Course code	Course Name	L-T-P -Credits	Year of Introduction
EE401	Electronic Communication	3-0-0-3	2016

Prerequisite: Nil

Course Objectives

- To introduce the applications of communication technology.
- To understand the methods and techniques used in communication field.

Syllabus:

AM and FM fundamentals-AM and FM transmitters and receivers-Television and radar systems-Digital communication-Satellite communication-Cellular telephone.

Expected outcome

The students will

i. Understand the need of modulation in transferring a signal through either wireless or wired communication systems
ii. Be able to apply analog modulation techniques and receiver fundamentals in analog communication.
iii. Be to apply baseband digital encoding & decoding techniques in the storage / transmission of digital signal through wired channel
iv. Understand the performance of communication systems in the presence of noise and interference

Text Books:

1. Kennedy G., *Electronic Communication Systems*, McGraw-Hill, New York, 2008.
2. Roody and Coolen, *Electronic Communication*, Prentice Hall of India LTD., New Delhi, 2007.

References:

1. William Scheweber, *Electronic Communication Systems*, Prentice Hall of India LTD, New Delhi, 2004.
2. Wayne Tomasi, *Electronic Communication Systems*, Prentice Hall of India LTD, New Delhi, 2004.
3. Frank R. Dungan, *Electronic Communication Systems*, 3/e, Vikas Publishing House, 2002.
4. Simon Haykins, *Communication Systems*, John Wiley, USA, 2006.
5. Bruce Carlson. *Communication Systems*, Tata McGraw Hill, New Delhi, 2001.
6. Taub and Schilling, *Principles of Communication Systems*, McGraw-Hill, New York, 2008.
7. Anokh Singh, *Principles of Communication Engineering*, S. Chand and Company Ltd., Delhi.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	**AM and FM fundamentals** AM – Frequency spectrum – vector representation – power relations – generation of AM – DSB, DSB/SC, SSB, VSB FM – frequency spectrum – power relations	6	15%
II	**AM and FM transmitters and receivers** Block diagrams of low power and high power AM transmission - AM receivers: straight receivers super hetrodyne receiver - choice of intermediate frequency - simple AVC circuit Block diagrams of direct FM transmitter and Armstrong transmitter - FM receivers (balanced - slope detector and Foster-Seely discriminator only).	8	15%
FIRST INTERNAL EXAMINATION			

III	**Television and radar systems** Principles of television engineering - Requirements and standards – need for scanning - types of camera tubes and picture tubes - B/W and colour systems - PAL - CCTV - Cable TV-high definition television. Radar and navigation: principle of radar and radar equation, block schematics of pulsed radar.	8	15%
IV	**Digital communication:** Principles of digital communication – - Sampling process-pulse modulation Techniques- sampling process-PAM, PWM and PPM concepts - PCM encoder and decoder Applications of data communication	6	15%
SECOND INTERNAL EXAMINATION			
V	**Satellite communication** Multiple access (MA) techniques-FDMA, TDMA, CDMA, SDMA - applications in satellite communication wire, MA techniques applications in wired communication. in satellite communication, earth station; Fibers – types: sources, detectors used, digital filters, optical link	8	20%
VI	**Cellular telephone -** Basic concepts, frequency reuse, interference cell splitting, sectoring, cell system layout, cell processing. Fibers – types: sources, detectors used, digital filters, optical link: Bluetooth, Zig-Bee, GPS, Wi-Fi, Wi-Max based communication	6	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks: 100 Exam Duration: 3Hourrs.

Part A: 8 compulsory questions.
One question from each module of Modules I - IV; and two each from Module V & VI.
Student has to answer all questions. (8 x5)=40

Part B: 3 questions uniformly covering Modules I & II. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part C: 3 questions uniformly covering Modules III & IV. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part D: 3 questions uniformly covering Modules V & VI. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Course code	Course Name	L-T-P - Credits	Year of Introduction
EE402	Special Electrical Machines	3-0-0-3	2016

Prerequisite: Nil

Course Objectives

- To get an overview of some of the special machines for control and industrial applications

Syllabus

AC Servomotors – construction – operation - DC servomotors – Stepper motor – operation – types-modes of excitation – AC series motor – Universal motor – Hysteresis motor – Reluctance motor – Switched reluctance motor – Permanent magnet DC motor – Brushless DC motor – Linear motors – Linear induction motors.

Expected outcome.

- The students will gain knowledge in the construction and principle of operation of certain special electrical machines having various applications.

Text Book:

E. G. Janardhanan, '*Special Electrical Machines*' PHI Learning Private Limited.

References:

1. Irving L. Kosow.'*Electrical Machinery and Transformers*', Oxford Science Publications.
2. T. J. E. Miller, '*Brushless PM and Reluctance Motor Drives*'.C.Larendon Press, Oxford.
3. Theodore Wildi, '*Electric Machines, Drives and Power Systems*', Prentice Hall India Ltd.
4. Veinott & Martin,'*Fractional & Subfractional hp Electric Motors*'.McGraw Hill International Edn.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	AC Servomotors- Construction-principle of operation – performance characteristics – damped AC servomotors – Drag cup servomotor – applications. DC servomotors – field and armature controlled DC servomotors – permanent magnet armature controlled – series split field DC servomotor.	7	15%
II	Stepper motors – Basic principle – different types – variable reluctance- permanent magnet – hybrid type – comparison – theory of operation – monofilar and bifilar windings – modes of excitation – drive circuits – static and dynamic characteristics – applications	7	15%
	FIRST INTERNAL EXAMINATION		
III	Single phase special electrical machines – AC series motor-construction – principle of working – phasor diagram – universal motor Hysteresis motor- constructional details- principle of operation – torque-slip characteristics – applications.	7	15%
IV	Reluctance motors – principle of operation – torque equation – torque slip characteristics-applications. Switched reluctance motors – principle of operation – power converter circuits – torque equation – different types – comparison – applications.	7	15%

SECOND INTERNAL EXAMINATION			
V	Permanent Magnet DC Motors – construction – principle of working. Brushless dc motor – construction – trapezoidal type-sinusoidal type – comparison – applications.	7	20%
VI	Linear motors – different types – linear reluctance motor – linear synchronous motors – construction – comparison. Linear induction motors – Expression for linear force – equivalent circuit – applications.	7	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks: 100 Exam Duration: 3Hourrs.

Part A: 8 compulsory questions.

One question from each module of Modules I - IV; and two each from Module V & VI.

Student has to answer all questions. (8 x5)=40

Part B: 3 questions uniformly covering Modules I & II. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part C: 3 questions uniformly covering Modules III & IV. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part D: 3 questions uniformly covering Modules V & VI. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

COURSE CODE	COURSE NAME	L-T-P-CREDITS	YEAR OF INTRODUCTION
EE403	DISTRIBUTED GENERATION AND SMART GRIDS	3-0-0-3	2016

Prerequisite: Nil

Course objective.

- To develop a conceptual introduction to various distributed generation systems, micro grids, smart grids and their control

Syllabus:

Introduction to distributed generation and smart grids - Distributed Energy Resources – Micro Grids and their control – Protection issues for Microgrids - Smart Grids: Components – NIST Reference architecture – Smart meters - Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU) - demand response- Demand Side Management - Smart Substations, HAN, NAN, SANET, Cloud computing in smart grid – Power Quality issues with smart grid

Expected Outcome:

The students will be able to:

i. Explain various distributed generation systems
ii. Understand the microgrids and their control schemes
iii. Understand various developments happening in the field of Smart Grids.

