics*. Tata McGraw-Hill Education.	**2011**

Classical Books:

8.	G. Seguier, C. Rombaut and R. Bausiere, *Power electronic Converters: Volume 2 AC-AC Conversion*, North Oxford Academic Publishers.	**1987**
9.	L. Gyugyi and B.R.Pelly, *Static Power Frequency Changers*, John Wiley and Sons 1976.	**1976**
10.	W. Mc Murray, *Theory and Design of Cycloconverters*, The MIT Press 1972, ISBN 0-262-13081-5.	**1972**
11.	B.R. Pelly, *Thyristor Phase Controlled Converters and Cycloconverters*, John Wiley & Sons	**1971**
12.	B.D. Bedford and R.G. Hoft, *Principles of Inverter Circuits*, John Wiley and Sons.	**1964**

MOOCs on this course are available at:

1. Dr. K. Afridi, Dr. R. Erickson, Dr. D. Maksimovic, *Power Electronics Specialization*, University of Colorado, Coursera

Program Elective I – E1

Course Name	**:**	**DC Controllers**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**
Segment	**:**	**1-3**

Total No. Lectures- 14
Total No. of Lab hours – 14

Course Objectives:

	The main objectives of this course are:
1.	To learn and apply the concepts of DC converters using power electronic devices.
2.	Utilize the concepts the students will be able to carry out harmonic reduction using different techniques.
3.	To learn about DC-DC switch mode converters

Course Contents:

Sr.No	Course Contents	No. of Lectures
1.	**AdvancedAC- DC Conversion circuits** Introduction to multi-pulse methods for reduction of harmonics: Principle of cancellation of harmonics, determination of phase shift and vector representation. Analysis of 12 pulse converter (Wye-Wye and Wye-Delta) configuration for 30 degree phase shift. Introduction to PWM rectifiers: Power factor corrected rectifiers.	**7**
2.	**Advanced DC-DC Switch Mode Converters** Small-signal Models of PWM Converters for CCM and DCM.Open-loop Small-signal Characteristics of Boost Converter for CCM. Voltage-mode Control of Boost Converter. Current-mode Control.	**7**

Lab Work:

Sr.No	Lab contents	No. of Hours
1.	To Obtain the performance of 12 pulse AC-DC Converter using Y-Y and Y-Δ transformers.	**2**
2.	To Obtain the performance of 12 pulse AC-DC Converter using zigzag transformers.	**2**
3.	To Obtain the AC and DC side performance of single phase PWM rectifier	**2**
4.	To Obtain the AC and DC side performance of three phase PWM rectifier	**2**
5.	To obtain current and voltage mode control of boost converter.	**2**

Course Outcomes:

	At the completion of this course, students will be able to:
1.	Use power electronic devices for designing theDC converters.
2.	Carry out harmonic reduction using different techniques and DC-DC switch mode converters

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/Reprint
1.	M.K. Kazimierczuk, *Pulse-width Modulated DC–DC Power Converters*, John Wiley and Sons.	**2008**
2.	Derek A Paice, *Power Electronic Converter Harmonics (Multipulse methods for Clean Power)* IEEE Press.	**1995**
3.	R.W.Erickson and D. Maksimovic, *Fundamentals of Power Electronics*, KLUWER Academic Publishers.	**2004**
4.	C.C. Marouchos, Christos C. *The Switching Function: Analysis of Power Electronic Circuits*. Vol. 17.	**2006**
5.	D.W. Hart. *Power Electronics*. Tata McGraw-Hill Education.	**2011**

MOOCs on this course are available at:

1. Dr. R. Erickson, *Convertor Control*, University of Colorado, Coursera

Course Name	**:**	**AC Controllers**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2 -0- 2**
Segment	**:**	**1-3**

Total No. Lectures - 14
Total No. of Lab hours – 14

Course Objectives:

	The main objectives of this course are:
1.	The basics about the AC controllers for the use in various practical applications

Course Contents:

Sr.No	Course Contents	No. of Lectures
1.	**Static Power Frequency Changers** Implementation of Modulating Functions. End Stop Control, Control of UDFFC, NCC and CDFFC. Application of Static Frequency Changers: Speed Control of AC Machines, Constant Frequency Power Supplies and Static VAR Generators.	**4**
2.	**PWM Inverters (DC-AC Conversion)** Review of PWM and Space Vector Modulation (SVM). Current controlled VSI.SVM of three level inverter. Methods of Harmonic Reduction. Current Source Inverter, Variable DC Link Inverter, Boost Inverter. Applications of Multilevel Inverters: Reactive Power Compensation, Back to Back Intertying and Adjustable Speed Drives. Resonant Pulse Inverters: Introduction, Series and Parallel Resonant Inverters, ZVS and ZCS Resonant Converters.	**10**

Lab Work:

Sr.No	Lab contents	No. of Hours
1.	To obtain the performance of different types of PWM techniques for three phase inverter.	**2**
2.	To obtain the performance of Space Vector modulated three phase inverter.	**2**
3.	To obtain the performance of cascaded H-Bridge multilevel inverter.	**2**
4.	To obtain the performance of ZVS and ZCS switched three phase inverters.	**2**
5.	To obtain the performance of Space Vector modulated three level inverter.	**2**

Course Outcomes:

	At the completion of this course, students will be able to:
1.	Apply the concept of AC controllers / regulators, static frequency changer, PWM inverters (DC-AC conversion) in single phase and three-phase circuits,
2.	Will be able to reduce harmonis in various AC regulators
3.	Design AC regulators and multi-lever invertors

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/Reprint
1.	M. H. Rashid,*Power Electronics: Circuits, Devices and Applications*, PHI.	**2014 / 4E**
2.	P.S. Bhimra, *Power Electronics*, Khanna Publications	**2012**
3.	IEEE research papers on multilevel inverters	

Classical Books:

1.	L. Gyugyi and B.R.Pelly, *Static Power Frequency Changers*, John Wiley and Sons.	**1976**
2.	G. Seguier, C. Rombaut and R. Bausiere *Power electronic Converters: Volume 2 AC-AC Conversion*, North Oxford Academic Publishers.	**1987**
3.	W. Mc Murray, *Theory and Design of Cyclo-converters*, The MIT Press.	**1972**
4.	B.R.Pelly, *Thyristor Phase Controlled Converters and Cycloconverters*", John Wiley and Sons.	**1971**
5.	B.D. Bedford and R.G. Hoft, *Principles of Inverter Circuits*, John Wiley and Sons.	**1964**

MOOCs on this course are available at:

1. Dr. R. Erickson, *Convertor Control*, University of Colorado, Coursera

Course Name	**:**	**Power Conditioning**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segment	**:**	**1-3**

Total No. of Lectures-21

Course Objectives:

	The main objectives of this course are:
1.	Develop understanding and apply various concepts of power conditioning and related terms such as harmonic generation and mitigation
2.	Transformation from 3 phase to single phase using two axis theory
3.	Learn about active power line conditioners
4.	Study the effect of harmonic in converters

Course Contents:

Sr No.	Course Contents	No. of Lectures
1.	**Harmonic Producing Loads, Mitigation and Power Supplies** Compensation of arc furnace and traction loads. Microwave ovens, light and temperature controllers, power supplies for appliances such as camera, X-Ray equipments. Power supplies in Telecommunication systems, High frequency induction heating, Dielectric heating, Power supplies in automobiles.	**4**
2.	**Power Definitions and Instantaneous Reactive Power Theory** Concepts and Evolution of Electric Power Theory, Electric Power Definitions, Instantaneous Power Theory: Basis of the pq Theory, Clarke Transformation, pq theory application to 3φ-3 wire and 3φ-4 wire systems, Modified pq theory, Instantaneous abc theory. Comparison of pq theory and Instantaneous abc theory. Synchronous Reference Frame Theory and applications.	**8**
3.	**Active Power Line Conditioners** Passive filters and limitations, active filters for harmonic and reactive power compensation in two wire, three wire and four wire ac systems, Shunt Active Filter, Hybrid and Series Active Filters, Combined Series and Shunt Power Conditioners. Case studies on microcomputer and DSP control in active filters and power supplies.	**9**

Course outcome:

	At the completion of this course, students will be able to:
1.	Apply various concepts of power conditioning and related terms such as harmonic generation and mitigation
2.	Utilize two axis theory for transformation from 3 phase to single phase.
4.	Analyse the effect of harmonic in converters

Bibliography:

Sr. No	Name of Book/ Authors/ Publisher	Year of Publication/Reprint
1.	H. Akagi, E.H. Watanabe and M. Aredes, *Instantaneous power Theory and applications to Power Conditioning*, IEEE Press, John Wiley and Sons Incorporate.	**2007**
2.	J. Arrilaga, D.A. Bradley and P.S. Bodger, *Power System Harmonics*, John Wiley and Sons Ltd.	**1995**
3.	J. Arrilaga and N.R Watson, *Power System Harmonics*, John Wiley and Sons Ltd.	**2003**
4.	A.E. Emanuel, *Power Definitions and the Physical Mechanism of Power Flow*, IEEE Press, John Wiley and Sons Ltd.	**2010**
5.	P.S. Revuelta, S.P. Litrán, J.P. Thomas, *Active Power Line Conditioners: Design, Simulation and Implementation*, Elsevier publications, 2016.	**2016**

Program Elective II – E2

Course Name	**:**	**Power Electronics Applications In Power Systems**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segment	**:**	**4-6**

Total No. Lectures - 21

Course Objectives:

	The main objectives of this course are:
1.	To highlight the requirements of modern transmission and distribution systems and specific power electronic solutions to realize them
2.	To analyze the transmission system behavior is analyzed in great detail in the basic and advanced courses on power systems

Course Contents:

Sr.No	Course Contents	No. of Lectures
1.	**Basics of FACTS Controllers** Basics of flexible AC transmission systems, Controlled rectifier and energy storage plants, Tap changers and phase shifters, Thyristor controlled VAR compensation and series compensation.	7
2.	Modern (synchronous link converter) VAR compensators, Unified power flow controller (UPFC) and Interline power flow controller, Power electronics in power generation.	14

Course Outcomes:

	At the completion of this course, students will be able to:
1.	The students in this course can apply the concepts of FACTS controllers for compensation in power systems

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	N.G. Hingorani, G. Laszlo and E.H. Mohamed. *Understanding FACTS: concepts and technology of flexible AC transmission systems*. IEEE Press.	**2000**
2.	T.J.E. Miller, *Reactive Power Control in Electric Systems* WILEY.	**2008**
3.	R.M. Mathur and R.K. Varma, *Thyristor-BasedFacts Controllers for Electrical Transmission Systems*" IEEE Press.	**2006**

Engineering Mathematics

Course Name	**:**	**FOURIER TRANSFORMS**
Course Code	**:**	
Credits	**:**	**01**
L T P	**:**	**2-1-0**
Segment	**:**	**1-2**

Total No. of Lectures– 10
Tutorials -5

Course Objectives:

The main Objectives of this course are:

1	To make the students understand the concept of Fourier transform and be able to compute it for standard examples.
2	To make the students able to apply Fourier transforms to solve differential equations and partial differential equations.

Course contents:

Sr.No	Course Contents	No. of Lectures
1	**Fourier Transforms:** Fourier Integral formulas, Definition and examples, Basic properties, Fourier cosine and sine transforms and examples, Basic properties of Fourier cosine and sine transforms, Multiple Fourier transforms.	05
2	**Fast Fourier Transforms and Short Term Fourier Transforms:** Definition and examples, Basic properties, Applications.	05

Course Outcomes:

At the end of the course, students will be able to:	
1	Solve differential equations by using Fourier transforms
2	Solve partial differential equations by using Fourier transforms
3	Apply FFT and STFT to engineering problems

Bibliography:

Sr.No.	Name of Book / Authors / Publishers	Year of Publication/ Edition
1	"Integral Transforms and Their Applications", Loknath Debnath, CRC Press, Inc.,	1995.
2	"Integral Transforms and their Applications", Brian Davies, 3rd Edition, Springer-Verlag, New York,Inc,	2001
3	"Fourier Transform and Its Applications", Ronald N. Bracewell, 2nd Edition, McGraw-Hill Inc.,US,	1986

Course Name	**:**	**NUMERICAL METHODS**
Course Code	**:**	
Credits	**:**	**01**
L T P	**:**	**2-0-2**
Segment	**:**	**3-4**

Total No. of Lectures – 10
Practicals -10

Course Objectives:
The main Objectives of this course are:

1	To make the students understand the basics of numerical methods.
2	To make the students able to solve problems on system of linear equations and Interpolation by numerical methods.

Course contents:

Sr.No	Course Contents	No. of Lectures
1	**Error Analysis:** Definition and sources of errors, Propagation of errors, Floating-point arithmetic and rounding errors.	02
2	**Interpolation:** Interpolation using Finite differences, Numerical Differentiation and Numerical integration, Trapezoidal and Simpson's rules.	04
3	**Numerical Solution of Differential Equations:** Picard's method, Taylor series method, Euler and modified Euler methods, Runge-Kutta methods, Predictor-Corrector method.	04

Lab Work:

Sr.No	Lab. Contents	No. of Hours
3.	Solving Interpolation, Numerical Differentiation and Numerical integration problems using Mathematica.	04
4.	Solving Differential equations numerically using Mathematica.	06

Course Outcomes:

By the end of the course, the students will be able to solve the following by numerical methods:
4. Problems on Interpolation 5. Problems on Differentiation, Integration. 6. Solve differential equations.

Bibliography:

Sr.No.	Name of Book / Authors / Publishers	**Year of Publication/ Edition**
1	"Introduction to Numerical Analysis",Atkinson K. E., John Wiley.	1989
2	"Applied Numerical Analysis", Gerald C. F. and Wheatley P. O., Pearson	2004
3	"Numerical Methods for Scientific and Engineering Computation", Jain M. K., Iyengar S.R.K. and Jain R. K., New Age International Publisher.	2004
4	"Elements of Numerical Analysis", Gupta R.S., Macmillan India Ltd .	2008

Course Name	**:**	**OPTIMIZATION TECHNIQUES AND GENETIC ALGORITHMS**
Course Code	**:**	
Credits	**:**	**01**
L T P	**:**	**2-0-2**

Total No. of Lectures – 10,

Practicals -10

Course Objectives:

The main Objectives of this course are:

1	To make the students understand the need of Optimization Techniques and develop the ability to form mathematical model of optimization problems.
2	To make the students able to identify and solve linear and non-linear models of optimization problemsusing Genetic Algorirhms.

Course contents:

Sr.No	Course Contents	No. of Lectures
1	Introduction to optimization problem, local and global optimum, conversion of a constrained problem to unconstrained problem.	04
2	Genetic Algorithms, Binary and Real coded Genetic Algorithms, Coding and decoding of variables, Key steps in a GA, starting population, fitness evaluation, reproduction, crossover, mutation, evaluation.	06

Lab Work:

Sr.No	Lab. Contents	No. of Hours
2.	Using Genetic Algorithms in various optimization Problems	10

Course Outcomes:

1	The students are able to form mathematical model of optimization problems .
2	The students are able to distinguish between linear and nonlinear models .
3	The students are able to solve simple problems using Mathematica/MATLAB

Bibliography:

Sr.No.	Name of Book / Authors / Publishers	Year of Publication/ Edition
1	"Practical Genetic Algorithms", Haupt, R. L. and Haupt, S.E., John Wiley &Sons	1998
2	"Genetic Algorithm in Search, Optimization and Machine Learning" , Goldberg, D.E., Addison Wesley.	1989
3	"Engineering Optimization", Ranjan, Ganguli,University Press.	2011

Semester 2

Soft Skills & Management

Course Name	**:**	**Communication Skills**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**1-0-4**
Segment	**:**	**1-3**

Total No. Tutorials-7
Total No. of Lab hours – 28

Course Objectives:

	The main objectives of this course are:
4.	To enhance competence in communication skills: verbal and nonverbal.
5.	To provide orientation in technical communication skills: spoken and written.
6.	To sensitize students to attitude formation and behavioural skills.

Course Contents:

Sr.No	Course contents	No. of Tutorials
1.	**Introduction to Communication Skills, Soft Skills and Interpersonal Communication**	**1**
2.	**Speech:** Structure, Elements, Content, Organization and Delivery, J-a-M	**1**
3.	**Writing Skills:** Letters, Minutes of Meeting	**1**
4.	**Technical Report Writing:** Concept and Structure	**1**
5.	**Research Writing:** Concept and Structural Framework	**1**
6.	**Power Point Presentation:** Project Presentation	**1**
7.	**Interviews**	**1**

Lab Work:

Sr.No	Lab contents	No. of Hours
11.	Self- Introduction	**2**
12.	Negotiation Skills & Role Play	**2**
13.	J-a-M Session	**2**
14.	Building Word Power through Reading	**2**
15.	Group Discussion and Case Study	**4**
16.	Writing Skills: Letters, Minutes of Meeting	**2**
17.	Technical Report Writing: Concept & Structure	**4**
18.	Research Writing: Concept and Structural Framework	**4**
19.	Power Point Presentation: Project Presentation	**4**
20.	Interviews	**2**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Show enhanced competence in communication skills and technical communication.
2.	Develop awareness of attitude formation and behavioural appropriateness
3.	Gain self-confidence and perform better in their academic and professional life.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	"Technical Communication", RamanMeenakshiand SharmaSangeeta, Oxford University Press.	2015
2.	"English for Research Paper Writing", WallworkAdrian, Springer, London.	2011
3.	"English Vocabulary In Use: Advanced+ CD", MichaelMcCarthy, CUP, Cambridge.	2004
4.	"Advanced English Grammar", HewingsMartin, CUP, Cambridge.	2003
5.	"Study Listening", TonyLynch, CUP, Cambridge.	2004
6.	"Study Speaking", KennethAnderson, CUP, Cambridge.	2010
7.	"Study Reading", Glendenning H. Eric, CUP, Cambridge.	2004
8.	"Study Writing", HampLyons Liz & HeasleyBen, CUP, Cambridge.	2004
9.	"Study Skills in English", WallaceMichael J., CUP, Cambridge.	2004

MOOCs on this course are available at:

1) "Take Your English Communication Skills to the Next Level". Available at Coursera (Offered by Georgia Institute of Technology), 4 weeks, Starts on September 10, 2018. https://www.coursera.org/learn/english-communication-capstone

2) "Effective Communication in Globalised Workplace- The Capstone". Available at Coursera (Offered by National University of Singapore), 3 weeks, Starts on August 06, 2018. https://www.coursera.org/specializations/effective-communication

Course Name	**:**	**Management Entrepreneurship and IPR**
Course Code	**:**	
Credits	**:**	**1**
L T P	**:**	**0-2-0**
Segment	**:**	**4-5**

Total No. Tutorials – 14

Course Objectives:

The main objectives of this course are:	
1.	To make students familiar with the concepts of Management, Entrepreneurship and Intellectual Property Rights (IPRs).
2.	To make students understand how to initiate a new Start-up and manage it effectively.
3.	To enable students to convert their innovative ideas into different forms of IPRs.

Course Contents:

Sr.No	Course contents	No. of Tutorials
1.	**Introduction to Management:** Concepts and Principles of Management	**1**
2.	**Functions of Management:** Planning Process - Hypothetical Planning of an Event/Activity, Form of Organization Structure - Case Study, Human Resource Planning and Process, Elements of Directing and Effective Control Mechanism, Activity: Role Playing/Management Game	**4**
3.	**Introduction to Entrepreneurship:** Concepts of Entrepreneurship and Characteristics of Entrepreneurs	**1**
4.	**Development Phases of Entrepreneurship:** Innovation and Idea Generation, Project Formulation and Validation (Feasibility Analysis), Business plan	**2**
5.	**Ecosystem for Entrepreneurship Development:** Government Schemes and Initiatives, Financial and Non-Financial Institutional Support, Legal Framework, Role of Incubator, Venture Capitalist, Angel Investor, Crowd Funding Accelerator etc.	**2**
6.	**Intellectual Property Rights (IPRs):** Concept and Relevance of IPRs, Process for filing IPR	**2**
7.	**Different Forms of IPRs:**Patents, Copyright, Trademarks, Industrial Designs and Geographic Indicator	**2**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Developand manage new project/Start-up.
2.	Apply managerial skills for success of entrepreneurial/business venture.
3.	Make effective use of IPR practicesin their ventures.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	"Management Principles and Practice", Srinivasan R. and Chunawalla S.A., Himalaya Publishing House.	**2017**
2.	"Introduction to Management", Schermerhorn John R. Jr. And Bachrach Daniel G., 13th Edition, Wiley Publications	**2016**
3.	"Principles & Practice of Management", Prasad L.M., 8th Edition, Sultan Chand & Sons.	**2015**
4.	"The New Era of Management", Daft R.L., 11th Edition, Pubs: Cengage Learning.	**2014**
5.	"Case Studies in Management", Pandey Chandra Akhilesh, 2nd Edition, I.K. International Publishing House Pvt. Ltd.	**2015**
6.	"Harvard Business Review: Manager's Handbook", Harvard Business School Press.	**2018**
7.	"Entrepreneurship", Trehan Alpana, Dreamtech Press.	**2016**
8.	"Entrepreneurship and Small Business" Schaper Michael, Volery Thierry, Weber Paull and Lewis Kate, 3rd Asia-Pacific Edition, Wiley Publications	**2018**
9.	"Harvard Business Review: Entrepreneur's Handbook", 1st Edition, Harvard Business Review Press	**2018**
10.	"Take Me Home", Bansal Rashmi, 1st Edition, Westland.	**2014**
11.	"Intellectual Property Law", Narayanan P., 3rd Edition, Eastern Law House	**2017**
12.	"Intellectual Property Rights", Pandey Neeraj and Dharni Khushdeep, PHI Learning	**2014**
13.	"Intellectual Property Rights", Rosedar S.R.A., LexisNexis (Quick Reference Guide – Q&A Series)	**2016**
14.	MSME Annual Publications (www.msme.gov.in)	**Annual**
15.	WIPO Annual Publications (www.wipo.int)	**Annual**

MOOCs on this course are available at:

1) "Entrepreneurship: Do Your Venture", Available at edx (Offered by IIM Bangalore), Self-Paced (6 weeks).
   https://www.edx.org/course/entrepreneurship-do-your-venture
2) "Becoming an Entrepreneur", Available at edx (Offered by MIT), Self-Paced (6 weeks).
   https://www.edx.org/course/becoming-entrepreneur-mitx-launch-x-4
3) "How to Build a Start-up", Available at Udacity, Self-Paced (One Month).
   https://in.udacity.com/course/how-to-build-a-startup--ep245
4) "Intellectual Property Rights: A Management Perspective, Available at edx (Offered by IIM Bangalore), Starts on 1 August 2018 (6 weeks).
   https://www.edx.org/intellectual-property-rights-a-management-perspective

Course Name	**:**	**Professional Ethics**
Course Code	**:**	
Credits	**:**	**0.5**
L T P	**:**	**0-1-0**
Segment	**:**	**6-6**

Total No. Tutorials -7

Course Objectives:

	The main objectives of this course are:
1.	To imbibe ethical values and understanding.
2.	To develop moral thinking that will help students to recognize their potential.
3.	To engage and motivate the students to perform ethically in their professional life.

Course Contents:

Sr.No	Course contents	No. of Tutorials
1.	**Introduction to Ethics:** Concept of Ethics – Nature, Scope, Sources, Types, Functions and Factors influencing Ethics, Ethics in Engineering	**2**
2.	**Ethics in Profession:** Concepts of Honesty, Integrity, Reliability, Risk, Safety and Liability, Responsibilities and Rights of Professionals, Professional accountability.	**2**
3.	**Ethics and Business:** Concept of Business Ethics – Nature and Objectives, Ethical dilemmas in business ethics.	**1**
4.	**Self-Development:** Concept of Self-Assessment – SWOT Analysis, Self-Concepts, Self-Confidence, Self-Esteem, Managing Time and Stress, Human values.	**2**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Demonstrate knowledge and better understanding of self and to manage time and stress effectively.
2.	Have subjective well-being.
3.	Have ethical decision making ability in their personal and professional life.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	"Professional Ethics", Subramaniam R., 2nd Edition, Oxford University Press.	**2017**
2.	"Introduction to Psychology", Kalat James W., 11th Edition, Cengage Learning.	**2017**

3.	"Business Ethics – Text and Cases", Murthy C.S.V., 1st Edition, Himalaya Publishing House.	**2014**
4.	"A Foundation Course in Human Values and Professional Ethics", Gaur R.R., Sangal R. and Bagaria G.P., Excel Books.	**2010**
5.	"Issues and Ethics in the Helping Professions", Corey G., Corey M.S. and Callanan P., 8th Edition, Brooks/Cole, Cengage Learning.	**2010**
6.	"The Curse of Self: Self-awareness, Egotism and the Quality of Human Life", Leary M.R., 1st Edition, Oxford University Press.	**2007**
7.	"Business Ethics", Hartman L.P. and Chatterjee A., 3rd Edition, Tata McGraw Hill.	**2006**
8.	"Business Ethics and Professional Values", Rao A.B., Excel Books.	**2006**
9.	"Business Ethics – Concepts and Cases", Velasquez M.G., 5th Edition, Prentice Hall.	**2001**
10.	"Theories of Personality", Hall C.S., Lindzey D. and Cambell J.B., 4th Edition, Hamilton Printing Company.	**1997**

MOOCs on this course are available at:

1) "Ethics in Engineering Practice". Available at SWAYAM(Offered by IIT Kharagpur), 8 weeks, Starts on August 27, 2018. https://swayam.gov.in/courses/4799-july-2018-ethics-in-engineering-practice
2) "Ethics, Technology and Engineering". Available at Coursera (Offered by EindhovenUniversity of Technology), 8 weeks, Starts on July 16, 2018.

   https://www.coursera.org/learn/ethics-technology-engineering

Program Core III

Course Name	**:**	**Power Electronics Controlled Electric Drives**
Course Code	**:**	
Credits	**:**	**3**
L T P	**:**	**2-0-2**
Segment	**:**	**1-6**

Total No. Lectures - 28
Total No. of Lab hours – 28

Course Objective:

	The main objectives of this course are:
1.	Develop ability to model AC and DC machine in generalized framework
2.	To use it to control the machine using power electronic converter

Course Contents:

Sr.No	Course Contents	No. of Lectures
1.	**Modeling of DC machine** Kron's Primitive Machine Model (Two Axis Model), statically induced EMF, Rotational or Dynamically Induced EMF, Generalized Torque Expression of Kron's Primitive machine. Mathematical model of DC machine (shunt, series, separately excited), steady state characteristics with armature and field control, dynamic behavior with constant flux.	**8**
2.	**Power Electronics Controlled DC Drives** Static convertor as power actuator for DC drives: single and three phase drives, control loop containing power electronics converters. Control of converter supplied DC drives	**6**
3.	**Modeling of Induction Machine** Modeling of three phase Symmetrical Induction Machines (IM) in abc variables, Co-Energy and Torque Expression. d-q (Transformation) Modeling of symmetrical 3 phase Induction Machine, Rotor Transformation, Torque expression in d-q Frame. Equivalent Circuit. Reference Frame Theory, Power Invariant and Amplitude Invariant Transformation, Stanley Reference Frame, Park Reference Frame, Synchronous Reference Frame and arbitrary Reference Frame. Induction Machine Modeling in Arbitrary Reference Frame.	**8**
4.	**Vector Control of Induction Machine** Vector Control of Induction Machine: Concept of Space Phasor, Principle of Decoupled Control, Rotor Flux Oriented Vector Control, Stator Flux Oriented Vector Control, Magnetizing Flux Oriented Vector Control. Torque Response. Flux Estimation Schemes.	**6**

Lab Work:

Sr.No	Lab contents	No. of Hours
1.	To obtain the speed control of DC machine using three phase full wave fully controlled thyristorized converter using cosine wave triggering method in open loop and analyze the dynamic performance of the drive under torque and speed reference change.	**5**
2.	To obtain the speed control of DC machine using three phase full wave fully controlled thyristorized converter using cosine wave triggering method in closed loop and analyze the dynamic performance of the drive under torque and speed reference change.	**6**
3.	To obtain speed control of induction motor using rotor flux oriented vector control and analyze its dynamic performance.	**6**
4.	To obtain speed control of induction motor using airgap flux oriented vector control and analyze its dynamic performance.	**6**
5.	To obtain speed control of induction motor using stator flux oriented vector control and analyse its dynamic performance.	**5**

Course Outcome:

	At the completion of this course, students will be able to:
1.	Applyconcepts to model AC and DC machine in generalized framework
2.	Utilize the concepts to control the machine using power electronic converter

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/Reprint
1.	W. Leonhard, *Control of Electrical Drives*, Springer.	**2001**
2.	R. Krishnan. *Electric Motor Drives: Modeling, Analysis, And Control*. Prentice Hall.	**2001**
3.	T.M. Undeland and W.P.Robbins, *Power Electronics: Converters applications and design by N Mohan*, John Wiley and Sons.	**2006**
4.	P. Wach, *Dynamics and Control of Electrical Drives*, Springer.	**2011**
5.	N. Mohan, *First Course On Power Electronics and Drives*", MNPERE.	**2011**

Classical Books:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/Reprint
1.	P C Sen, "Thyristor DC Drives", Wiley-Interscience Publication.	**1981**
2.	P. Vas, *Vector Control of AC Machines*, Clarendon Press Oxford.	**1990**

MOOCs on this course are available at:

1. Prof S.P Das, *Advanced Electric Drives NPTEL Lectures*, IIT Kanpur.
2. Dr. R. Erickson, *Introduction to Power Electronics*, University of Colorado, Coursera

Program Core IV

Course Name	**:**	**Control Techniques In Power Electronics**
Course Code	**:**	
Credits	**:**	**3**
L T P	**:**	**3-0-0**
Segment	**:**	**1-6**