TEXT BOOKS/REFERENCES:

1. Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, ISBN: 978-0-470-62761-7, Wiley
2. James Momoh, Smart Grid: Fundamentals of Design and Analysis, ISBN: 978-0-470-88939-8, Wiley
3. R. C. Durgan, M. F. Me Granaghen, H. W. Beaty, “Electrical Power System Quality”, McGraw-Hill
4. Remus Teodorescu, Marco Liserre, Pedro Rodriguez, Grid Converters for Photovoltaic and Wind Power Systems, ISBN: 978-0-470-05751-3, Wiley
5. S. Chowdhury, S.P. Chowdhury and P. Crossley, Microgrids and Active Distribution Networks, ISBN 978-1-84919-014-5, IET, 2009

COURSE PLAN

Module	Contents	Hours	End. Sem. Exam. Marks
I	Distributed generation – Introduction - Integration of distributed generation to Grid – Concepts of Micro Grid - Typical Microgrid configurations - AC and DC micro grids - Interconnection of Microgrids - Technical and economical advantages of Microgrid -	7	15%

	Challenges and disadvantages of Microgrid development Smart Grid: Evolution of Electric Grid - Definitions and Need for Smart Grid, Opportunities, challenges and benefits of Smart Grids		
II	Distributed energy resources: Introduction - Combined heat and power (CHP) systems - Solar photovoltaic (PV) systems – Wind energy conversion systems (WECS) - Small-scale hydroelectric power generation - Storage devices: Batteries: Lead acid, nickel metal hydrate, and lithium ion batteries , ultra-capacitors, flywheels Control of Microgrids: Introduction to Central Controller (CC) and Microsource Controllers (MCs) - Control functions for microsource controller, Active and reactive power control, Voltage control, Storage requirement for fast load tracking, Load sharing through power-frequency control	6	15%
III	Protection issues for Microgrids: Introduction, Islanding, Different islanding scenarios, Major protection issues of stand-alone Microgrid - Impact of DG integration on electricity market, environment, distribution system, communication standards and protocols. Smart Grid: Components – NIST Smart Grid Reference Architecture Introduction to Smart Meters, Electricity tariff – one part tariff, two tariff and maximum demand tariff - Dynamic pricing: time-of-use (TOU) pricing, critical-peak pricing (CPP) and Real Time Pricing- Automatic Meter Reading(AMR), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation. Intelligent Electronic Devices (IED) and their application for monitoring & protection, Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU).	7	15%
IV	Smart energy efficient end use devices-Smart distributed energy resources- Load Curves-Load Shaping Objectives-Methodologies - Peak load shaving - Energy management-Role of technology in demand response- Demand Side Management – Numerical Problems	7	15%
V	Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood-Area Networks (NANs), Sensor and Actuator Networks (SANETs) Smart Substations, Substation Automation, IEC 61850 Substation Architecture, Feeder Automation.	7	20%

VI	Cloud computing in smart grid: Private, public and Hybrid cloud. Cloud architecture of smart grid. Power quality: Introduction - Types of power quality disturbances - Voltage sag (or dip), transients, short duration voltage variation, Long duration voltage variation, voltage imbalance, waveform distortion, and voltage flicker - Harmonic sources: SMPS, Three phase power converters, arcing devices, saturable devices, fluorescent lamps, harmonic indices (THD, TIF, DIN, C – message weights) Power quality aspects with smart grids.	8	20%

QUESTION PAPER PATTERN:

Maximum Marks: 100 Exam Duration: 3Hourrs.

Part A: 8 compulsory questions.

One question from each module of Modules I - IV; and two each from Module V & VI.

Student has to answer all questions. (8 x5)=40

Part B: 3 questions uniformly covering Modules I & II. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part C: 3 questions uniformly covering Modules III & IV. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part D: 3 questions uniformly covering Modules V & VI. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Course code	Course Name	L-T-P - Credits	Year of Introduction
EE404	INDUSTRIAL INSTRUMENTATION AND AUTOMATION	3-0-0-3	2016

Prerequisite: Nil

Course Objectives

- To impart knowledge about Industrial instrumentation and automation

Syllabus:

Dynamic characteristic of instrumentation- Transducers: Characteristics, Applications – Nano instrumentation - signal conditioning, MEMS, Virtual instrumentation-Automation system - actuators – sequence control, PLC

Expected Outcome:

After the completion of the course, the students will be able to:

i. Select instruments and transducers for various physical variables.
ii. Get an insight on data acquisition, processing and monitoring system
iii. Design various signal conditioning systems for transducers.
iv. Analyze dynamic responses of various systems.
v. Get the concepts of virtual instrumentation
vi. Understand the programming realization of PLC

Text books:

1. Curtis D Johnson ," *Process Control Instrumentation Technology"*, PHI, 1986
2. Doeblin E.O, 'Measurement Systems: Application and Design, Fourth Edition, McGraw Hill, Newyork, 1992
3. DVS. Murty, 'Transducers and Instrumentation' Second Edition, PHI Learning Pvt Ltd New Delhi ,2013
4. Madhuchhanda Mitra, Samarjit Sengupta, 'Programmable Logic Controllers and Industrial Automation An Introduction', Penram International Publishing (India) Pvt Ltd., 2009
5. Mickell. P. Groover 'Automation, Production and computer integrated manufacturing' Prentice Hall of India, 1992
6. Patranabis, D., 'Principles of Industrial Instrumentation', Second Edition Tata McGraw Hill Publishing Co. Ltd.. New Delhi
7. Robert B. Northrop, 'Introduction to instrumentation and measurements', CRC, Taylor and Francis 2005

References:

1. G.K.McMillan, 'Process/Industrial Instrument and control and hand book' McGraw Hill, New York,1999
2. Michael P .Lucas, 'Distributed Control system', Van Nastrant Reinhold Company, New York

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Introduction to Process Control - block diagram of process control loop, definition of elements. Sensor time response - first and second order responses. Review of Transducers: Characteristics and Choice of transducer-	6	15%

	factors influencing choice of transducer		
II	Applications of Transducers Displace measurement: Resistance potentiometer, Capacitive and Inductive. Capacitive differential pressure measurement Torsional, shearing stress and rotating shaft Torque measurement using strain gauge. Flow measurement :Hotwire anemometer, constant resistance Constant current type Eddy current sensors, Variable reluctance tachometers Phase measurement :Analog and digital phase detectors Nano Instrumentation	8	15%
FIRST INTERNAL EXAMINATION			
III	Signal conditioning circuits-Instrumentation amplifiers- Unbalanced bridge. Bridge linearization using op amp Precision rectifiers, Log amplifiers, Charge amplifiers, Isolation amplifier, Switched capacitor circuits, Phase sensitive detectors, Noise problem in instrumentation and its minimisation	7	15%
IV	Micro Electromechanical system (MEMS) Advantages and Applications, MEMS micro sensors and actuators, Manufacturing process: Bulk micro machining and surface micromachining, MEMS accelerometers Virtual instrumentation system: architecture of virtual instruments – Virtual instruments and traditional instruments – concepts of graphical programming	7	15%
SECOND INTERNAL EXAMINATION			
V	Overview of Automation System - Architecture of Industrial Automation Systems, Different devices used in Automation Actuators, definition, types, selection. Pneumatic, Hydraulic, Electrical, Electro-Pneumatic and valves , shape memory alloys	7	20%
VI	Introduction to Sequence Control, PLCs - Working, Specifications of PLC Onboard/Inline/Remote IO's, Comparison of PLC & PC, Relay Ladder Logic- PLC Programming- realization of AND, OR logic, concept of latching, Introduction to Timer/Counters, Exercises based on Timers, Counters. Basic concepts of SCADA, DCS and CNC	7	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks: 100 Exam Duration: 3Hourrs.