Total No. Lectures:-42

Course Objectives:

	The main objectives of this course are:
1.	Development of the working of different switching devices with respect to their characteristics

Course Contents:

Sr.No	Course Contents	No. of Lectures
1.	**Modeling of DC-to-DC Power Converters** State space modeling and simulation of linear systems, Discrete time models, conventional controllers using small signal models	**8**
2.	**Control Design Method of Power Converters** Sliding Mode & Fuzzy control, Variable structure control, Hysteresis controllers, Output and state Feedback switching controllers	**10**
3.	**Linearized Model and Control of Power Converters** Linear Feedback Control, Controller Design by Pole Placement, Proportional-Derivative Control via State Feedback, State Feedback Control via Observer Design, GPI Controller Design	**12**
4.	**Nonlinear Methods in the Control of Power Electronics Devices** Feedback Linearization, Passivity Based Control, Exact Error Dynamics Passive Output Feedback Control, Non-linear observers for power converters.	**12**

Course Outcomes:

	At the completion of this course, students will be able to:
1.	The students in this course can apply concepts to model power converters using different control techniques and their linear and nonlinear control.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/Reprint
1.	R.W.Erickson and D. Maksimovic, *Fundamentals of Power Electronics*", KLUWER Academic Publishers.	**2004**
2.	S.R. Hebertt andR.S. Ortigoza *Control Design Techniques in Power Electronics Devices*, Springer.	**2006**

Program Elective III – E3

Course Name	**:**	**Smart Grid Technologies**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segment	**:**	**1-3**

Total No. Lectures - 21

Course Objectives:

	The main objectives of this course are:
1.	Develop understand the fundamentals of smart grid technologies such as smart measurements.
2.	Understanding the smart technology for smart substations, micro grid and distributed energy sources,
3.	Importance of power quality management in smart grid, information and communication technology for smart grid

Course Contents:

Sr.No	Course Contents	No. of Lectures
1.	**Introduction to Smart Grid:** Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference betw. conventional & smart grid, Concept of Resilient & Self-Healing Grid, Present development & International policies in Smart Grid. Case study of Smart Grid. CDM opportunities in Smart Grid.	**4**
2.	**Smart Grid Technologies:** Part 1:Introduction to Smart Meters, Real Time Pricing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid.	**4**
3.	**Smart Grid Technologies**: Part 2: Smart Substations, Substation Automation, Feeder Automation. Geographic Information System(GIS), Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU).	**4**
4.	**Micro grids and Distributed Energy Resources**: Concept of micro grid, need & applications of micro-grid, formation of micro grid, Issues of Inter-connection, protection & control of micro grid. Plastic & Organic solar cells, Thin film solar cells, Variable speed wind generators, fuel cells, micro turbines, Captive power plants, Integration of renewable energy sources, power quality issues in renewable energy integration.	**5**
5.	**Information and Communication Technology for Smart Grid:** Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN). Bluetooth, Zig-Bee, GPS, Wi-Fi, Wi-Max based communication,	**4**

	Wireless Mesh Network, Basics of CLOUD Computing & Cyber Security for Smart Grid.	

Course Outcomes:

	At the completion of this course, students will be able to:
1.	Use smart measurements of smart grid technologies.
2.	Characterize the smart technology for smart substations, micro grid and distributed energy sources,
3.	Apply power quality management in smart grid, information and communication technology for smart grid

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/Reprint
1.	C.W. Gellings, *The Smart Grid: Enabling Energy Efficiency and Demand Response*,CRC Press	**2000**
2.	J. Ekanayake, N. Jenkins, K. Liyanage, W. Jianzhong andA. Yokoyama, *Smart Grid: Technology and Applications*, Wiley	**2012**
3.	A. Keyhani, M.N. Marwali, M. and Dai, *Integration of Gr. and Renewable Energy in Electric Power Systems*, Wiley	**2001**
4.	P. S. Fox-Penner, *Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities*, Island Press	**2011**
5.	T. Flick and J. Morehouse, *Securing the Smart Grid*, Elsevier Inc.	**2000**

Classical Books:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/Reprint
1.	J.C. Sabonnadière, N. Hadjsaïd, "Smart Grids", Wiley Blackwell	**1996**
2.	A. Yokoyama, *Smart Grid: Technology and Applications*, Wiley	**1994**

MOOCs on this course are available at:

1. Dr. M. Vadari and M. Balasubramanyan, *Smart Grids: Electricity for the Future*, IEEE & EDX
2. P.S. Prat, *Smart Grids for Smart Cities: Towards Zero Emissions*, FutureLearn, InnoEbergy, *homuork*
3. M. Vadari, M. Balasubramanyan, *Distributed Energy – Smart Grid Resources for the Future*, IEEE, Coursera

Course Name	**:**	**Advanced Electric Drives**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**
Segment	**:**	**1-3**

Total No. Lectures - 14
Total No. of Lab hours – 14

Course Objectives:

	The main objectives of this course are:
1.	The understanding of advanced electric drives, machine modeling, vector and direct torque control
2.	Knowledge on permanent magnet machines and their control,
3.	Understanding of the concept of special motor and their control for electric drives.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1.	**Advanced control of AC Machines** DTC of Induction Motor: Introduction, Space Vector PWM of Induction Machine. Modeling of Synchronous Motor in two axis framework. Vector Control of Synchronous Motor Drive, Dynamics of Vector Control in Synchronous Motor Drive, Equivalent Circuit, Torque Production.	**4**
2.	**Permanent Magnet Machines and Control** Permanent Magnet Motors: Permanent Magnet Materials, Principles of Permanent Magnet Synchronous Motor and Brushless DC Motors. Dynamic Modeling of BLDC Motors, Control of Brushless DC Motor. Dynamic Modeling of PMSM, Vector Control of PMSM in Park Reference Frame.	**6**
3.	**Special Motors and their Control** Switched Reluctance Motor (SRM): Principle of Operation, Torque Production, Modes of Operation, Closed Loop Speed Control of SRM. Stepper Motors: Principle of Operation and Types, Torque Production, Converters for Stepper Motors, Control of Stepper Motors.	**4**

Lab Work:

Sr.No	Lab contents	No. of Hours
1.	To Obtain the performance DTC Induction Motor Drive.	**2**
2.	To Obtain the performance of Vector Controlled Synchronous Motor Drive.	**2**
3.	To Obtain the performance of Vector Controlled PMSM Drive.	**2**
4.	To Obtain the performance of Vector Controlled PMBLDC Motor Drive.	**2**
5.	To Obtain the performance of switched reluctance and stepper motor drive systems	**2**

Course Outcomes:

	At the completion of this course, students will be able to:
1.	Understand the fundamentals advanced electric drives, machine modeling, vector and direct torque control
2.	Utilize the knowledge acquired on permanent magnet machines and their control.
3.	Control various types of electric drives.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/Reprint
1.	P.C. Krause, O. Wasynezuk, D.S. Scott,*Analysis Of Electric Machinery And Drive Systems*, WILEY	**2013**
2.	Werner Leonhard, *Control of Electric Drives*, Springer.	**2000**
3.	R. Krishnan, *Switched Reluctance Motor Drives*, CRC Press 2001.	**2001**
4.	R. Krishnan. *Electric Motor Drives: Modeling, Analysis, And Control*. Prentice Hall.	**2001**

Classical Books:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/Reprint
1.	P. Vas, *Vector Control of AC Machines*, Clarendon Press Oxford	**1990**
2.	Peter Vas, *Sensor less Vector and Direct Torque Control*, Oxford University Press.	**1998**

MOOCs on this course are available at:

1. Prof S.P Das, *Advanced Electric Drives NPTEL Lectures*, IIT Kanpur.

Course Name	**:**	**Advanced DC/AC Converters**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segment	**:**	**1-3**

Total No. Lectures - 21

Course Objective:

	The main objectives of this course are:
1.	To learn the concepts of Advanced DC-AC controllers

Course Contents:

Sr.No	Course Contents	No. of Lectures
1.	**Impedance Source Inverters** Comparison with VSI and CSI, Equivalent circuit and operation. Quasi impedance source inverters and their topologies.	**7**
2.	**Advanced Multilevel Inverters** Trinary Hybrid Multilevel Inverter (THMI), Laddered Multilevel DC/AC Inverters Used in Solar Panel, Super-Lift Converter Multilevel DC/AC Inverters, Switched Capacitor and Switched Inductor Multilevel Inverters	**14**

Course Outcome:

	At the completion of this course, students will be able to:
1.	Design advanced DC-AC controllers

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/Reprint
1.	F.L. Luo & H. Ye *Advanced DC/AC Inverters*, CRC Press.	**2000**
2.	IEEE papers on impedance source inverters	
3.	IEEE papers on new multilevel inverters.	

Program Elective IV – E4

Course Name	**:**	**Advanced DC/DC Converters**
Course Code	**:**	**.**
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segment	**:**	**4-6**

Total No. Lectures - 21

Course Objective:

	The main objectives of this course are:
1.	To learn the concepts of Advanced DC-DC controllers

Course Contents:

Sr.No	Course Contents	No. of Lectures
1.	**Introduction** Pump Circuits: Fundamental pumps, Developed Pumps, Transformer type Pumps, Superlift Pumps. Introduction to 1^{st},2^{nd},3^{rd},4^{th},5^{th} and sixth generation DC-DC Converters	**7**
2.	**Advanced Converters** Voltage Lift Converters, Positive and Negative Output Super Lift Converters, Positive and Negative Output Cascade Boost Converters.	**14**

Course Outcome:

	At the completion of this course, students will be able to:
1.	Design advanced DC-DC controllers

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/Reprint
1.	F.L. Luo & H. Ye*Advanced DC/DC Inverters*, CRC Press.	**2000**
2.	IEEE papers on advanced DC-DC converters.	

Course Name	**:**	**Advanced Control In Power Electronics & Drives**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segment	**:**	**4-6**

Total No. Lectures - 21

Course Objective:

	The main objectives of this course are:
1.	To learn the concepts of concepts of advanced controllers for Power Electronics and Electric Drive Systems

Course Contents:

Sr.No	Course Contents	No. of Lectures
1.	**Predictive Control of Power Converters and Drives** Basic concepts, theory and methods of Predictive Control. Application of predictive control in AC-DC-AC Convertor System.	**10**
2.	**Neuro and Nonlinear Control of Power Converters and Drives** Adaptive Neuro controllers for Drive Systems: Basic Concepts, Theory and Applications.Advanced Control and Optimization Techniques in AC Drives and DC/AC Sine Wave Voltage Inverters: Selected Problems	**11**

Course Outcome:

	At the completion of this course, students will be able to:
1.	Apply concepts of Advanced controllers for Power Electronics and Electric Drive Systems

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/Reprint
1.	T.O. Kowalska, F. Blaabjerg and J. Rodríguez *Advanced and Intelligent Control in Power Electronics and Drives*. Springer Publications.	**2003**
2.	Research papers on MPC controllers for power electronics convertors	

Control Systems

Semester I

Soft Computing

Course Name	**:**	**Internet of Things**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**1-3**

Total no. of lectures: 14
Total no. of Lab hrs. : 14

Course Objectives:

The main objectives of this course are:	
1.	Understand core technology, applications, sensors used and IOT architecture along with the industry perspective.
2.	Principles and operations of different types of sensors commonly used on mobile platform will be taught in a manner that by the end of the course the students will be able to design and implement real time solutions using IOT.

Course Contents:

S.No.	**Course Contents**	**No. of Lectures**
1	**Introduction to IoT** What is IoT, how does it work? Difference between Embedded device and IoT device, Properties of IoT device, IoT Ecosystem, IoT Decision Framework, IoT Solution Architecture Models, Major IoT Boards in Market	**2**
2	**Setting Up Raspberry/Arduino to Create Solutions** Explore Raspberry Pi, Setting up Raspberry Pi, Showing working of Raspberry Pi using SSH Client and Team Viewer, Understand Sensing actions, Understand Actuators and MEMS	**3**
3	**Communication Protocols used in IoT** Types of wireless communication, MajorwirelessShort-rangecommunicationdevices,properties,comparisonofthesedevices (Bluetooth, WIFI, ZigBee, 6LoWPAN), Major wireless Long-range communication devices, properties, comparison of these devices (Cellular IoT,LPWAN)	**3**
4	**IoT Applications** Industrial Internet 4.0, Applications such as: Smart home, wearables, smart city, smart grid, , connected car, connected health(digital health, telehealth, telemedicine), smart retail	**3**
5	**Sensors:** Applications of various sensors: Google Maps, Waze, Whats App, Ola Positioningsensors: encoders and accelerometers, Image sensors: cameras, Global positioning sensors: GPS, GLONASS, IRNSS, Galileo and indoor localization systems, Motion&OrientationSensors:Accelerometer,Magnetometer,ProximitySensor, GyroscopeCalibration,noise modeling and characterization and-noisefiltering and sensor data processing. Privacy &Security	**3**

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Design and build systems that will use sensors, communication protocol and actuators.	14

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Understand concept of IOT and ability to implement in real time scenarios
2.	Design solutions based on IOT architecture and applications in various fields
3.	Critically analyze security and privacy issues in IOT
4.	Apply knowledge to Design and develop variousapplicationsofsensorsinIndustrial,healthcare,commercial,andbuildingautomation

Bibliography:

S.No.	Book Detail	Year of Publishing
1	Vijay Madisetti and ArshdeepBahga, Internet of Things (AHands-on Approach), 1st Edition, VPT	2014
2	Francis daCosta, Rethinking the Internet of Things: A ScalableApproach to Connecting Everything, 1stEdition, Apress Publications	2013
3	CunoPfister, Getting Started with the Internet of Things, OReillyMedia	2011
4	Kyung, C.-M., Yasuura, H., Liu, Y., Lin, Y.-L., Smart Sensorsand Systems, Springer International Publishing	2015

MOOCs on this course are available at:

1) Introduction to Internet of Things - https://www.edx.org/course/introduction-to-the-internet-of-things-iot
2) IoT Programming and Big Data -https://www.edx.org/course/iot-programming-big-data-curtinx-iot4x

Course Name	**:**	**Machine Learning**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2 0 2**
Segment	**:**	**4-6**

Total no. of lectures: 14
Total no. of lab hrs: 14

Course Objectives:

	The main objectives of this course are:
1.	To formulate machine learning problems corresponding to different applications.
2.	To understand a range of machine learning algorithms along with their strengths and weaknesses.
3.	To develop reasoning behind Model selection, model complexity, etc.

Course Contents:

S.No.	Course Contents	No. of Lectures
1	**BASICS OF MACHINE LEARNING:** Applications of Machine Learning, processes involved in Machine Learning, Introduction to Machine Learning Techniques: Supervised Learning,Unsupervised LearningandReinforcementLearning,ReallifeexamplesofMachineLearning.	**3**
2	**SUPERVISED LEARNING:** Classification and Regression: K-Nearest Neighbour, Linear Regression,Logistic Regression, Support Vector Machine (SVM), Evaluation Measures: SSE, MME, R2,confusionmatrix,precision,recall,F-Score,ROC-Curve.	**6**
3	**UNSUPERVISED LEARNING:** Introductiontoclustering,TypesofClustering:Hierarchical-AgglomerativeClustering and Divisive clustering; Partitional Clustering - K-means clustering, Principal Component Analysis,ICA.	**5**

Lab Work:

S.No.	Lab Contents	No. of hours
1	Python Introduction: Loops and Conditions and other preliminarystuff, Functions, Classes and Modules, Exceptions, Database access, Mathematical computing with Python packages like: numpy, Mat- plotLib,pandas Tensor Flow, Keras	**8**
2	Application Oriented Project Work	**6**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Design and implement machine learning solutions to classification, regression and clustering problems
2.	Evaluate and interpret the results of the different ML techniques
3.	Design and implement various machine learning algorithms in a range ofReal-world applications.
4.	Use Python for various applications.

Bibliography:

S.No.	Book Detail	Year of Publishing
1.	Tom Mitchell, Machine Learning, McGraw Hill,	2017
2.	Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer,	2011.
3.	T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e,	2008.
4.	Yuxi (Hayden) Liu, "Python Machine Learning By Example", Packet Publishing Limited	2017

MOOCs on this course are available at:

1) Data Science: Machine Learning -https://www.edx.org/course/data-science-machine-learning
2) Machine Learning - https://www.coursera.org/learn/machine-learning

Design of Experiments and Research Methodology

Course Name	**:**	**Design of Experiments and Research Methodologies**
Course Code	**:**	
Credits	**:**	**3**
L T P	**:**	**2 0 2**
Segment	**:**	**1-6**

Total No. Lectures: 28

Total No. of Lab hrs. 28

Course Objectives:

The students should be able to develop an understanding of how to identify research topics, formulate research questions / hypotheses, select an appropriate research and, where applicable, experimental design. Provides a basis so the student can effectively develop a research proposal for either a capstone project, master's thesis, research project, or designed experiment.

Course Contents:

Sr. No.	Course contents	No. of Lectures
1.	**Introduction**: Types of Research and Their Purposes, Locating, Analysing, stating and evaluating research problem, need for literature review, steps in conducting literature review, Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis, research questions and hypothesis, types of hypothesis, evaluation of hypothesis.	**3**
2.	**Research Design and Sampling Design:** Concept of research design, features of a good research design, concept of population and sample, characteristics of sample design, types of sampling techniques	**2**
3.	**Methods of data collection and measurement:** Primary data and Secondary data, data collection techniques: observation, interview, questionnaires, schedules, case-study, levels of measurement, problems in measurement in research – validity, reliability.	**3**
4.	**Statistical Methods of Analysis:** Descriptive statistics: mean, median, mode, range, mean deviation and standard deviation, regression and correlation analysis, inferential statistics: t-tests, Chi-square tests. Correlation (rank difference and product moment), Analysis of variance (ANOVA) (one way)	**4**
5.	**Procedure for writing a research report and manuscript:** Types of research reports, steps of writing a report, layout of report, layout of research paper, ethical issues related to publishing, Plagiarism and Self-Plagiarism.	**2**

Lab Work:

Sr. No.	Lab contents	No. of Hours
1.	Select a problem from your area of interest, identifying the type of research problem it is and perform the SWOT analysis of the existing literature.	4
2.	Generate research questions and hypotheses for a problem from your area of interest.	4
3.	Identify the population and sample for the study (highlighting the technique used for sample selection) for a problem from your area of	4

	interest.	
4.	Design a questionnaire for the problem of interest.	4
5.	Utilizing software such as Statistical Package for the Social Sciences(SPSS), Mini Tab, etc. for the statistical analysis of the results obtained for the desired questionnaire.	6
6.	Preparing a research paper for the problem of interest	6

Course Outcomes:

At the end of the course, students will be able to:	
1.	Develope an understanding of how to identify research topics, formulate research questions and corresponding hypotheses, select an appropriate research and where applicable, experimental design.
2.	Perform required statistical analyses for any univariate application in a business / industrial setting, regardless of data form, and will be familiar with major indices for measuring correlation and association.
3.	Further, the underlying assumptions related to each statistical test and its interpretation will be thoroughly reviewed.

Bibliography:

Sr. No.	Book Detail	Year of Publication
1.	Probability and Statistics for Engineers and scientists by Anthony J. Hayter, Cencage Learning, 4th Edition	2016
2.	Probability and Statistics for Engineers and scientists by Walpole, Myers, Myers and Ye, 8th ed Pearson Education	2007
3.	Research Methodology - Methods and Techniques, C. K. Kothari, New Age International, 2nd Edition	2004
4.	English for writing research papers by Adrian Wallwork, 2nd Edition. Springer	2016
5.	Statistics: Concepts and Controversies by David S. Moore, William I. Notz, W. H. Freeman	2016

Available MOOCS:

1. https://www.coursera.org/learn/research-methods

2. https://www.lawctopus.com/certificate-course-on-research-methodology-online/

Program Core I

Course Name	**:**	**Modern Control Systems**
Course Code	**:**	
Credits	**:**	**3**
L T P	**:**	**2-0-2**
Segment	**:**	**1-6**

Total No. of Lectures – 28
Total No. of Lab hours – 28

Course Objectives:

	The main objectives of this course are:
3.	To learn the modeling concepts of system, modelling using state space.
4.	Tolearn and implement the optimal control techniques.
5.	To design the digital control system and nonlinear systems.

Course Contents:

Sr No.	Course Contents	No. of Lectures
1	**Introduction:** Control systems design requirements, classical versus modern approaches of design	**2**
2	**State Space Representation:** Concepts related to state space , state space representation, state transition matrix, solution of linear time invariant and linear time varying state equations, canonical forms	**3**
3	**Control System Design in State Space:** Controllability, pole placement design using full state feedback-regulator and tracking systems, observers, observability and compensators, full order and reduced order observers	**6**
4	**Linear Optimal Control :** Optimal control problem, infinite time linear optimal regulator design, optimal control of tracking systems (Riccati equation based designs).	**6**
5	**Digital Control Systems:** Basic concepts, z-transform, stability, performance, state space modeling and solution of linear digital equations, design using pole placement,: regulators and observers and compensators, linear optimal control of digital systems.	**7**
6	**Nonlinear Control Systems:** Sources of nonlinearities and characteristics of nonlinear systems, describing function method, phase plane analysis, Lyapunov stability theory.	**4**

Lab Work:

Sr. No.	Lab Contents	Lab Hours
1	State space modeling of continuous time system and study of stability and state and output responses	**02**
2	Pole placement design using state feedback for regulator and tracking systems	**02**

3	Full and reduced order observer design	**02**
4	State space modeling of discrete time system and study of responses	**02**
5	Pole placement design for regulator and tracking discrete time systems	**02**
6	Observer design for discrete time systems	**02**
7	Describing function analysis of nonlinear systems	**02**
8	Phase plane analysis of nonlinear systems	**02**
9	Project 1	**04**
10	Project 2	**04**
11	Project 3	**04**

Course Outcomes:

By the end of this course, the student will be:	
1	able to apply the modeling concepts of system modeling using state space and understand the design issues in the framework of modern control.
2	conversant with the optimal control techniques.
3	conversant with the concepts of digital control system and non-linear systems.

Bibliography:

Sr.No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	A.Tewari, *Modern Control Design with MATLAB and Simulink*. JohnWiley and Sons Ltd.	**2002**
2	K. Ogata, *Modern Control Engineering*.PHI.	**2014**
3	M. Gopal, *Modern Control System Theory*. New Age International (P) Ltd.	**2005**
4	M.Gopal, *Digital Control and State Variable Methods*. TMH.	**2003**
5	W. L. Brogan, *Modern Control Theory*. Pearson Education India.	**2011**

MOOCs on this course are available at:

1) Lecture Series On Control Engineering, Prof. Sd Agashe, IIT Bombay: nptel.iitm.ac.in.

2) **2)**Introduction to Control System Design - A First Look, Jacob White, Joe Steinmeyer, MIT,

https://www.edx.org/course/introduction-control-system-design-first-mitx-6-302-0x

3) Non-linear systems, Slotine, MIT, http://web.mit.edu/nsl/www/videos/lectures.html

Program Core II

Course Name	**:**	**Linear Optimal Control**
Course Code	**:**	
Credits	**:**	**3**
L T P	**:**	**2-0-2**
Segment	**:**	**1-6**

Total No. Lectures - 28
Total No. of Lab hours – 28

Course Objectives:

	The main objectives of this course are:
1.	To learn theoretically as well as practically the concepts of state-space fundamentals.
2.	To design the linear state feedback control laws, observer and observer based controllers.
3.	To learn the optimal control: general mathematical procedures, optimal feedback control.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1	**Introduction:** Optimal control issues and frame work.	**3**
2	**State Feedback Control :**State feedback for regulation and tracking, observer based compensators and separation property, steady state tracking with observer based compensators.	**4**
3	**Optimal Control: General mathematical procedures:** Formulation of optimal control problem, calculus of variation, minimum principle, dynamic programming.	**8**
4	**Optimal Feedback Control:** Linear state regulator, continuous time linear state regulator, use of linear regulator to solve other linear optimal control problems, Suboptimal Linear regulators, Minimum time control of LTI systems.	**6**
5	**Stochastic Optimal Linear Estimation and Control:** Stochastic processes and linear systems, optimal estimation for linear continuous & discrete time systems, stochastic optimal linear regulator.	**7**

Lab Work:

Sr.No	Lab contents	No. of Hours
1	MATLAB/Simulink based simulations for state feedback design	**04**
2	Optimal control design for deterministic systems.	**04**
3	Optimal control design for stochastic systems.	**04**
4	Optimal Estimator for linear systems.	**04**
5	Project 1	**04**
6	Project 2	**04**
7	Project 3	**04**

Course Outcomes:

By the end of this course, the student will be able to:	
1	Apply practically the concepts of state-space fundamentals.
2	Design the linear state feedback control laws, observer and observer based controllers.
3	Implement optimal control concepts: general mathematical procedures, optimal feedback control.

Bibliography:

Sr.No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	R.L. Williams II, andD.A. Lawrence, *Linear State-Space Control Systems*. John Wiley & Sons.	**2007**
2	M.Gopal, *Modern Control System Theory*. New Age International (P) Limited.	**2015**
3	K.J.Astrom, *Introduction Stochastic Control Theory*. Academic Press.	**2006**

Classical Books:

Sr.No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	R.E. Bellman, *Dynamic Programming*. Princeton University Press.	**1957**
2	B.D.O. Anderson, and J.B. Moore, *Linear Optimal Control*. Prentice Hall.	**1990**

MOOCs on this course are available at:

1) Optimal Control , Dr. Barjeev Tyagi, IIT Roorkee, https://onlinecourses.nptel.ac.in/noc17_ee11/preview

2) Optimal Control, MIT Open course ware, https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-323-principles-of-optimal-control-spring-2008/lecture-notes/

3) Introduction to Stochastic Optimal Control, MIT Open course ware, https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-832-underactuated-robotics-spring-2009/video-lectures/lecture-16-introducing-stochastic-optimal-control/

Program Elective I – E1

Course Name	**:**	**Neural Network Based Control**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**
Segment	**:**	**1-3**

Total No. Lectures - 14
Total No. of Lab hours – 14

Course Objectives:

	The main objectives of this course are:
1.	To learn the basic conceptsof ANN.
2.	To design the ANN models.
3.	To apply ANN for control applications.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1	**Introduction:** Overview of neural networks and training approaches; relevance of neural networks modeling and control.	**3**
2	**Neural network models:** feedforward networks (multilayered networks and radial basis function networks), recurrent networks (Hopfield networks, memory neuron networks and dynamic neural networks), CMAC, self organizing map.	**4**
3	**Neural network architecture:** Indirect and direct adaptive control, model reference control, interval model based control, predictive control, adaptive critic based control.	**3**
4	**Case studies of NN based control:** Engineering applications of backpropagation and radial basis feed-forward networks based control.	**4**

Lab Work:

Sr.No	Lab contents	No. of Hours
1	MATLAB/Simulink based simulations for ANN-1	**02**
2	MATLAB/Simulink based simulations for ANN-2	**02**
3	MATLAB/Simulink based simulations for ANN-3	**02**
4	NN based control-1	**02**
5	NN based control-2	**02**
6	Project 1	**02**
7	Project 2	**02**

Course Outcomes:

By the end of this course, the student will be able to:	
1	Understand the ANN models.
2	Apply the basic conceptsof ANN and their models in control applications.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	S. Bassis, A. Esposito, F.C. Morabito, Ed.,*Advances In Neural Networks: Computational And Theoretical Issues*. Springer.	**2015**
2	N. Siddique, *Intelligent Control: A Hybrid Approach Based On Fuzzy Logic, Neural Networks And Genetic Algorithms*. Springer.	**2013**
3	L. Belera, and I. Kar,*Intelligent Systems And Control: Principles And Applications.*Oxford University Press.	**2009**
4	M. Norgaard, O. Ravn, N.K. Poulsen, andL.K. Hansen,*Neural Networks For Modelling And Control Of Dynamic Systems: A Practitioner's Handbook.* Advanced textbooks in control and signal processing. Springer.	**2000**

Classical Books:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	S. Haykin, *Neural Networks – A Comprehensive Foundation*. Macmillan Publishing Co., New York.	**1994**
2	J.M.Jurada,*Introduction To Artificial Neural Networks*. Jaico Publishers Mumbai.	**1997**
3	Z.X. Cai, *Intelligent Control: Principles, Techniques And Applications*. World Scientific Publishing Company.	**1998**
4	S.V. KartaloPoulos, *Understanding Neural Networks and Fuzzy logic*. PHI.	**1996**

MOOC on this course are available at:

1) Neural Networks for Machine Learning, Geoffrey Hinton: https://www.coursera.org/learn/neural-networks

2) Neural Networks and Applications, Prof. S. Sengupta, IIT Kharagpur, **http://nptel.ac.in/courses/117105084/**

3) Neural networks [1.1] : Feedforward neural network - artificial neuron, https://www.youtube.com/watch?v=SGZ6BttHMPw

Course Name	**:**	**Introduction to Adaptive Control**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**
Segment	**:**	**1-3**

Total No. Lectures – 14
Total No. of Lab hours – 14

Course Objectives:

	The main objectives of this course are:
1.	To learn the real time parameter estimation.
2.	To design the deterministic self tuning regulators and model reference adaptive system.
3.	To apply these concepts practically.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1	**Introduction:** Effects of process variations, Adaptive schemes, adaptive control problems, applications.	**2**
2	**Parameter estimation:** Least squares and regression models estimating parameters, simulation of recursive estimation.	**3**
3	**Deterministic self tuning regulators:** Pole placement design, indirect self tuning regulators, continuous time self tuners, direct self tuning regulators, disturbances with known characteristics.	**4**
4	**Model Reference Adaptive Systems:** MIT Ruler determination of adaptive gain, Lyapnov theory, Design of MRAS using Lyapnov theory, applications to adaptive control, Output feedback relation betw. MRAS and STR.	**5**

Lab Work:

Sr.No	Lab contents	No. of Hours
1	MATLAB/Simulink based simulations for MRAC	**2**
2	Implementation of self tuning regulators	**2**
3	Applications of adaptive control techniques in engineering problems	**2**
4	Project 1	**2**
5	Project 2	**2**
6	Project 3	**2**
7	Project 4	**2**

Course Outcomes:

By the end of this course, the student will be able to:	
1	be conversant with basics of adaptive control.
2	apply the concepts of parameter estimation, deterministic self tuning regulators practically.
3	implementmodel reference adaptive systems for simple engineering problems.