Part A: 8 compulsory questions.

One question from each module of Modules I - IV; and two each from Module V & VI.

Student has to answer all questions. (8 x5)=40

Part B: 3 questions uniformly covering Modules I & II. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part C: 3 questions uniformly covering Modules III & IV. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part D: 3 questions uniformly covering Modules V & VI. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Course code	Course Name	L-T-P - Credits	Year of Introduction
EE405	Electrical System Design	3-1-0-4	2016

Prerequisite : Nil

Course Objectives

- To gain the knowledge of acts and rules used for regulating the electrical supply in our country.
- To impart sound knowledge in the design and estimation of low voltage and medium voltage electrical installations.
- To gain the knowledge of selection of distribution transformers and their installations.
- To gain the knowledge of Earthing designs in different installations and the standard dimensions of earthing systems.

Syllabus

Electrical system design practices – general awareness of IS Codes, Electricity Acts & Rules, NEC etc. Domestic Installations, Motor Installations, 11 kV substation installations. Cinema theatre, auditorium and high rise building installations. Standby generator selection and their Installations. Underground cable installations and their accessories. Types of earthing, lightning arresters, fire fitting and lifts.

Expected outcome

The students will

i. Know the basic Rules and regulations in electrical installations.
ii. To prepare the schematic diagram, installation plan, quantity of materials and estimate for different electrical installations.

Text Book:

1. J. B. Gupta, A Course in Electrical Installation Estimating and Costing, S.K. Kataria & Sons; Reprint 2013 edition (2013).
2. K. B. Raina, S. K. Bhattacharya, Electrical Design Estimating Costing, NEW AGE; Reprint edition (2010).
3. M.K.Giridharan, Electrical Systems Design, , M/s I K International Publishers, New Delhi, 2nd edition, 2016

Data Book (Approved for use in the examination):

M K Giridharan, Electrical Systems Design Data Hand book, , M/s I K International Publishers , New Delhi, 2011

References:

1. National Electric Code, Bureau of Indian Standards publications, 1986.
2. Relevant Indian Standard – specifications (IS – 732, IS – 746, IS – 3043, IS – 900), etc.
3. S.L.Uppal, Electrical Wiring Estimating & Costing, Khanna Publishers (2008)

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	General awareness of IS Codes (IS 3043, IS 732, IS 2675, IS 5216-P1-2, IS 2309), The Indian Electricity Act 1910, The Indian Electricity supply Act 1948, Indian Electricity Rules 1956, The Electricity Regulatory Commission Act 1998, Electricity Act 2003, Bureau of Energy Efficiency (BEE) and its labeling. National Electric Code (NEC) - scope and safety aspects applicable to low and medium (domestic) voltage installations, Electric services in buildings, Classification of voltages, standards and specifications.	8	15%
II	Safety aspects applicable to low and medium voltage installations. General aspects of the design of electrical installations for domestic dwellings (low and medium voltage installations)–connected load calculation, sub circuit determination, selection of main distribution board, sub distribution board, MCB, ELCB, MCCB and cables for sub	10	15%

	circuits. Pre-commissioning tests of domestic installations.		
FIRST INTERNAL EXAMINATION			
III	Medium and HV installations – selection of cables and cable glands, guidelines for cable installation in detail. Panel boards: LT & HT control panel boards. Installation of induction motors: Design of distribution systems with light power and motor loads. Design of automatic power factor correction (APFC) Panel. Selection and installation of transformers, switchgears and protective devices – Design of indoor and outdoor 11 kV substation upto 630 kVA.	10	15%
IV	Air-conditioning loads and its specifications. Energy conservation techniques. Selection of standby generator – installation and its protection. Introduction to Automatic Main Failure (AMF) System. Pre-commissioning tests of cables, transformers and generators.	8	15%
SECOND INTERNAL EXAMINATION			
V	Design of earthing system for an HT consumer, Dimensions and drawings of typical earth electrodes (1) Pipe Earthing, (2) Plate Earthing. Touch, Step and Transfer potentials at EHT Sub-Stations, Earth-mat, installations of special equipment like X-Ray, Neon-Sign, Basics of lightning arresters.	8	20%
VI	Design of illumination systems – Yard lighting, street lighting and flood lighting. Kerala Cinema Regulation Act – 1958, design and layout of installation for recreational or assembly buildings, cinema theatre and high rise building. Design of Electrical system related to firefighting, lifts and escalators.	10	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks: 100 Exam Duration: 3Hourrs.

Part A: 8 compulsory questions.

One question from each module of Modules I - IV; and two each from Module V & VI.

Student has to answer all questions. (8 x5)=40

Part B: 3 questions uniformly covering Modules I & II. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part C: 3 questions uniformly covering Modules III & IV. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part D: 3 questions uniformly covering Modules V & VI. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Course code.	Course Name	L-T-P - Credits	Year of Introduction
EE407	DIGITAL SIGNAL PROCESSING	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To impart knowledge about digital signal processing and its applications in engineering

Syllabus

Introduction to signals and systems – Discrete Fourier Transforms – Fast Fourier Transforms - Introduction to FIR and IIR systems - FIR filter design - Finite word length effects in digital Filters - Introduction to FDA Toolbox in MATLAB - Introduction to TMS320 Family - Design & Implementation and Filter Structures - Introduction to Code Composer Studio

Expected outcome .

The students will be able to:

i. Analyse DT systems with DFT
ii. Design digital filters IIR and FIR filters
iii. Analyse finite word length effects in signal processing
iv. Design filters using Matlab FDA tool box
v. Understand Digital Signal Controllers and their Applications

Text Books:

1. Alan V.Oppenheim, Ronald W. Schafer & Hohn. R.Back, "Discrete Time Signal Processing", Pearson Education, 2nd edition, 2005.
2. Emmanuel.C..Ifeachor, & Barrie.W.Jervis, "Digital Signal Processing", Second editi on, Pearson Education / Prentice Hall, 2002.
3. John G. Proakis & Dimitris G.Manolakis, "Digital Signal Processing Principles, Algorithms &Applications", Fourth edition, Pearson education / Prentice Hall, 2007

References:

1. Johny R. Johnson, Introduction to Digital Signal Processing, PHI, 2006.
2. P.P.Vaidyanathan, Multirate Systems & Filter Banks, Prentice Hall, Englewood cliffs, NJ, 1993.
3. S.K. Mitra, Digital Signal Processing, A Computer Based approach, Tata Mc GrawHill, 1998.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Introduction to signals and systems - Discrete Fourier transform: Frequency domain sampling, Discrete Fourier transform (DFT): DFT pair, properties of DFT, frequency response analysis of signals using the DFT, circular convolution using DFT , linear filtering based on DFT Fast Fourier transform (FFT); Introduction, Radix -2 decimation in time FFT algorithm, Radix-2 decimation in frequency algorithm.	7	15%
II	Introduction to FIR and IIR systems : Structures for realization of discrete time systems – structures for FIR and IIR systems – signal flow graphs, direct-form, cascade-form, parallel form, lattice and transposed structures and linear Phase FIR filters.	7	15%
	FIRST INTERNAL EXAMINATION		
III	Design of digital filters – general considerations – causality and its	7	15%

	implications, characteristics of practical frequency selective filters IIR filter design : Discrete time IIR filter (Butterworth and Chebyshev) from analog filter – IIR filter (LPF, HPF, BPF, BRF) design by Impulse Invariance, Bilinear transfor mation, Approximation of derivatives. filter design		
IV	FIR filter design : Structures of FIR filter- Linear phase FIR filter – Filter design using windowing techniques, frequency sampling techniques	7	15%
SECOND INTERNAL EXAMINATION			
V	Finite word length effects in digital Filters : Fixed point and floating point number representations - Comparison - Truncation and Rounding errors - Quantization noise - derivation for quantization noise power - coefficient quantization error - Product quantization error - Overflow error – Round-off noise power - limit cycle oscillations due to product round-off and overflow errors - signal scaling **Introduction to FDA Toolbox in MATLAB:** Design of filters using FDA toolbox (**Demo/Assignment only**)	7	20%
VI	Introduction to TMS320 Family: Architecture, Implementation, C24x CPU Internal Bus Structure, Memory Central Processing unit , Memory and I/O Spaces , Overview of Memory and I/O Spaces, Program control Address Modes System Configuration and Interrupts clocks and low Power Modes Digital input / output (I/O), Assembly language Instruction , Instruction Set summary , Instruction Description, Accumulator, arithmetic and logic Instruction , Auxiliary Register and data page Pointer Instructions , TREG, PREG, and Multiply Instruction ,Branch Instructions , Control Instructions I/O and Memory Instruction **Design & Implementation and Filter Structures:** MATLAB functions and TMS320 Implementation (**Demo/Assignment only**) **Introduction to Code Composer Studio** (**Demo only**)	7	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks: 100 Exam Duration: 3Hourrs.

Part A: 8 compulsory questions.

One question from each module of Modules I - IV; and two each from Module V & VI.

Student has to answer all questions. (8 x5)=40

Part B: 3 questions uniformly covering Modules I & II. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part C: 3 questions uniformly covering Modules III & IV. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part D: 3 questions uniformly covering Modules V & VI. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Course code	Course Name	L-T-P - Credits	Year of Introduction
EE409	Electrical Machine Design	3-0-0-3	2016

Prerequisite: EE202 & EE205

Course Objectives

- To impart knowledge on principles of design of static and rotating electrical machines.
- To give a basic idea about computer aided design (CAD) and finite element method.

Syllabus

Machine design basic principles, Heating and cooling of electrical machines, Magnetic circuit design, Design of - Dc machine, Synchronous machine , Three phase induction motor, Computer aided design, Finite element method.

Expected outcome

- The students will be able to design transformers, DC machines, synchronous machines and induction motors

Text Book:

1. A K Sawhney, " A Course in Electrical Machine Design", Dhanpat rai *and* sons, Delhi.

References:

1. M. V. Deshpande, " Design and Testing of Electrical Machines", Wheeler Publishing.
2. R. K. Agarwal, " Principles of Electrical Machine Design", Essakay Publications, Delhi.
3. Ramamoorthy M, "Computer Aided Design of Electrical Equipment", East-West Press.
4. M. N. O. Sadiku, " Numerical techniques in Electromagnetics", CRC Press Edition-2001.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Principles of electrical machine design - General design considerations - specifications of machines - types of enclosures - types of ventilation - heating - short time rating - overload capacity - temperature rise time curve - hot spot rating. Magnetic circuit calculation - calculation of field ampere turns - air gap mmf - effect of slot and ventilating duct - active iron length - mmf for teeth - real and apparent flux densities - mmf per pole Magnetic Leakage Calculation- Effects of Leakage. Armature Leakage –Components. Unbalanced Magnetic Pull-Practical aspects of unbalanced magnetic pull	8	15%
II	Design of transformers - single phase and three phase transformers - distribution and power transformers - output equation - core design - window area - window space factor - overall dimensions of core. Windings – no. of turns - current density - conductor section - Cooling of transformers	6	15%
FIRST INTERNAL EXAMINATION			
III	Design of DC machines - output equation - specific loading - choice of speed and no of poles - calculation of main dimensions - choice of type of winding - number of slots - number of conductors per slot-current density - conductor section - slot insulation -	8	15%

	length of air gap - design of field winding - conductor cross section - height of pole - design of inter pole - flux density under inter pole - calculation of turns of inter polar winding – design of compensating winding – brushes and commutators.		
IV	Design of synchronous machines - specific loading - output equation - main dimensions - types of winding - number of turns - number of slots and slot design - field design for water wheel and turbo alternators - cooling of alternators.	6	15%
SECOND INTERNAL EXAMINATION			
V	Design of three phase induction motors - main dimensions - stator design - squirrel cage and slip ring types - number of stator and rotor slots - rotor bar current - design of rotor bar - end ring current - design of end ring - design of slip ring rotor winding.	7	20%
VI	Introduction to computer aided design. Analysis and synthesis methods -hybrid techniques. Introduction to Finite element method - historical background, applications, advantages. Study of new computer aided machine software using Finite Element Case study: Complete design of an ac machine –steps.(Assignment only)	7	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks: 100 Exam Duration: 3Hourrs.

Part A: 8 compulsory questions.

One question from each module of Modules I - IV; and two each from Module V & VI.

Student has to answer all questions. (8 x5)=40

Part B: 3 questions uniformly covering Modules I & II. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part C: 3 questions uniformly covering Modules III & IV. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part D: 3 questions uniformly covering Modules V & VI. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Course code.	Course Name	L-T-P - Credits	Year of Introduction
EE431	Power Systems Lab	0-0-3-1	2016

Prerequisite : EE306 Power System Analysis

Course Objectives

- Impart practical knowledge about various power system equipment
- Get a knowledge about the operation of power systems and the philosophy behind the relay settings, fault calculations etc.
- Simulate the power system operations which will be helpful in the design of power systems

List of Exercises/Experiments: (At least 12 experiments out of 18 experiments listed are mandatory**)**

1. **Visit a local Substation.**
   Aim: To see firsthand apparatus that will be studied in this course and learn about their role in operation and protection of power systems.
2. **Introduction to PSCAD/MATLAB/MIPOWER**
   Aim: 1). Learn the usage of PSCAD/MATLAB/MIPOWER in modeling of ac circuits and plotting of results.
   2). Understanding reactive power and power factor in single-phase and three-phase circuits.
3. **Transmission Line and Modeling.**
   Aim: Obtaining the parameters of a 345 kV transmission line and modeling it in PSCAD/MATLAB/MIPOWER
4. **Power Flow**
   Aim: To carry out power flow calculations.
5. **Transformers in Power Flow.**
   Aim: To look at the influence of including a tap-changer and a phase-shifter on power flow and bus voltages.
6. **Including an HVDC Transmission Line for Power Flow.**
   Aim: 1). To include an HVDC transmission line and see its effect on power transfer on other transmission line.
   2). To understand the operating principle of 12-pulse thyristor converters used in HVDC transmission systems.
7. **Power Quality.**
   Aim: To obtain the current harmonics drawn by power electronics interface.
8. **Synchronous Generators.**
   Aim: To obtain the effect of sudden short-circuit on a synchronous generator output.
9. **Voltage Regulation.**
   Aim: 1). To study the effect of real and reactive powers on bus voltages.
   2). Understanding the operation of a Thyristor Controlled Reactor (TCR).
10. **Transient Stability.**
    Aim: To simulate transient stability in a 3-bus example power system.

10. **A. Making a Power System Reliable.**
    Aim: 1). To understand the planning/design process that goes into making a power system reliable.