Bibliography:

Sr.No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	I.D. Landau, R. Lozano, M.M'Saad, and A. Karimi,*Adaptive Control: Algorithms, Analysis And Applications.* Springer Science & Business Media.	**2011**
2	K.J Astrom, and B. Wittenmark, *Adaptive Control.* Second Edition, Eaglewood, cliffs.	**1995**
3	P.R Kumar, and P. Varaiya, *Stochastic Systems – Estimation, Identification And Adaptive Control*.	**1986**
4	S. Sastry, *Adaptive Control: Stability, Convergence And Robustness*. Prentice Hall.	**1989**

MOOC on this course are available at:

1) Introduction to Adaptive Control, Rahul Rai: https://www.coursera.org/lecture/intelligent-machining/introduction-to-adaptive-control-uZlZf.
2) Why adaptive control?: https://www.youtube.com/watch?v=pU5vq6rjmKk
3)1 01 Introduction to the course System Identification and Parameter Estimation: https://www.youtube.com/watch?v=d8dXoJ9MoDs

Course Name	**:**	**System Dynamics**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**
Segment	**:**	**1-3**

Total No. Lectures - 14
Total No. of Lab hours – 14

Course Objectives:

	The main objectives of this course are:
1.	To learn the basic concepts of strategic modeling with system dynamics.
2.	To learn how to initiate strategic change in organizations
3.	To implement the feedback based simulation models.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1	**Basics:** General systems theory, systems thinking, system dynamics, relationship betw. system Dynamics and Cybernetics. System dynamics as an approach to understand the behavior of complex systems over time.	**2**
2	**Models:** Classification of Models-Abstract, physical, Static, Dynamic, linear nonlinear, stable, unstable, steady state, transient, opens, closed, models in physical sciences engineering and social sciences and mental models.	**2**
3	**Principles:** formulation of System Dynamics models, time relationship, amplification, information distortion, correspondence of models and real system variables.	**3**
4	**Building Blocks:** Basic concepts behind the study of complex systems. Examining the patterns of behavior that real-world systems exhibit, understanding the basis of the structure that causes such patterns to emerge.	**3**
5	**Causal loop diagrams:** Reinforcing and balancing loops, positive and negative feedback, conceptualization exercises, loop polarity and shift in loop dominance.	**2**
6	**Generic structures:** S shaped growth, unexpected behavior of Ist order, 2nd order, 3rd order, and 4th order loops, Exponential, oscillating systems.	**2**

Lab Work:

Sr.No	Lab contents	No. of Hours
1	Modeling and simulation Exercises of negative Feedback Loops	**02**
2	Modeling and simulation Exercises of Positive Feedback Loops	**02**
3	Modeling and simulation exercises of Exponential shape growth	**02**

4	Modeling and simulation exercises of S shape growth	**02**
5	Modeling and simulation Exercises of Oscillating systems	**02**
6	Modeling and simulation Exercise of higher order systems	**02**
7	Modeling exercise of Dynamics of energy system	**02**

Course Outcome:

By the end of this course, the student will be able to:	
1	Learn the concepts of system dynamics and cybernetics, feedback loops, non-linearity, casual loop diagram, generic structures, transferability of structures, systems thinking and dynamics of energy systems.
2	Understand the dynamic relationship, model classifications, principles formulation of system dynamic models.
3	Learn the feedback loops, non-linearity, casual loop diagram, generic structures, transferability of structures, systems thinking and dynamics of energy systems.

Bibliography:

Sr.No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	J. N. Warfield,*Introduction to Systems Science*.	**2006**
2	D.H. Kim, *Systems thinking Tools- A users Reference guide*.Pegaus Communication [available online].	**2000**
3	MIT System Dynamics Society OCW resources.	**2002**
4	D. H. Meadows, *Thinking in Systems: A Primer eBook*.	**2008**

Classical Books:

Sr.No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	M. J. Radzicki, and R.A. Taylor,*Introduction to System Dynamics*. U.S Department of Energy.	**1997**
2	P.Senge,Fifth discipline.	**1990**

MOOCs on this course are available at:

1)Introduction to System Engineering, Dr Mike Ryan, Senior Lecturer, Dr Ian Faulconbridge , Industry Fellow : https://www.coursera.org/learn/systems-engineering.

2)Introduction to System Dynamics: Overview:
https://www.youtube.com/watch?v=AnTwZVviXyY

Program Elective II – E2

Course Name	**:**	**Fuzzy Logic Based Control**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**
Segment	**:**	**4-6**

Total No. Lectures - 14
Total No. of Lab hours – 14

Course Objectives:

	The main objectives of this course are:
1.	To learn the basic conceptsof fuzzy logic theory.
2.	To design the fuzzy logic systems.
3.	To implement the applications of fuzzy logic control for different system control and improvement.

Course Contents:

Sr.No	**Course Contents**	**No. of Lectures**
1	Fuzzy Logic Basics: Fuzzy sets &membership,Operation& properties of classical sets, Fuzzy set operation and properties of fuzzy sets, Features of MF, standard forms and boundaries.	**4**
2	Types of Fuzzy Logic Systems:Mamdani Fuzzy Logic and Takagi Sugeno Fuzzy Logic system.	**3**
3	Design of Fuzzy Logic systems:Fuzzification, Membership value of assignments, fuzzy sets and fuzzy relations, de-fuzzificationmethods.Fuzzy Rule Based Systems.	**3**
4	Applications of fuzzy controllers in Engineering.	**4**

Lab Work:

Sr.No	**Lab contents**	**No. of Hours**
1	MATLAB/Simulink based simulations for fuzzy logic systems-1	**02**
2	MATLAB/Simulink based simulations for fuzzy logic systems-2	**02**
3	Application of fuzzy logics in control design-1	**02**
4	Application of fuzzy logics in control design-2	**02**
5	Project 1	**02**
6	Project 2	**02**
7	Project 3	**02**

Course Outcome:

By the end of this course, the student will be able to:	
1	Apply the basic conceptsof fuzzy logic theory .
2	Use fuzzy logic control for engineering applications.

Bibliography:

Sr.No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	J.R. Timothy, *Fuzzy logic with Engineering Applications*. McGraw Hill, Inc.	**1997**
2	S.V. KartaloPoulos, *Understanding Neural Networks and Fuzzy logic*. PHI.	**1996**
3	G. J. Klir, and B. Yaun, *Fuzzy Sets & Fuzzy logic Theory & applications*. PHI.	**1995**
4	S. Rajasekaran, and G.V. Pai, *Neural Networks, Fuzzy Logic And Genetic Algorithm: Synthesis And Applications*. PHI Learning Pvt. Ltd.	**2003**
5	N. Siddique, *Intelligent Control: A Hybrid Approach Based On Fuzzy Logic, Neural Networks And Genetic Algorithms*. Springer.	**2013**
6	F. Matía, G.N. Marichal, E. Jiménez, Eds,*Fuzzy Modeling and Control: Theory and Applications*. Paris, France:Atlantis Press.	**2015**

MOOC on this course are available at:

1) Introduction to Fuzzy logic: http://nptel.ac.in/courses/106105173/2

2) Introduction to Intelligent Systems and Control**:** http://nptel.ac.in/courses/108104049/

3) Introduction to Fuzzy logic control**:** http://nptel.ac.in/courses/108104049/16

Course Name	**:**	**AdvancedTechniques in Adaptive Control**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**
Segment	**:**	**4-6**

Total No. Lectures - 14
Total No. of Lab hours – 14

Course Objectives:

	The main objectives of this course are:
1.	To learn the advanced techniques of adaptive control techniques.
2.	To implement the adaptive control techniques for practical applications.
3.	To design the auto-tuning and gain scheduling methods for the practical applications.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1	**Properties of Adaptive Systems:** Nonlinear dynamics, adaptation of a feedforward gain, analysis of indirect discrete time self tuners, Averaging, application of averaging techniques. Averaging in stochastic systems, robust adaptive controllers.	**3**
2	**Stochastic and Predictive Self Tuning Regulators:** Design of minimum variance and moving average controllers, stochastic self tuning regulators, Linear quadratic STR Adaptive Predictive control.	**3**
3	**Stochastic Adaptive Control:** Multistep decision problems, stochastic adaptive problem dual control, suboptimal strategies.	**3**
4	**Auto-tuning:** PID Control, auto tuning techniques, transient response methods, methods based on relay feedback, relay oscillations.	**2**
5	**Gain Scheduling:** Principles, design of gain scheduling controllers, applications of gain scheduling.	**3**

Lab Work:

Sr.No	Lab contents	No. of Hours
1	MATLAB/Simulink based simulations for self tuning regulator	**02**
2	Implementation of gain scheduling controller	**02**
3	Applications of adaptive control in engineering problems	**02**
4	Project 1	**02**
5	Project 2	**02**
6	Project 3	**02**
7	Project 4	**02**

Course Outcome:

By the end of this course, the student will be able to:	
1	Be conversant with the advanced adaptive control techniques.
2	Apply the concepts of real time parameter estimation,
3	Design deterministic self tuning regulators, Stochastic and Predictive Self Tuning Regulators, model reference adaptive system, stochastic adaptive control, auto-tuning and gain scheduling to simple engineering problems

Bibliography:

Sr.No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	I.D. Landau, R. Lozano, M.M'Saad, and A. Karimi,*Adaptive Control: Algorithms, Analysis And Applications.* Springer Science & Business Media.	**2011**
2	K.J Astrom, and B. Wittenmark, *Adaptive Control.* Second Edition, Eaglewood, cliffs.	**1995**
3	P.R Kumar, and P. Varaiya, *Stochastic Systems – Estimation, Identification And Adaptive Control*.	**1986**
4	S. Sastry, *Adaptive Control: Stability, Convergence And Robustness*. Prentice Hall.	**1989**

MOOC on this course are available at:

1) Gain Scheduling of PID controllers: https://www.youtube.com/watch?v=g7R1USqJOUo
2)Stochastic Self tuning regulators**:** https://slideplayer.com/slide/1577262/
3) Online Parameter Estimation and Adaptive Control**:**
https://www.youtube.com/watch?v=KAHBUtwWHSg

Course Name	**:**	**Applications of System Dynamics**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**
Segment	**:**	**4-6**

Total No. Lectures - 14
Total No. of Lab hours – 14

Course Objectives:

	The main objectives of this course are:
1.	To learn the advanced techniques of system dynamics.
2.	To learn the advanced concepts of the system archetypes.
3.	To implement the application of archetypes to organizational issues and problems.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1	**Group Modeling -** System thinking as paradigm, necessity and benefit of system dynamics, exercise in group modeling, Transferability of structures.	**2**
2	**System Archetypes 1 -**Feedback loops for the archetypes - Fixes that Backfire, Shifting the Burden, Limits to Success, Tragedy of the Commons Accidental Adversaries.	**3**
3	**System Archetypes 2-** Feedback loops for the archetype - Escalation,DriftingGoals,Success to the Successful Growth and Underinvestment.	**3**
4	**System Dynamics Applications -** Applying Systems Thinking System dynamics and Common Archetypes to Organizational Issues and problems.	**4**
5	**Energy Modeling-** Basics of world and India energy systems.	**2**

Lab Work:

Sr.No	Lab contents	No. of Hours
1	Modeling and simulation of Structure transfer in analogus systems-1	**02**
2	Modeling and simulation of Structure transfer in analogus systems-2	**02**
3	Modeling and simulation of Archetype -1	**02**
4	Modeling and simulation of Archetype-2	**02**
5	Modeling and simulation of Archetype- 3	**02**
6	Modeling and simulation of Archetype-4	**02**
7	Modeling and simulation of Archetype- 5	**02**

Course Outcome:

By the end of this course, the student will be able to:	
1	Learn the advanced concepts of system dynamics.
2	Understand the system archetypes application of archetypes to Organizational Issues and problems.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	J. N. Warfield,*Introduction to Systems Science*.	**2006**
2	D.H. Kim, *Systems thinking Tools- A users Reference guide.*Pegaus Communication [available online].	**2000**
3	MIT System Dynamics Society OCW resources.	**2002**
4	D. H. Meadows, *Thinking in Systems: A Primer eBook*.	**2008**

Classical Books:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	M. J. Radzicki, and R.A. Taylor,*Introduction to System Dynamics*. U.S Department of Energy.	**1997**
2	P.Senge,Fifth discipline.	**1990**

MOOCs on this course are available at:

1) An Introduction to System Dynamics by George Richardson**:** https://www.youtube.com/watch?v=MSo8kqbLDlw

2) Systems Dynamics and Control: Module 2 - Introduction to Modeling**:** https://www.youtube.com/watch?v=vwso-xHLNGc

3) System Thinking - System Archetypes - Tragedy of the Commons**:** https://www.youtube.com/watch?v=Pu6vfId92II

Engineering Mathematics

Course Name	**:**	**FOURIER TRANSFORMS**
Course Code	**:**	
Credits	**:**	**01**
L T P	**:**	**2-1-0**
Segment	**:**	**1-2**

Total No. of Lectures– 10
Tutorials -5

Course Objectives:

The main Objectives of this course are:

1	To make the students understand the concept of Fourier transform and be able to compute it for standard examples.
2	To make the students able to apply Fourier transforms to solve differential equations and partial differential equations.

Course contents:

Sr.No	Course Contents	No. of Lectures
1	**Fourier Transforms:** Fourier Integral formulas, Definition and examples, Basic properties, Fourier cosine and sine transforms and examples, Basic properties of Fourier cosine and sine transforms, Multiple Fourier transforms.	05
2	**Fast Fourier Transforms and Short Term Fourier Transforms:** Definition and examples, Basic properties, Applications.	05

Course Outcomes:

At the end of the course, students will be able to:	
1	Solve differential equations by using Fourier transforms
2	Solve partial differential equations by using Fourier transforms
3	Apply FFT and STFT to engineering problems

Bibliography:

Sr.No.	Name of Book / Authors / Publishers	Year of Publication/ Edition
1	"Integral Transforms and Their Applications", Loknath Debnath, CRC Press, Inc.,	1995.
2	"Integral Transforms and their Applications", Brian Davies, 3rd Edition, Springer-Verlag, New York,Inc,	2001
3	"Fourier Transform and Its Applications", Ronald N. Bracewell, 2nd Edition, McGraw-Hill Inc.,US,	1986

Course Name	**:**	**NUMERICAL METHODS**
Course Code	**:**	
Credits	**:**	**01**
L T P	**:**	**2-0-2**
Segment	**:**	**3-4**

Total No. of Lectures – 10
Practicals -10

Course Objectives:
The main Objectives of this course are:

1	To make the students understand the basics of numerical methods.
2	To make the students able to solve problems on system of linear equations and Interpolation by numerical methods.