11. AGC and Economic Dispatch.

Aim: Study the dynamic interaction between two control areas using *Simulink* modeling and economic dispatch.

12. Short Circuit Faults and Overloading of Transmission Lines.

Aim: To study the effect of short-circuit faults and overloading of transmission lines.

12.A. Fault Analysis with Relay Settings.

Aim : To study a power system with faults and determine relay settings based on calculated fault currents

13. Switching Over-Voltages and Modeling of Surge Arresters.

Aim. : To study over-voltages resulting from switching of transmission lines and limiting them by sing ZnO arresters

14. Power Factor improvement:

Aim : To calculate rating of capacitors for power factor correction for a load and verifying it experimentally.

15. Solar Power Calculations :

Aim : To calculate the rating of solar panel required for a given area on rooftop or for a given load

16. Demonstration of Ferranti Effect on a transmission line

17. Methods of Insulation Testing

18. Modern Energy Meter calibration schemes

Expected outcome.

- Students will be able to design, setup and analyse various power systems and its simulations.

Text Book:

Ned Mohan, First Course in Power Systems , Wiley.

Course code	Course Name	L-T-P -Credits	Year of Introduction
EE461	Modern Operating Systems	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To impart the knowledge on the need and requirement of an interface between Man and Machine.
- To teach the features of operating systems and the fundamental theory associated with process, memory and file management components of operating systems.

Syllabus :

Operating System Structure, Operating system services, Process management, Memory management, File management, Storage structure, security issues.

Expected outcome.

The students will be able to

i. describe the general architecture of computers
ii. describe, contrast and compare differing structures for operating systems
iii. understand and analyse theory and implementation of: processes, resource control (concurrency etc.), physical and virtual memory, scheduling, I/O and files

Text Book:

William Stallings, Operating Systems: Internals and Design Principles, 6 th Ed., Pearson Education

References:

1. Nutt G.J., Operating Systems, 3 rd Ed., Pearson Education.
2. Silberschatz, Galvin, & Gagne, Operating System Concepts, 8 th Ed., Wiley
3. Tanenbaum A.S., Modern Operating Systems, 3 rd Ed., Prentice Hall

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Introduction-Definition– Operating System Structure- Operating System Operations, Process Management- Memory Management- Storage Management- Protection and Security- Distributed Systems-	7	15%
II	Computing Environments- Open Source Operating Systems- Operating-System Services- User Operating-System Interface- System Calls- Types of System Calls- System Programs	7	15%
	FIRST INTERNAL EXAMINATION		
III	Process Management- Process Concept- Operations on Processes- Threads Overview- Multithreading Models- Thread Libraries- Threading Issues - CPU Scheduling- Basic Concepts- Scheduling Criteria- Scheduling Algorithms- Thread Scheduling- Multiple-Processor Scheduling- Process Synchronisation-	6	15%
IV	Memory Management-Swapping- Contiguous Memory Allocation- Paging Segmentation- Virtual Memory- Demand Paging	6	15%

SECOND INTERNAL EXAMINATION			
V	- File Management- File-System Interface- File Concept- Access Methods - Directory and Disk Structure - File-System Mounting - File Sharing- Protection- File-System Implementation- File-System Structure- File-System Implementation- Directory Implementation- Allocation Methods Free-Space Management - Efficiency and Performance	8	20%
VI	Mass Storage Structure- Disk Scheduling- Disk Management- RAID Structure - Stable Storage Implementation- Protection and Security- Protection- Goals of Protection- Principles of Protection- Domain of Protection- Access Matrix Implementation of Access Matrix- Access Control- Revocation of Access Rights Security- The Security Problem -Program Threats- System and Network Threats	8	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks: 100 Exam Duration: 3Hourrs.

Part A: 8 compulsory questions.

One question from each module of Modules I - IV; and two each from Module V & VI.

Student has to answer all questions. (8 x5)=40

Part B: 3 questions uniformly covering Modules I & II. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part C: 3 questions uniformly covering Modules III & IV. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part D: 3 questions uniformly covering Modules V & VI. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Course code	Course Name	L-T-P -Credits	Year of Introduction
EE462	Design of Digital Control Systems	3-0-0-3	2016

Prerequisite: Nil

Course Objectives

- To introduce the need and concept of digital control system.
- To impart knowledge about different strategies adopted in the design of digital controllers.
- To familiarize with the design of different types of digital controllers.

Syllabus

Basic digital control system-Pulse transfer function-Digital PID controller design- compensator design using frequency response - compensator design using root locus - Direct design-method of Ragazzini - Dead-beat controller design - State space analysis and controller design.

Expected outcome.

On successful completion, the students will have the ability to

i. design digital controllers.
ii. analyse discrete time system using state space methods.
iii. analyse the stability of discrete time system.

Text Books:

1. Benjamin C. Kuo, Digital Control Systems, 2/e, Saunders College Publishing, Philadelphia, 1992.
2. C. L. Philips, H. T. Nagle, Digital Control Systems, Prentice-Hall, Englewood Cliffs, New Jersey, 1995.
3. M. Gopal, Digital Control and State Variable Methods, Tata McGraw-Hill, 1997
4. Ogata K., Discrete-Time Control Systems, Pearson Education, Asia.

References:

1. Constantine H. Houpis and Gary B. Lamont, Digital Control Systems Theory, Hardware Software, McGraw Hill Book Company, 1985.
2. Isermann R., Digital Control Systems, Fundamentals, Deterministic Control, V. I, 2/e, Springer Verlag, 1989.
3. Liegh J. R., Applied Digital Control, Rinchart & Winston Inc., New Delhi.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Basic digital control system- Examples - mathematical model-ZOH and FOH- choice of sampling rate-principles of discretization - Mapping between s-domain and z-domain	7	15%
II	Pulse transfer function- Different configurations for the design- Modified z-transform-Time responses of discrete data systems-Steady state performance.	7	15%
	FIRST INTERNAL EXAMINATION		
III	Digital PID and Compensator Design: Design of digital PID controller, Design of lag, lead compensators - based on frequency response method.	7	15%
IV	Digital Controller Design: Design based on root locus in the z-plane, direct design - method of Ragazzini. Dead-beat response design- Deadbeat controller.	7	15%
	SECOND INTERNAL EXAMINATION		
V	State variable model of discrete data systems -Various canonical form representations-controllable, observable, diagonal and Jordan forms-Conversion from state space to transfer function -Computation of state transition matrix using Cayley-Hamilton theorem and z-transform method	7	20%

VI	Digital state feedback controller design: Complete state and output Controllability, Observability, stabilizability and reachability - Loss of controllability and observability due to sampling.Pole placement design using state feedback for SISO systems.	7	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks: 100 Exam Duration: 3Hourrs.

Part A: 8 compulsory questions.

One question from each module of Modules I - IV; and two each from Module V & VI.

Student has to answer all questions. (8 x5)=40

Part B: 3 questions uniformly covering Modules I & II. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part C: 3 questions uniformly covering Modules III & IV. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part D: 3 questions uniformly covering Modules V & VI. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Course code	Course Name	L-T-P - Credits	Year of Introduction
EE463	Computer Aided Power Systems Analysis	3-0-0-3	2016

Prerequisite: EE306 Power system analysis

Course Objectives

- To introduce computer applications in the analysis of power systems
- To understand the solution methods and techniques used in power system studies

Syllabus:

Development of network matrices from Graph theory-Formulation of Bus Impedance matrices-Load Flow Analysis-Optimal Power Flow-Network fault calculations-Contingency analysis in Power systems.

Expected outcome:

- The students will gain the ability to critically analyse the solution methods used in power system studies.

Text Books:

1. Arthur R. Bergen, Vijay Vittal, Power Systems Analysis (English) 2nd Edition, Pearson Higher Education
2. G.L.Kusic, Computer Aided Power System Analysis, PHI, 1989
3. John J. Grainger, William D. Stevenson, Jr., Power System Analysis, Tata McGraw-Hill Series in Electrical and Computer Engineering.
4. M. A. Pai, Computer Techniques in Power Systems Analysis, Tata McGraw-Hill, Second edition 2005

References:

1. I.J.Nagrath and D.P.Kothari, "Modern Power System Analysis", Tata McGraw Hill, 1980
2. J. Arriliga and N.R. Watson, Computer modelling of Electrical power systems, 2/e, John Wiley, 2001
3. LP. Singh, “Advanced Power System Analysis and Dynamics”, 3/e, New Age Intl, 1996.
4. Stagg and El Abiad, "Computer methods in Power system Analysis", McGraw Hill,1968.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Overview of Graph theory -tree, co-tree and incidence matrix, Development of network matrices from Graph theoretic approach. Review of solution of Linear System of equations by Gauss Jordan method, Gauss elimination, LDU factorization.	7	15%
II	Bus Reference Frame: Injections and Loads. Zbus and Y bus. Formulation of Bus Impedance matrix for elements without Mutual Coupling.	7	15%
	FIRST INTERNAL EXAMINATION		
III	Inversion of YBUS for large systems using LDU factors, Tinney's Optimal ordering. Review of Gauss-Seidel Iteration using YBUS, Newton-Raphson method, Fast Decoupled Load Flow (FDLF) DC load flow, Three-phase Load Flow.	6	15%
IV	Adjustment of network operating conditions, Optimal power flow: concepts, active/reactive power objectives (Economic dispatch, MW and MVAr loss minimization) – applications- security constrained optimal power flow.	8	15%
	SECOND INTERNAL EXAMINATION		

V	Network fault calculations using ZBUS and YBUS Table of Factors, Algorithm for calculating system conditions after fault – three phase short circuit, three phase to ground, double line to ground, line to line and single line to ground fault.	7	20%
VI	Contingency analysis in Power systems : Contingency Calculations using ZBUS and YBUS Table of Factors. State estimation – least square and weighted least square estimation methods for linear systems.	7	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks: 100 Exam Duration: 3Hourrs.

Part A: 8 compulsory questions.
One question from each module of Modules I - IV; and two each from Module V & VI.
Student has to answer all questions. (8 x5)=40

Part B: 3 questions uniformly covering Modules I & II. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part C: 3 questions uniformly covering Modules III & IV. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part D: 3 questions uniformly covering Modules V & VI. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Course code	Course Name	L-T-P - Credits	Year of Introduction
EE464	Flexible AC Transmission Systems	3-0-0-3	2016

Prerequisite: Nil

Course Objectives

- To introduce various Power Electronics controllers used in the Power Systems for the fast real and reactive power control.

Syllabus

Power flow control - Benefits of FACTS -Transmission line compensation. Uncompensated line - shunt and series compensation .Reactive power compensation . Static shunt and series compensators - Static Voltage and Phase Angle Regulators (TCVR &TCPAR). Switching Converter type shunt and series Compensators - principle of operation, configuration and control. Unified Power Flow Controller

Expected outcome .

The students will be able to:

- Understand various power electronics based FACTS devices for the control of active and reactive power in the system
- Understand the control schemes of various FACTS devices.

References:

1. Hingorani and L Gyugyi, “Understanding FACTS”, IEEE Press, 2000
2. J Arriliga and N R Watson, "Computer modeling of Electrical Power Systems”, Wiley, 2001 T J E Miller, "Reactive Power Control in Power Systems'', John Wiley, 1982
3. K R Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age International Publishers, 2007
4. Ned Mohan et. al "Power Electronics”, John Wiley and Sons.
5. Y.H. Song and A.T. Johns, “Flexible ac Transmission Systems (FACTS)”, IEE Press, 1999

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Power flow in Power Systems – Steady-state and dynamic problems in AC systems – Voltage regulation and reactive power flow control in Power Systems – control of dynamic power unbalances in Power System Power flow control -Constraints of maximum transmission line loading - Benefits of FACTS - Transmission line compensation: Compensation by a series capacitor connected at the midpoint of the line, Shunt Compensation connected at the midpoint of the line -Phase angle control	7	15%
II	Reactive power compensation – shunt and series compensation principles – reactive compensation at transmission and distribution level – Static versus passive VAr Compensators	6	15%
	FIRST INTERNAL EXAMINATION		
III	Static shunt Compensator - Objectives of shunt compensations, Methods of controllable VAR generation -		15%

	Variable impedance type VAR Generators -TCR , TSR, TSC, FC-TCR Principle of operation, configuration and control Static Series compensator - Objectives of series compensations, Variable impedance type series compensators - TCSC - Principle of operation, configuration and control.	8	
IV	Static Voltage and Phase Angle Regulators (TCVR & TCPAR): Objectives of Voltage and Phase angle regulators Thyristor controlled Voltage and Phase angle Regulators	7	15%
SECOND INTERNAL EXAMINATION			
V	Switching converter type shunt Compensators.- Principle of operation, configuration and control , Comparison between SVC and STATCOM- Applications Switching converter type Series Compensators-(SSSC)- Principle of operation, configuration and control	7	20%
VI	Unified Power Flow Controller: Circuit Arrangement, Operation and control of UPFC General Equivalent Circuit for Facts Controllers (Shunt+series) Introduction to interline power flow controller.	7	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks: 100 Exam Duration: 3Hourrs.

Part A: 8 compulsory questions.

One question from each module of Modules I - IV; and two each from Module V & VI. Student has to answer all questions. (8 x5)=40

Part B: 3 questions uniformly covering Modules I & II. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part C: 3 questions uniformly covering Modules III & IV. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part D: 3 questions uniformly covering Modules V & VI. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Course code	Course Name	L-T-P - Credits	Year of Introduction
EE465	Power Quality	3-0-0-3	2016

Prerequisite: Nil

Course Objectives:

- To discuss various power quality issues and different methods to control them.

Syllabus:

Power quality issues in distribution systems, Need for power quality monitoring, IEEE guides, standards and recommended practices, Modelling of networks and components under non sinusoidal conditions, Harmonic Analysis, Effects of Power System harmonics on Power System equipment and loads, Harmonic elimination, Power Quality Management in Smart Grid, Electromagnetic Interference.

Expected Outcome:

- The students will be able to identify the power quality problems, causes and suggest suitable mitigating techniques.