Course contents:

Sr.No	Course Contents	No. of Lectures
1	**Error Analysis:** Definition and sources of errors, Propagation of errors, Floating-point arithmetic and rounding errors.	02
2	**Interpolation:** Interpolation using Finite differences, Numerical Differentiation and Numerical integration, Trapezoidal and Simpson's rules.	04
3	**Numerical Solution of Differential Equations:** Picard's method, Taylor series method, Euler and modified Euler methods, Runge-Kutta methods, Predictor-Corrector method.	04

Lab Work:

Sr.No	Lab. Contents	No. of Hours
1.	Solving Interpolation, Numerical Differentiation and Numerical integration problems using Mathematica.	04
2.	Solving Differential equations numerically using Mathematica.	06

Course Outcomes:

By the end of the course, the students will be able to solve the following by numerical methods:
1. Problems on Interpolation 2. Problems on Differentiation, Integration. 3. Solve differential equations.

Bibliography:

Sr.No.	Name of Book / Authors / Publishers	**Year of Publication/ Edition**
1	"Introduction to Numerical Analysis",Atkinson K. E., John Wiley.	1989
2	"Applied Numerical Analysis", Gerald C. F. and Wheatley P. O., Pearson	2004
3	"Numerical Methods for Scientific and Engineering Computation", Jain M. K., Iyengar S.R.K. and Jain R. K., New Age International Publisher.	2004
4	"Elements of Numerical Analysis", Gupta R.S., Macmillan India Ltd .	2008

Course Name	**:**	**OPTIMIZATION TECHNIQUES AND GENETIC ALGORITHMS**
Course Code	**:**	
Credits	**:**	**01**
L T P	**:**	**2-0-2**
Segments	**:**	**5-6**

Total No. of Lectures – 10,

Practicals -10

Course Objectives:

The main Objectives of this course are:

1	To make the students understand the need of Optimization Techniques and develop the ability to form mathematical model of optimization problems.
2	To make the students able to identify and solve linear and non-linear models of optimization problemsusing Genetic Algorirhms.

Course contents:

Sr.No	Course Contents	No. of Lectures
1	Introduction to optimization problem, local and global optimum, conversion of a constrained problem to unconstrained problem.	04
2	Genetic Algorithms, Binary and Real coded Genetic Algorithms, Coding and decoding of variables, Key steps in a GA, starting population, fitness evaluation, reproduction, crossover, mutation, evaluation.	06

Lab Work:

Sr.No	Lab. Contents	No. of Hours
3.	Using Genetic Algorithms in various optimization Problems	10

Course Outcomes:

1	The students are able to form mathematical model of optimization problems .
2	The students are able to distinguish between linear and nonlinear models .
3	The students are able to solve simple problems using Mathematica/MATLAB

Bibliography:

Sr.No.	Name of Book / Authors / Publishers	Year of Publication/ Edition
1	"Practical Genetic Algorithms", Haupt, R. L. and Haupt, S.E., John Wiley &Sons	1998
2	"Genetic Algorithm in Search, Optimization and Machine Learning" , Goldberg, D.E., Addison Wesley.	1989
3	"Engineering Optimization", Ranjan, Ganguli,University Press.	2011

Semester II

Soft Skills & Management

Course Name	**:**	**Communication Skills**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**1-0-4**
Segment	**:**	**1-3**

Total No. Tutorials-7
Total No. of Lab hours – 28

Course Objectives:

	The main objectives of this course are:
6.	To enhance competence in communication skills: verbal and nonverbal.
7.	To provide orientation in technical communication skills: spoken and written.
8.	To sensitize students to attitude formation and behavioural skills.

Course Contents:

Sr.No	Course contents	No. of Tutorials
1.	**Introduction to Communication Skills, Soft Skills and Interpersonal Communication**	**1**
2.	**Speech:** Structure, Elements, Content, Organization and Delivery, J-a-M	**1**
3.	**Writing Skills:** Letters, Minutes of Meeting	**1**
4.	**Technical Report Writing:** Concept and Structure	**1**
5.	**Research Writing:** Concept and Structural Framework	**1**
6.	**Power Point Presentation:** Project Presentation	**1**
7.	**Interviews**	**1**

Lab Work:

Sr.No	Lab contents	No. of Hours
21.	Self- Introduction	**2**
22.	Negotiation Skills & Role Play	**2**
23.	J-a-M Session	**2**
24.	Building Word Power through Reading	**2**
25.	Group Discussion and Case Study	**4**
26.	Writing Skills: Letters, Minutes of Meeting	**2**
27.	Technical Report Writing: Concept & Structure	**4**
28.	Research Writing: Concept and Structural Framework	**4**
29.	Power Point Presentation: Project Presentation	**4**
30.	Interviews	**2**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Show enhanced competence in communication skills and technical communication.
2.	Develop awareness of attitude formation and behavioural appropriateness
3.	Gain self-confidence and perform better in their academic and professional life.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	"Technical Communication", RamanMeenakshiand SharmaSangeeta, Oxford University Press.	2015
2.	"English for Research Paper Writing", WallworkAdrian, Springer, London.	2011
3.	"English Vocabulary In Use: Advanced+ CD", MichaelMcCarthy, CUP, Cambridge.	2004
4.	"Advanced English Grammar", HewingsMartin, CUP, Cambridge.	2003
5.	"Study Listening", TonyLynch, CUP, Cambridge.	2004
6.	"Study Speaking", KennethAnderson, CUP, Cambridge.	2010
7.	"Study Reading", Glendenning H. Eric, CUP, Cambridge.	2004
8.	"Study Writing", HampLyons Liz & HeasleyBen, CUP, Cambridge.	2004
9.	"Study Skills in English", WallaceMichael J., CUP, Cambridge.	2004

MOOCs on this course are available at:

1) "Take Your English Communication Skills to the Next Level". Available at Coursera (Offered by Georgia Institute of Technology), 4 weeks, Starts on September 10, 2018. https://www.coursera.org/learn/english-communication-capstone

2) "Effective Communication in Globalised Workplace- The Capstone". Available at Coursera (Offered by National University of Singapore), 3 weeks, Starts on August 06, 2018. https://www.coursera.org/specializations/effective-communication

Course Name	**:**	**Management Entrepreneurship and IPR**
Course Code	**:**	
Credits	**:**	**1**
L T P	**:**	**0-2-0**
Segment	**:**	**4-5**

Total No. Tutorials – 14

Course Objectives:

The main objectives of this course are:	
1.	To make students familiar with the concepts of Management, Entrepreneurship and Intellectual Property Rights (IPRs).
2.	To make students understand how to initiate a new Start-up and manage it effectively.
3.	To enable students to convert their innovative ideas into different forms of IPRs.

Course Contents:

Sr.No	Course contents	No. of Tutorials
1.	**Introduction to Management:** Concepts and Principles of Management	**1**
2.	**Functions of Management:** Planning Process - Hypothetical Planning of an Event/Activity, Form of Organization Structure - Case Study, Human Resource Planning and Process, Elements of Directing and Effective Control Mechanism, Activity: Role Playing/Management Game	**4**
3.	**Introduction to Entrepreneurship:** Concepts of Entrepreneurship and Characteristics of Entrepreneurs	**1**
4.	**Development Phases of Entrepreneurship:** Innovation and Idea Generation, Project Formulation and Validation (Feasibility Analysis), Business plan	**2**
5.	**Ecosystem for Entrepreneurship Development:** Government Schemes and Initiatives, Financial and Non-Financial Institutional Support, Legal Framework, Role of Incubator, Venture Capitalist, Angel Investor, Crowd Funding Accelerator etc.	**2**
6.	**Intellectual Property Rights (IPRs):** Concept and Relevance of IPRs, Process for filing IPR	**2**
7.	**Different Forms of IPRs:**Patents, Copyright, Trademarks, Industrial Designs and Geographic Indicator	**2**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Developand manage new project/Start-up.
2.	Apply managerial skills for success of entrepreneurial/business venture.
3.	Make effective use of IPR practicesin their ventures.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	"Management Principles and Practice", Srinivasan R. and Chunawalla S.A., Himalaya Publishing House.	**2017**
2.	"Introduction to Management", Schermerhorn John R. Jr. And Bachrach Daniel G., 13th Edition, Wiley Publications	**2016**
3.	"Principles & Practice of Management", Prasad L.M., 8th Edition, Sultan Chand & Sons.	**2015**
4.	"The New Era of Management", Daft R.L., 11th Edition, Pubs: Cengage Learning.	**2014**
5.	"Case Studies in Management", Pandey Chandra Akhilesh, 2nd Edition, I.K. International Publishing House Pvt. Ltd.	**2015**
6.	"Harvard Business Review: Manager's Handbook", Harvard Business School Press.	**2018**
7.	"Entrepreneurship", Trehan Alpana, Dreamtech Press.	**2016**
8.	"Entrepreneurship and Small Business" Schaper Michael, Volery Thierry, Weber Paull and Lewis Kate, 3rd Asia-Pacific Edition, Wiley Publications	**2018**
9.	"Harvard Business Review: Entrepreneur's Handbook", 1st Edition, Harvard Business Review Press	**2018**
10.	"Take Me Home", Bansal Rashmi, 1st Edition, Westland.	**2014**
11.	"Intellectual Property Law", Narayanan P., 3rd Edition, Eastern Law House	**2017**
12.	"Intellectual Property Rights", Pandey Neeraj and Dharni Khushdeep, PHI Learning	**2014**
13.	"Intellectual Property Rights", Rosedar S.R.A., LexisNexis (Quick Reference Guide – Q&A Series)	**2016**
14.	MSME Annual Publications (www.msme.gov.in)	**Annual**
15.	WIPO Annual Publications (www.wipo.int)	**Annual**

MOOCs on this course are available at:

1) "Entrepreneurship: Do Your Venture", Available at edx (Offered by IIM Bangalore), Self-Paced (6 weeks).
   https://www.edx.org/course/entrepreneurship-do-your-venture
2) "Becoming an Entrepreneur", Available at edx (Offered by MIT), Self-Paced (6 weeks).
   https://www.edx.org/course/becoming-entrepreneur-mitx-launch-x-4
3) "How to Build a Start-up", Available at Udacity, Self-Paced (One Month).
   https://in.udacity.com/course/how-to-build-a-startup--ep245
4) "Intellectual Property Rights: A Management Perspective, Available at edx (Offered by IIM Bangalore), Starts on 1 August 2018 (6 weeks).

https://www.edx.org/intellectual-property-rights-a-management-perspective

Course Name	**:**	**Professional Ethics**
Course Code	**:**	
Credits	**:**	**0.5**
L T P	**:**	**0-1-0**
Segment	**:**	**6-6**

Total No. Tutorials -7

Course Objectives:

	The main objectives of this course are:
1.	To imbibe ethical values and understanding.
2.	To develop moral thinking that will help students to recognize their potential.
3.	To engage and motivate the students to perform ethically in their professional life.

Course Contents:

Sr.No	Course contents	No. of Tutorials
1.	**Introduction to Ethics:** Concept of Ethics – Nature, Scope, Sources, Types, Functions and Factors influencing Ethics, Ethics in Engineering	**2**
2.	**Ethics in Profession:** Concepts of Honesty, Integrity, Reliability, Risk, Safety and Liability, Responsibilities and Rights of Professionals, Professional accountability.	**2**
3.	**Ethics and Business:** Concept of Business Ethics – Nature and Objectives, Ethical dilemmas in business ethics.	**1**
4.	**Self-Development:** Concept of Self-Assessment – SWOT Analysis, Self-Concepts, Self-Confidence, Self-Esteem, Managing Time and Stress, Human values.	**2**

Course Outcomes:

At the completion of this course, students will be able to:	
1.	Demonstrate knowledge and better understanding of self and to manage time and stress effectively.
2.	Have subjective well-being.
3.	Have ethical decision making ability in their personal and professional life.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	"Professional Ethics", Subramaniam R., 2nd Edition, Oxford University Press.	**2017**
2.	"Introduction to Psychology", Kalat James W., 11th Edition, Cengage Learning.	**2017**

3.	"Business Ethics – Text and Cases", Murthy C.S.V., 1st Edition, Himalaya Publishing House.	**2014**
4.	"A Foundation Course in Human Values and Professional Ethics", Gaur R.R., Sangal R. and Bagaria G.P., Excel Books.	**2010**
5.	"Issues and Ethics in the Helping Professions", Corey G., Corey M.S. and Callanan P., 8th Edition, Brooks/Cole, Cengage Learning.	**2010**
6.	"The Curse of Self: Self-awareness, Egotism and the Quality of Human Life", Leary M.R., 1st Edition, Oxford University Press.	**2007**
7.	"Business Ethics", Hartman L.P. and Chatterjee A., 3rd Edition, Tata McGraw Hill.	**2006**
8.	"Business Ethics and Professional Values", Rao A.B., Excel Books.	**2006**
9.	"Business Ethics – Concepts and Cases", Velasquez M.G., 5th Edition, Prentice Hall.	**2001**
10.	"Theories of Personality", Hall C.S., Lindzey D. and Cambell J.B., 4th Edition, Hamilton Printing Company.	**1997**

MOOCs on this course are available at:

1) "Ethics in Engineering Practice". Available at SWAYAM(Offered by IIT Kharagpur), 8 weeks, Starts on August 27, 2018. https://swayam.gov.in/courses/4799-july-2018-ethics-in-engineering-practice
2) "Ethics, Technology and Engineering". Available at Coursera (Offered by EindhovenUniversity of Technology), 8 weeks, Starts on July 16, 2018.

   https://www.coursera.org/learn/ethics-technology-engineering

Program Core III

Course Name	**:**	**Discrete Time Control Systems**
Course Code	**:**	
Credits	**:**	**3**
L T P	**:**	**2-0-2**
Segment	**:**	**1-6**

Total No. Lectures - 28
Total No. of Lab hours – 28

Course Objectives:

	The main objectives of this course are:
1.	To learn the concepts of signal processing and digital control and z-transformation.
2.	To study the state-variable analysis of digital control system.
3.	To design the state feedback digital control system and apply these concepts practically on real time systems.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1	**Introduction:** control system terminology, computer based control, control theory (history & trends).	**3**
2	**Signal processing in digital control:** advantages of digital control, basic digital control scheme, principle of signal conversion, basic discrete-time signals, time domain & transfer function models, stability in z –plane, sampling,z-transformation.	**8**
3	**State Variable Analysis of Digital Control System:** state description of digital processors, state description of sampled continuous-time plants, solution of state difference equations controllability and observability.	**8**
4	Digital Control System with State Feedback, dead beat control by state feedback and dead beat observers, lyapunov stability analysis for discrete-time systems.	**9**
5	**Practical labs:** MATLAB/Simulink based simulations for discrete time state space modeling, pole placement method and discrete time LQR design.	**14**

Lab Work:

Sr.No	Lab contents	No. of Hours
1	MATLAB/Simulink based simulations for discrete time state space Modeling.	**02**
2	Design based on Pole placement method	**02**
3	Discrete time LQR design.	**02**
4	Deadbeat observer design	**04**

5	Project 1	**06**
6	Project 2	**06**
7	Project 3	**06**

Course Outcome:

By the end of this course, the student will be able to:	
1	Apply the concepts of signal processing and digital control,
2	Apply z-transformation, state-variable analysis of digital control system.
3	Design state feedback digital control system for engineering systems.