References:

1. Angelo Baggini (Ed.) *Handbook of Power Quality,* Wiley, 2008
2. C. Sankaran, *'Power Quality',* CRC Press, 2002
3. G. T. Heydt, *'Power Quality',* Stars in circle publication, Indiana, 1991
4. Jose Arillaga, Neville R. Watson, *'Power System Harmonics',* Wiley, 1997
5. Math H. Bollen, *'Understanding Power Quality Problems'* Wiley-IEEE Press, 1999
6. R. C. Durgan, M. F. Me Granaghen, H. W. Beaty, *'Electrical Power System Quality',* McGraw-Hill

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Power quality phenomenon - Sources and Effects of power quality problems, types of power quality disturbances - Voltage sag (or dip), Swell, Transients, short duration voltage variation, Long duration voltage variation, voltage imbalance, waveform distortion, and voltage flicker	6	15%
II	IEEE guide lines, standards and recommended practices. Harmonics -mechanism of harmonic generation-harmonic indices (THD, TIF, DIN, C – message weights - Power Quality Costs Evaluation -. Harmonic sources – Switching devices, arcing devices, saturable devices. Effects of Power System harmonics on Power System equipment and loads.	7	15%
FIRST INTERNAL EXAMINATION			
III	Harmonic Analysis - Fourier series and coefficients, the Fourier transforms, discrete Fourier transform, fast Fourier transform, Window function- numerical problems. .	5	15%
IV	Power quality Monitoring considerations: Power line disturbance analyzer, power quality measurement equipment, harmonic spectrum analyzer, flicker meters, disturbance analyzer	7	15%
SECOND INTERNAL EXAMINATION			

V	Harmonic elimination - Design and analysis of filters to reduce harmonic distortion – Power conditioners ,passive filter, active filter - shunt , series, hybrid filters,	7	20%
VI	Power Quality Management in Smart Grid: Power Quality in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid. Electromagnetic Interference (EMI -introduction - Frequency Classification - Electrical fields-Magnetic Fields - EMI Terminology - Power frequency fields - High frequency	10	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks: 100 Exam Duration: 3Hourrs.

Part A: 8 compulsory questions.

One question from each module of Modules I - IV; and two each from Module V & VI.

Student has to answer all questions. (8 x5)=40

Part B: 3 questions uniformly covering Modules I & II. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part C: 3 questions uniformly covering Modules III & IV. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part D: 3 questions uniformly covering Modules V & VI. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Course code	Course Name	L-T-P - Credits	Year of Introduction
EE466	Digital Image Processing	3-0-0-3	2016

Prerequisite: Nil

Course Objectives

- To study the image fundamentals and mathematical transforms necessary for image processing.
- To impart the image enhancement, image restoration and image compression procedures
- To know about morphological image processing.
- To study the image segmentation and representation techniques.

Syllabus

Elements of visual perception, Basic geometric transformations, Separable Image Transforms, Spatial Domain methods, Frequency domain filters, Model of Image Degradation/restoration process, Compression Techniques, Morphological Processing, Segmentation, Representation and Description

Expected Outcomes.

The students will be able to

i. Demonstrate understanding of the basic concepts of two-dimensional signal acquisition, sampling, and quantization.
ii. Demonstrate understanding of spatial filtering techniques, including linear and nonlinear methods.
iii. Demonstrate understanding of 2D Fourier transform concepts, including the 2D DFT and FFT, and their use in frequency domain filtering.
iv. Apply programming skills in digital image processing related problems

Text Book:

Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing, Pearson Education

References:

1. K. Jain, Fundamentals of Digital Image Processing, PHI
2. Chanda Dutta Magundar, Digital Image Processing and Applications, PHI
3. MilanSonka, Vaclav Hlavac, Roger Boyle, Image Processing, Analysis and Machine Vision, CL Engineering, 2007
4. William K. Pratt, Digital Image Processing, John Wiley & Sons

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Elements of visual perception – Image sampling and quantization Basic relationship between pixels – Basic geometric transformations-Introduction to Fourier Transform and DFT – Properties of 2D Fourier Transform – FFT – Separable Image Transforms -Walsh –Hadamard – Discrete Cosine Transform, Haar transforms	7	15%
II	Spatial Domain methods: Basic grey level transformation – Histogram equalization –Image subtraction – Image averaging Spatial filtering: Smoothing, sharpening filters – Laplacian filters Frequency domain filters : Smoothing – Sharpening filters – Homomorphic filtering.	7	15%
FIRST INTERNAL EXAMINATION			

III	Model of Image Degradation/restoration process – Noise models – Inverse filtering –Least mean square filtering – Constrained least mean square filtering – Blind image restoration – Pseudo inverse – Singular value decomposition	7	15%
IV	Lossless compression: Variable length coding – LZW coding – Bit plane coding, predictive coding-DPCM. Lossy Compression: Transform coding – Wavelet coding – Basics of Image compression standards: JPEG, MPEG	7	15%
SECOND INTERNAL EXAMINATION			
V	Morphological Image Processing-Dilation, Erosion, Morphological Reconstruction- Gray Scale Morphology Edge detection – Thresholding - Region Based segmentation	7	20%
VI	Boundary representation: chair codes- Polygonal approximation –Boundary segments – boundary descriptors: Simple descriptors Fourier descriptors - Regional descriptors –Simple descriptors	7	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks: 100 Exam Duration: 3Hourrs.

Part A: 8 compulsory questions.

One question from each module of Modules I - IV; and two each from Module V & VI.

Student has to answer all questions. (8 x5)=40

Part B: 3 questions uniformly covering Modules I & II. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part C: 3 questions uniformly covering Modules III & IV. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part D: 3 questions uniformly covering Modules V & VI. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Course code	Course Name	L-T-P -Credits	Year of Introduction
EE467	Nonlinear Control Systems	3-0-0-3	2016

Prerequisite: Nil

Course Objectives:

- To introduce the need and concept of nonlinear system.
- To impart knowledge about different strategies adopted in the analysis of nonlinear systems.
- To familiarize with the design of different types of nonlinear controllers.

Syllabus:

Characteristics of nonlinear systems- equilibrium points-phase plane analysis-periodic orbits-stability of nonlinear systems-Lyapunov stability-variable gradient method-centre manifold theorem-circle criterion-Popov criterion-Feedback linearization-Exact Feedback linearization.

Expected outcome

The students will be able to

i. design controllers for nonlinear systems.
ii. analyse the stability of nonlinear systems using various approaches.

Text Books:

1. Alberto Isidori, "*Nonlinear Control Systems: An Introduction*", Springer-Verlag, 1985
2. Hassan K Khalil, Nonlinear Systems, Prentice - Hall International (UK), 2002.
3. Jean-Jacques E. Slotine and Weiping Li, "*Applied Nonlinear Control*", Prentice-Hall, NJ, 1991.

References:

1. M. Vidyasagar, "*Nonlinear Systems Analysis*", Prentice-Hall, India, 1991,
2. Shankar Sastry, "*Nonlinear System Analysis, Stability and Control*", Springer, 1999.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Introduction - Characteristics of nonlinear systems - Classification of equilibrium points- analysis of systems with piecewise constant inputs using phase plane analysis.	7	15%
II	Periodic orbits - limit cycles-Poincare-Bendixson criterion-Bendixson criterion. Existence and uniqueness of solutions, Lipschitz condition.	7	15%
FIRST INTERNAL EXAMINATION			
III	Stability of Nonlinear Systems - Lyapunov stability - local stability - local linearization and stability in the small- Direct method of Lyapunov - generation of Lyapunov function for linear and nonlinear systems – variable gradient method.	7	15%
IV	Centre manifold theorem - region of attraction - Feedback Control and Feedback Stabilisation-Analysis of feedback systems- Circle Criterion – Popov Criterion.	7	15%
SECOND INTERNAL EXAMINATION			

V	Feedback linearization- Design via linearization- stabilization - regulation via integral control- gain scheduling.	7	20%
VI	Exact Feedback Linearization - Input state linearization - input output linearization - state feedback control - stabilization - tracking - integral control.	7	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks: 100 Exam Duration: 3Hourrs.

Part A: 8 compulsory questions.

One question from each module of Modules I - IV; and two each from Module V & VI.