Bibliography:

Sr.No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	M. Gopal, *Digital Control and State variable methods*. Tata McGraw-Hill publishing company limited.	**2008**
2	G. Gu, *Discrete-Time Linear Systems: Theory and Design with Applications*. Springer Science & Business Media.	**2012**
3	Y. Okuyama, *Discrete control systems*. Springer London.	**2014**
4	K. Abidi, J,X. Xu, *Advanced Discrete-Time Control.* Springer Singapore: Imprint: Springer.	**2015**

Classical Books:

Sr.No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	B.C. Kuo, *Digital Control Systems*.Orlando Florida: Saunders College Publishing.	**1992**
2	G.F.Franklin, J.D. Powel, and M.L. Workmen, *Digital Control of Dynamic Systems*. John Wiley & Sons.	**1997**
3	K. Ogata, *Discrete-time Control Systems*. Englewood cliffs, New jersey: Prentice-hall.	**1995**
4	R. Gayakward, and L. Sokoff, *Analog and Digital Control Systems*. Englewood cliffs, New Jersey: Prentice-hall.	**1988**

MOOCs on this course are available at:

1) Discrete time Signal Processing, Alan V. Oppenheim, Tom Baran:https://www.edx.org/course/discrete-time-signal-processing-mitx-6-341x-1

2) Digital Control Systems: http://nptel.ac.in/courses/108103008/

3) ECE320 Lecture10-2b: Discrete-time Systems Design**:** https://www.youtube.com/watch?v=5cyozZiFLPg

Program Core IV

Course Name	**:**	**Non-linear Control Systems**
Course Code	**:**	
Credits	**:**	**3**
L T P	**:**	**2-0-2**
Segment	**:**	**1-6**

Total No. Lectures - 28
Total No. of Lab hours – 28

Course Objectives:

	The main objectives of this course are:
1.	To learn the concepts of learn theoretically and apply practically the various concepts of non linear control for qualitative analysis.
2.	To study the controllability and observability of the non linear systems under different disturbances.
3.	To design variable structure control.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1	General Properties of linear and non-linear systems, perturbation theory, and perturbation dynamics.	**2**
2	Controllability and Observability of Non-linear systems	**2**
3	Stability of Non-linear Systems – Lyapunov Theorems, small gain theorem, phase-plane Analysis, describing functions.	**8**
4	Non-Linear Control techniques:feedback linearization, Nonlinear observers	**8**
5	Variable Structure control: and sliding mode control	**8**

Lab Work:

Sr.No	Lab contents	No. of Hours
1	MATLAB/Simulink based analysis using describing function method	**02**
2	MATLAB/Simulink based analysis using phase plane .	**02**
3	MATLAB/Simulink based Sliding model control-1	**02**
4	MATLAB/Simulink based Sliding model control-2	**02**
5	MATLAB/Simulink simulation for feedback linearization	**02**
6	Project 1	**06**
7	Project 2	**06**
8	Project-3	**06**

Course Outcomes:

By the end of this course, the student will be able to:	
1	Model uncertainties existing in the systems
2	Apply practically the various concepts of non-linear control for the analysis of the non linear systems under different conditions.
3	Design variable structure control for stability analysis of non linear control systems.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	S. Vaidyanathan, C. Volos, Eds., *Advances and Applications in Nonlinear Control Systems*. Berlin, Germany: Springer.	**2016**
2	I.Fantoni, R. Lozano, *Non-linear Control for Underactuated Mechanical Systems*. Springer Science & Business Media.	**2002**
3	H.J. Marquez,*Nonlinear control systems: Analysis and Design*. Hoboken: Wiley-Interscience.	**2003**
4	A.Astolfi, L. Marconi,*Analysis and Design of Nonlinear Control Systems*.	**2008**
5	H. Khalil H, *Nonlinear Systems*. 3rd edition, Macmillan.	**2002**

Classical Books:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	J.J. Slotine, andW.P. Li , *Applied Nonlinear Control*. Prentice Hall.	**1991**
2	A.Isidori, *Nonlinear Control Systems*. 2nd edition Springer.	**1989**

MOOCs on this course are available at:

1) Non-linear systems, Slotine, MIT, **http://web.mit.edu/nsl/www/videos/lectures.html**

2) Online Controls Tutorial in MATLAB: http://ctms.engin.umich.edu/CTMS/index.php?aux=Home

3) Non-linear control systems: https://www.youtube.com/watch?v=BIJz4dqkj3U

Program Elective III – E3

Course Name	**:**	**Introduction to Robust Control**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**
Segment	**:**	**1-3**

Total No. Lectures – 14
Total No. of Lab hours – 14

Course Objectives:

	The main objectives of this course are:
1.	To learn thefundamentals of robust control systems.
2.	To design the LQRs, LQG/LTR and study the singular values and robustness.
3.	To learn the robust control techniques.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1	**Introduction**: Vector spaces, Linear subspaces, invariant subspaces, vector norms and matrix norms, singular value decomposition, semidefinite matrices, description of linear systems, operations on systems, state space realizations for transfer matrices.	**3**
2	**Linear Quadratic Regulators:** return ratio and difference, design of LQR and robustness analysis.	**5**
3	**LQG/LTR:** design and its robustness analysis	**2**
4	**Singular Values:** Properties, applications and stability, robustness and sensitivity.	**2**
5	**Robust Control techniques:** Introduction to H_2 and $H\infty$ control techniques and their design formulations.	**2**

Lab Work:

Sr.No	Lab contents	No. of Hours
1	MATLAB/Simulink based simulations for LQG/LTR design-1	**02**
2	MATLAB/Simulink based simulations for LQG/LTR design-2	**02**
3	Implementation of LQR control-1	**02**
4	Implementation of LQR control-2	**02**
5	Applications of robust control techniques in real problems	**02**
6	Project 1	**02**
7	Project 2	**02**

Course Outcome:

By the end of this course, the student will be able to:	
1	Be conversant with the basics of robust control
2	Apply the design approaches such as LQR, LQG/LTR, Singular values.
3	Analyze robustness of the control systems.
4	Design robust control algorithms on the engineering systems.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	A.Belmiloudi,*Stabilization, Optimal And Robust Control: Theory And Applications In Biological And Physical Sciences*. Springer Science & Business Media.	**2008**
2	R.K. Yedavalli, *Robust Control Of Uncertain Dynamic Systems*. Springer-Verlag New York.	**2016**
3	K. Zhou, and J.C. Doyle, *Essentials of Robust Control*. Prentice Hall	**1998**

Classical Books:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	J.C. Doyle, B. Francis, and A. Tannenbaum, *Feedback Control Theory*.	**1992**
2	R.S. Sanchez-Pena, and M.Sznaier, *Robust Systems Theory and Applications*. John Wiley & Sons.	**1998**
3	J.M.Maciejowski, *Multivariable Feedback Design.*Addison-Wesley Publishing Company.	**1989**

MOOCs on this course are available at:

1) Robust control systems :https://www.iitk.ac.in/new/ee654a
2) Robust Control Course, Dr. Hamid D. Taghirad, http://saba.kntu.ac.ir/eecd/ecourses/robust.htm
3) Control Bootcamp: Introduction to Robust Control**:** https://www.youtube.com/watch?v=Y6MRgg_TGy0

Course Name	**:**	**Introduction to System Modeling And Identification**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**
Segment	**:**	**1-3**

Total No. Lectures - 14
Total No. of Lab hours – 14

Course Objectives:

	The main objectives of this course are:
1.	To learn thefundamentals of system modelling.
2.	To study the different types of models
3.	To study and design the various identification methods.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1	Introduction to modeling: Black-box and grey-box models	**3**
2	Parametric and non-parametric models; ARX, ARMAX (etc.) models.	**3**
3	Predictive, open-loop, black-box identification methods. Time and frequency domain methods.	**4**
4	Subspace identification methods. Optimal experimental design, Cramer-Rao bounds, input signal design.	**4**

Lab Work:

Sr.No	Lab contents	No. of Hours
1	MATLAB/Simulink based simulations for ARX models	**02**
2	Implementation of ARMAX models	**02**
3	Applications of system Modeling and identification methods in real problems	**02**
4	Project 1	**04**
5	Project 2	**04**

Course Outcome:

By the end of this course, the student will be able to:	
1	Be conversant with the basics of system Modeling and identification
2	Apply practically the concepts of Modeling and identification to simple engineering problems.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	K.J Keesman,*System Identification: An Introduction*. Springer Science & Business Media.	**2011**
2	L.Ljung, *System Identification : Theory For Users*. Prentice Hall.	**1986**
3	G.C. Goodwin, and R.C. Payne, *Dynamic System Identification: Experiment Design And Data Analysis*, New York: Academic Press.	**1977**

MOOC on this course are available at:

1)System Identification and Parameter Estimation, Dr. Erwin de Vlugt: https://ocw.tudelft.nl/courses/system-identification-and-parameter-estimation/

2) System Identification, Prof. MuntherDahleh: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-435-system-identification-spring-2005/

3) 1 01 Introduction to the course System Identification and Parameter Estimation**:** https://www.youtube.com/watch?v=d8dXoJ9MoDs

4) Introduction to System Identification**:** https://www.youtube.com/watch?v=u7hJ1aF-JrU

Program Elective IV – E4

Course Name	**:**	**Advanced Techniques in System Identification**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**
Segment	**:**	**4-6**

Total No. Lectures - 14
Total No. of Lab hours – 14

Course Objectives:

	The main objectives of this course are:
1.	To learn the advanced concepts of system identification.
2.	To study the closed-loop identification strategies.
3.	To implement the various identification methods.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1	Optimal experimental design, Cramer-Rao bounds, input signal design.	**2**
2	Parametric identification methods. On-line and batch approaches.	**4**
3	Closed-loop identification strategies. Trade-off betw. controller performance and information available for identification. Auto-tuners.	**4**
4	Model validation in classical and robust control frameworks. Set based modeling.Iterative identification and design approaches.	**4**

Lab Work:

Sr.No	Lab contents	No. of Hours
1	MATLAB/Simulink based simulation for parametric identification.	**02**
2	MATLAB/Simulink based simulation forclosed loop identification methods	**02**
3	Applications of system Modeling and identification methods in real problems-1	**02**
4	Applications of system Modeling and identification methods in real problems-2	**02**
5	Project 1	**02**
6	Project 2	**02**
7	Project 3	**02**

Course Outcome:

By the end of this course, the student will be able to:	
1	Be conversant with the advanced identification techniques.
2	Apply closed loop identification techniques.
3	Apply practically the concepts of identification to simple engineering problems.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	K.J Keesman,*System Identification: An Introduction*. Springer Science & Business Media.	**2011**
2	L.Ljung, *System Identification : Theory For Users*. Prentice Hall.	**1986**
3	G.C. Goodwin, and R.C. Payne, *Dynamic System Identification: Experiment Design And Data Analysis*, New York: Academic Press.	**1977**

MOOC on this course are available at:

1)System Identification and Parameter Estimation, Dr. Erwin de Vlugt: https://ocw.tudelft.nl/courses/system-identification-and-parameter-estimation/
2) System Identification, Prof. MuntherDahleh: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-435-system-identification-spring-2005/

Course Name	**:**	**H∞ Control**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**
Segment	**:**	**4-6**

Total No. Lectures - 14
Total No. of Lab hours – 14

Course Objectives:

	The main objectives of this course are:
1.	To learn the concepts of H2 and H∞ spaces for robust control systems.
2.	To study the structure stability, performance, uncertainty and linear fractional transformations.
3.	To study and design the parameterized controllers.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1	**H2 and H∞ Spaces:** Hilbert spaces, H2 and H∞ spaces, computing of L2 and H2 norms, computing of L∞ and H∞ norms.	**2**
2	**Internal Stability:** Feedback Structure, internal stability, coprime factorization over RH∞.	**2**
3	**Performance Specifications:** Feedback properties. Weighted H2 and H∞ performances, selection of weighting functions.	**2**
4	**Uncertainty and Robustness:** Model uncertainty, small gain theorem, stability under unstructured uncertainties, robust performance.	**2**
5	**Linear Fractional Transformations:** Linear Fractional Transformations, block diagrams, basic principles, Redheffer star products.	**2**
6	**Controller parametrization:** Existence of stabilizing controller, controller parametrization, coprime factorization approach.	**2**
7	**H∞ Control:** Various problem formulations, general H∞ solutions, H∞ control, Case studies of controller designs	**2**

Lab Work:

Sr.No	Lab contents	No. of Hours
1	MATLAB/Simulink based simulations for H∞ control design-1	**02**
2	MATLAB/Simulink based simulations for H∞ control design-2	**02**
3	Implementation of H_2 control technique	**02**
4	MATLAB/Simulink based simulations for H_2 /H∞ control design-1	**02**
5	Applications of robust control techniques in real problems	**02**
6	Project 1	**02**

7	Project 2	**02**

Course Outcome:

By the end of this course, the student will be able to:	
1	Become conversant with the H∞ based robust control techniques
2	Apply robust techniques for the control problems of engineering disciplines.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	A.Belmiloudi,*Stabilization, Optimal And Robust Control: Theory And Applications In Biological And Physical Sciences*. Springer Science & Business Media.	**2008**
2	R.K. Yedavalli, *Robust Control Of Uncertain Dynamic Systems*. Springer-Verlag New York.	**2016**
3	K. Zhou, and J.C. Doyle, *Essentials of Robust Control*. Prentice Hall	**1998**

Classical Books:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	J.C. Doyle, B. Francis, and A. Tannenbaum, *Feedback Control Theory*.	**1992**
2	R.S. Sanchez-Pena, and M.Sznaier, *Robust Systems Theory and Applications*. John Wiley & Sons.	**1998**
3	J.M.Maciejowski, *Multivariable Feedback Design.*Addison-Wesley Publishing Company.	**1989**

MOOCs on this course are available at:

1) Robust control systems :https://www.iitk.ac.in/new/ee654a
2) Multivariable Control Systems**:** https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-245-multivariable-control-systems-spring-2004/
3) Robust Control Course: http://saba.kntu.ac.ir/eecd/ecourses/robust.htm

Open Electives

Course Name	**:**	**Renewable Energy Systems**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segment	**:**	**1-3**

Total No. of Lectures-21

Course Objectives:

	The main objectives of this course are:
1.	Making students conversant with the non-conventional energy systems such as solar energy, wind energy, energy from biomass, hydro energy (micro/mini hydro plants). .
2.	Further the students shall be expected to design renewable energy systems

Course Contents:

Sr No.	Course Contents:	No. of Lectures
1.	**Introduction** Introduction to Energy Sources: Energy sources and their availability, Non-renewable reserves and resources; renewable resources.	**4**
2.	**Solar Energy** Solar processes and spectral composition of solar radiation; Radiation flux at the Earth s surface. Solar collectors. Types and performance characteristics. solar energy storage. b) Application of solar energy: Solar thermal electric conversion, Thermal electric conversion systems, solar electric power generation, Design of photovoltaic system for power generation solar cells.	**6**
3.	**Wind Energy** Wind energy conversion; efficiency limit for wind energy conversion, types of converters, aerodynamics of wind rotors, power ~ speed and torque ~ speed characteristics of wind turbines, wind turbine control systems; conversion to electrical power: induction and synchronous generators, grid connected and self-excited induction generator operation, constant voltage and constant frequency generation with power electronic control, reactive power compensation;	**5**
4.	**Tidal Energy:** Wave characteristics, Conversion systems and their performance features application	**1**
5.	**Geothermal Energy:** Introduction to Geothermal Energy Conversion	**1**
6.	**Biomass Energy:** Introduction to Biomass Energy Conversion	**2**
7.	**Hydro Energy:** Electricity generation and Water pumping, Micro/Mini hydropower systems	**2**

Course outcome:

	At the completion of this course, students will be able to:
1.	Design and analyze the non- conventional energy systems

Bibliography:

Sr. No	Name of Book/ Authors/ Publisher	Year of Publication/Reprint
1.	D. P. Kothari, K. C. Singal and R. Ranjan, *Renewable Energy Sources and Emerging Technologies*, Prentice Hall of India.	**2008**
2.	S. N. Bhadra, D. Kastha, S. Banerjee, *Wind Electrical Systems*, Oxford Univ. Press.	**2005**
3.	S. A. Abbasi, N. Abbasi, *Renewable Energy Sources and Their Environmental* PHILearning	**2008**

MOOCs on this course are available at:

1. A. Smets, *Sustainable Energy: Design a Renewable Future*, TU Delft & EDX
2. A. Smets, S*olar Energy*, TU Delft & EDX
3. A. Stegner, P.P. Drobinski, *Wind resources for renewable energies*, École Polytechnique& Coursera

Course Name	**:**	**Digital Signal Processing And Applications**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**2-0-2**

Total No. Lectures - 14
Total No. of Lab hours – 14

Course Objectives:

	The main objectives of this course are:
1.	To learn the concept of digital signal processing techniques.
2.	Tolearn the concept of signal processing.
3.	To implement the digital signal processing techniques in practical applications.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1.	**Review of Discrete Time LTI Systems & Signal Processing:** Why digital signal processing, standard discrete time signals & classification. Classification of discrete time system Time Domain Representation of LTI systems, impulse response and convolution integral	**02**
2.	**Transformations**: Discrete Fourier transform, computation of the DFT of real sequences, introduction to FFT algorithms, introduction to Z- transform, the inverse Z- transform, ROC for Z-transform, stability test, application of Z-transform in the analysis of discrete time LTI systems	**03**
3.	**Theory and design of digital filters:** Introduction to filtering concept, introduction to filter design with design of Butterworth and Chebyshev filters, introduction to other filter types, standard structures for realising IIR filters, frequency transformations betw. low, high and band pass filter, Introduction to FIR filters and the basic filter structures, design of filters using window functions.	**05**
4.	**DSP processor** Introduction to DSP processor, design of various FIR and IIR filters on MATLAB, design and analysis of LTI systems.	**02**

Lab Work:

Sr.No	Lab contents	No. of Hours
1.	Implement (i) a Butterworth filter and (ii) a Chebyshev filter for a given filter specification on MATLAB platform and compare performance of the two.	**03**
2.	Details study of any DSP processor.	**06**

Course Outcome:

By the end of this course, the student will be able to:	
1	Acquired the ability to use digital signal processing techniques for various process controls.
2	The students are expected to learn the concept of digital signal and signal processing, time domain representation, transformation, filtered design etc. for their projects and research applications.

References:

Sr.No	**Name of Book/ Authors/ Publisher**	**Year of Publication/Reprint**
1.	Digital Signal Processing by Mitra, Sanjit.k. Publisher: McGraw Hill Education	**Third edition**
2.	Digital Digital Filters: Analysis, Design, and Signal Processing Applications by Andreas Antoniou	**2018**

MOOCs on this course are available at:

1. P. Prandoni, *Digital Signal Processing*, École Polytechnique Fédérale de Lausanne& Coursera.
2. A.V. Oppenhiem and T. Bran, *Discrete-Time Signal Processing*, MIT & EDX
3. A.V. Oppenhiem, *Digital Signal Processing*, MIT Open Courseware

Course Name	**:**	**PLC & Automation**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segment	**:**	**1-3**

Total No. Lectures - 21

Course Objective:

	The main objectives of this course are:
1.	Impact knowledge of industrial automation through PLC which acting as a controller or brain to make decision.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1.	Understanding Automation & Control	**2**
2.	Basic Components of Automation Hardware / Software & classification	**2**
3.	Industrial Automation concept	**2**
4.	Design of PLC programming Ladder Logic	**3**
5.	Programmable Logic Controllers basic's Software / Hardware	**2**
6.	Creating & Editing Ladder Logic Program	**2**
7.	Interfacing PLC with various field input/output devices	**3**
8.	PLC Fault Finding, Trouble Shooting Forcing I/O's Detailed sequence of wiring	**3**
9.	PLC Control Panel Wiring Interfacing with Relay logics	**2**

Course Outcome:

By the end of this course, the student will be able to:	
1.	After going through this course students will be able to understand the concept automation of an industry
2.	Apply their knowledge to Industry for Intelligent Control automatically.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/Reprint
1.	W.W. John,*Programmable Logic Controller Programming Methods and Applications*, Pearson Education	**2003**
2.	W.Bolton, *Programmable Logic Controller*, Elsevier	**2009**
3.	T. Thakur, *Mechatronics*, Oxford University Press.	**2016**

MOOCs on this course are available at:

1. R. Rai, *Programmable Logic Controllers (PLC)*, University of Buffalo & Coursera

Course Name	**:**	**Intelligent Control**
Course Code	**:**	
Credits	**:**	**3**
L T P	**:**	**2-0-2**
Segment	**:**	**4-6**

Total No. Lectures - 14
Total No. of Lab hours – 14

Course Objectives:

	The main objectives of this course are:
1.	To learn the basic conceptsof ANN.
2.	To study the fuzzy logic theory.
3.	To study and design the ANNs and fuzzy logic systems for practical applications.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1	Neural network learning rules-hebbian, perception, delta, windrow-Holf learning rule. Winner Take all, outstar learning	**2**
2	Multilayer networks back propagation, algorithm and their training limitations, applications, Feed forward networks – Radial basis function.	**2**
3	Counter propagation network; adaptive resonance theory, Kohenenself organizing maps.	**2**
4	Auto Associative memories and Bidirectional memories**.**	**2**
5	Fuzzy sets & membership ,Operation & properties of classical sets, Fuzzy set operation and properties of fuzzy sets, Features of MF, standard forms and boundaries, Fuzzification, Membership value of assignments, fuzzy sets and fuzzy relations, de-fuzzificationmethods.Fuzzy Rule Based Systems,	**3**
6	Applications of neural networks and fuzzy controllers in Engineering.	**3**

Lab Work:

Sr.No	Lab contents	No. of Hours
1	NN based control-1	**02**
2	NN based control-2	**02**
3	FLC based control-1	**02**
4	FLC based control-2	**02**
5	Project 1	**02**
6	Project 2	**02**
7	Project 3	**02**

Course Outcomes:

At the end of the course, students will be able :	
1	To develop ANN models and fuzzy logic theory .
2	To apply concepts of fuzzy control
3	To apply control applications of these to engineering problems.

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	S. Bassis, A. Esposito, F.C. Morabito, Ed.,*Advances in neural networks: computational and theoretical issues*. Springer.	**2015**
2	N. Siddique, *Intelligent control: a hybrid approach based on fuzzy logic, neural networks and genetic algorithms*. Springer.	**2013**
3	L. Belera, and I. Kar,*Intelligent systems and control: Principles and Applications.*Oxford University Press.	**2009**
4	M. Norgaard, O. Ravn, N.K. Poulsen, andL.K. Hansen,*Neural networks for modelling and control of dynamic systems: a practitioner's handbook*. Advanced textbooks in control and signal processing. Springer.	**2000**
5	S. Rajasekaran, and G.V. Pai, *Neural networks, fuzzy logic and genetic algorithm: synthesis and applications*. PHI Learning Pvt. Ltd.	**2003**
6	F. Matía, G.N. Marichal, E. Jiménez, Eds,*Fuzzy Modeling and Control: Theory and Applications*. Paris, France:Atlantis Press.	**2015**
7	J.R. Timothy, *Fuzzy logic with Engineering Applications*. McGraw Hill, Inc.	**1997**

Classical Books:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	S. Haykin, *Neural Networks – A Comprehensive Foundation*. Macmillan Publishing Co., New York.	**1994**
2	J.M.Jurada,*Introduction to Artificial neural networks*. Jaico Publishers Mumbai.	**1997**
3	Z.X. Cai, *Intelligent control: Principles, techniques and applications*. World Scientific Publishing Company.	**1998**
4	S.V. KartaloPoulos, *Understanding Neural Networks and Fuzzy logic*. PHI.	**1996**
5	J.R. Timothy, *Fuzzy logic with Engineering Applications*. McGraw Hill, Inc.	**1997**

6	G. J. Klir, and B. Yaun, *Fuzzy Sets & Fuzzy logic Theory & applications*. PHI.	**1995**

MOOC on this course are available at:

1)Neural Networks for Machine Learning, Geoffrey Hinton: https://www.coursera.org/learn/neural-networks

2)Neural Networks and Applications, Prof. S. Sengupta, IIT Kharagpur, http://nptel.ac.in/courses/117105084/

3)Introduction to Intelligent Systems and Control**:** http://nptel.ac.in/courses/108104049/

4) Introduction to Fuzzy logic control**:** http://nptel.ac.in/courses/108104049/16

Course Name	**:**	**Supervisory Control and Data Acquisition (SCADA) systems**
Course Code	**:**	**.**
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segment	**:**	**4-6**

Total No. Lectures - 21

Course Objectives:

	The main objectives of this course are:
1.	Acquire knowledge of the fundamentals of SCADA.
2.	Understanding of the components in SCADA and its communication protocols

At the end of this course, the student should be able to acquire knowledge of the fundamentals of SCADA ,its components and its communication protocols

Course Contents:

Sr.No	Course Contents	No. of Lectures
1.	Introduction to Supervisory Control and Data Acquisition.	**2**
2.	SCADA Functional requirements and Components.	**3**
3.	General features, Functions and Applications, Benefits.	**2**
4.	Configurations of SCADA, RTU (Remote Terminal Units) Connections	**3**
5.	SCADA Communication requirements.	**2**
6.	SCADA Communication protocols: Past Present and Future.	**3**
7.	Structure of a SCADA Communications Protocol.	**3**
8.	Industrial Application of SCADA	**3**

Course Outcomes:

After completion of the course,the students will be conversant with various optimization techniques and will be able to apply these techniques to engineering problems.	
1.	List and describe the hardware components, typical communications architectures and software/communication components of a SCADA system.
2.	Describe common SCADA communication protocols and their main characteristics.
3.	Describe common industrial applications of Supervisory Control and Data Acquisition (SCADA) systems

Bibliography:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication/Reprint
1.	S.A. Boyer, SCADA: *Supervisory Control And Data Acquisition*,ISA: The Instrumentation, Systems, and Automation Society	**2010**

2.	J.D. McDonald and M.S. Thomas, *Power System SCADA and Smart Grids*,	**2015**
3.	R. Mehra, PLCs & SCADA : Theory and Practice, CRC Press	**2012**
4.	D. Reynders, E. Wright, and G.Clarke,*Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems*, Elsevier	**2004**
5	D. Bailey, *Practical SCADA for Industry*, Elsevier	**2003**

Course Name	**:**	**Advanced Mechatronics**
Course Code	**:**	
Credits	**:**	**1.5**
L T P	**:**	**3-0-0**
Segments	**:**	**4-6**

Total No. Lectures – 21

Course Objectives:

	The main objectives of this course are:
4.	To impart knowledge and information about design and development of intelligent systems.
5.	To study the control of intelligent systems.

Course Contents:

Sr.No	Course Contents	No. of Lectures
1.	**Understanding Mechatronics :**Basic Components of Mechatronics and Advanced mechatronics Examples : Manufacturing,CNC Robotics, Transportation equipment, Medical equipment, Defense equipment, Space exploration, Sports, Smart homes ,Smart Grid ,Smart City	**03**
2.	**Hardware concept of Mechatronics** : **(i)Transducers and Sensors**: Ultrasonic transducer, Laser ultrasonic, Hall Effect sensor, Variable reluctance sensor, Pressure sensor, and Accelerometer, **(ii)Signal condition devices** : Analog and Digital Circuits and Devices **(iii)Controllers** :Microprocessor based system, Microcontroller based system, Programmable Logic Controller based System **(iv)Actuators:** Mechanical ,Electrical Piezoelectric ,Hydraulic and Pneumatic,Electromechanical.	**06**
3.	**Software concept of mechatronics** : Programming Languages ,Assembly,C,C++ ,Matlab ,Ladder ,Simulink etc. Real time system	**03**
4.	**Advance Mechatronics Approach** : Systems Modeling and Simulation, transfer function, system response,Linear /non-linear system analysis, system stability Digital control Applications, , On- Off Control, Supervisory Controller , Direct Digital Controller ,P-I-D Controller	**05**
5.	System Fault Finding, Trouble Shooting	**01**
6.	**Mecharonics system hands on training and project design & development**: Sensor/transducer system, Signal conditioning ,Controller, Actuator, Advanced design and development approach .	**03**

Course Outcomes:	
1.	After going through this course students will be able to understand the process involved in design ,development and control of intelligent systems .Their knowledge will help to understand working of any intelligent system and think to

	design and develop their own system of intereset.

References:

Sr.No	Name of Book/ Authors/ Publisher	Year of Publication
1.	Tilak Thakur Mechatronics ,Oxford University Press ,2016	**2016**
2.	C. De Silva. Mechatronics: An Integrated Approach. CRC Press, 2005	**2005**
3.	W. Bolton. Mechatronics: A Multidisciplinary Approach. 4th Edition, Pearson, 2008	**2008**

MOOCs on this course are available at:

1. Prof. D. Trumper, Mechatronics, MIT Open Courseware