Student has to answer all questions. (8 x5)=40

Part B: 3 questions uniformly covering Modules I & II. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part C: 3 questions uniformly covering Modules III & IV. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part D: 3 questions uniformly covering Modules V & VI. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Course code	Course Name	L-T-P -Credits	Year of Introduction
EE468	Computer Networks	3-0-0-3	2016

Prerequisite: Nil

Course Objectives

- To impart the mode of operation of different types of computer networks that are used to interconnect a distributed community of computers and various interfacing standards and protocols

Syllabus

Introduction on Computer Networks, Network Hardware, Protocol architecture, functionalities, MAC protocols, Network layer, Transport layer, Application Layer

Expected Outcome.

The students will be able to:

i. Analyze the requirements for a given organizational structure and select the most appropriate networking architecture and technologies.
ii. Specify and identify deficiencies in existing protocols, and then go onto formulate new and better protocols.
iii. Analyze, specify and design the topological and routing strategies for an IP based networking infrastructure.

Text Book:

1. Jim Kurose and Keith Ross, ``Computer Networking: A Top-Down Approach," 5th Edition, Pearson Education, 2012
2. Larry L. Peterson and Bruce S. Davie , ``Computer Networks: A Systems Approach," Morgan Kaufmann, 5/e, 2011

References:

1. Andrew S, Computer Networks by Tanenbaum, Prentice Hall of India, New Delhi
2. Foronzan, Data Communications and Networking, Tata McGraw Hill, New Delhi
3. Neil Jenkins, Understanding Local area Network, SAMS Publishers
4. Peter Hudson, Local area Networks by, Thomson Learning

Course Plan

Module	Contents	Hours	Sem.ExamMarks
I	Introduction-Uses of Computer Networks, Network Hardware, Network Software, Reference Models, Example Networks,	6	15%
II	Network Standardization. The Medium Access Control Sublayer- The Channel Allocation Problem, Multiple Access Protocols, Ethernet, Wireless LANs, Broadband Wireless, Bluetooth.	7	15%
	FIRST INTERNAL EXAMINATION		
III	The Network Layer- Network Layer Design Issues, Routing Algorithms, Congestion Control Algorithms, Quality of Service, Internetworking, The Network Layer in the Internet	7	15%

IV	The Transport Layer- The Transport Service, Elements of Transport Protocols, A Simple Transport Protocol,	7	15%
SECOND INTERNAL EXAMINATION			
V	The Internet Transport Protocols: UDP, The Internet Transport Protocols: TCP, Performance Issues.	7	20%
VI	The Application Layer- DNS-The Domain Name System, Electronic Mail, The World Wide Web, Multimedia	8	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks: 100 Exam Duration: 3Hourrs.

Part A: 8 compulsory questions.

One question from each module of Modules I - IV; and two each from Module V & VI.

Student has to answer all questions. (8 x5)=40

Part B: 3 questions uniformly covering Modules I & II. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part C: 3 questions uniformly covering Modules III & IV. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part D: 3 questions uniformly covering Modules V & VI. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Course code	Course Name	L-T-P -Credits	Year of Introduction
EE469	Electric and Hybrid Vehicles	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To present a comprehensive overview of Electric and Hybrid Electric Vehicles

Syllabus

Introduction to Hybrid Electric Vehicles, Conventional Vehicles, Hybrid Electric Drive-trains, Electric Propulsion unit, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, switched reluctance motor, Energy Storage Requirements in Hybrid and Electric Vehicles, Sizing the drive system, Design of a Hybrid Electric Vehicle , Energy Management Strategies.

Expected outcome.

The students will be able to

i. Choose a suitable drive scheme for developing an electric hybrid vehicle depending on resources
ii. Design and develop basic schemes of electric vehicles and hybrid electric vehicles.
iii. Choose proper energy storage systems for vehicle applications
iv. Identify various communication protocols and technologies used in vehicle networks.

Text Book:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003

References:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
2. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.	7	15%
II	Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.	7	15%
FIRST INTERNAL EXAMINATION			
III	Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives	7	15%
IV	Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices.	7	15%
SECOND INTERNAL EXAMINATION			
V	Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power	7	20%

	electronics, selecting the energy storage technology,		
VI	Communications, supporting subsystems: In vehicle networks- CAN, Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies	**7**	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks: 100 Exam Duration: 3Hourrs.

Part A: 8 compulsory questions.

One question from each module of Modules I - IV; and two each from Module V & VI.

Student has to answer all questions. (8 x5)=40

Part B: 3 questions uniformly covering Modules I & II. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part C: 3 questions uniformly covering Modules III & IV. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part D: 3 questions uniformly covering Modules V & VI. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Course code	Course Name	L-T-P - Credits	Year of Introduction
EE472	Internet of Things	3-0-0-3	2016

Prerequisite: Nil

Course Objectives

- To introduce IoT and impart its Vision
- To understand IoT Market perspective.
- To know data and knowledge Management and use of devices in IoT Technology.
- To understand State of the Art – IoT Architecture.
- To understand real world IoT Design Constraints, Industrial Automation and Commercial Building Automation in IoT.

Syllabus

Internet in general and Internet of Things, IoT Technology Fundamentals, Communication Technology for IoT, Data Management, Sensors and security of IoT, Standardisation and Protocol, IoT architectures, Embedded design for IoT, Case Studies and smart applications

Expected outcome.

The students will be able to

i. Explain in a concise manner how the general Internet as well as Internet of Things work.
ii. Understand constraints and opportunities of wireless and mobile networks for Internet of Things.
iii. Use basic measurement tools to determine the real-time performance of packet based networks.
iv. Analyse trade-offs in interconnected wireless embedded sensor networks.

Text Books:

1. Adrian McEwen (Author), Hakim Cassimally." Designing the Internet of Things" 1st Edition, Wiley, 2014
2. Vijay Madisetti and ArshdeepBahga, **"**Internet of Things (A Hands-on-Approach)"**,** 1st Edition, VPT, 2014

References:

1. Ovidu Vermesan and Peter Friess (Ed) Internet of Things - From Research and Innovation to Market Deployment -RIVER PUBLISHERS
2. Ovidu Vermesan and Peter Friess (Ed), The Internet of Things : Converging Technologies for Smart Environments and Integrated Ecosystems, , River Publishers.
3. Samuel Greengard , The Internet of Things (The MIT Press Essential Knowledge series)Paperback – March 20, 2015

Course Plan

Module	Contents	Hours	Sem Exam Marks
I	Introduction : Definition , Internet of Things Vision, Internet of Things Today, Internet of Things Tomorrow , Potential Success Factors of Internet of Things , IoT Application Areas , IoT Functional View	6	15%
II	IoT Technology Fundamentals : Internet of Things Layered Architecture , IoT Related future Internet Technologies: Cloud computing , IoT and Semantic Technologies; Networking Technology , Communication Technology : Devices and gateways , Local and wide area networking , WIRELESS AND	8	15%

	IoT : Overview , Broadcast, Sensor Networks, Wi-Fi , Bluetooth ,Other Low Power Radios		
FIRST INTERNAL EXAMINATION			
III	Data management ,DCA, Big Data , Semantic Sensor Networks and Semantic Annotation of Data ,Virtual Sensors ; Security , Privacy and Trust for Internet of Things :Security for Internet of Things ,Privacy for Internet of Things , Trust for Internet of Things ;	8	15%
IV	IoT related Standardisation : Role of Standardisation , Current Situation , Interoperability of IoT , Standards considerations and Protocols , IoT Protocols Convergence : MQTT ,CoAP , AMQP, DDS , API , REST , XMPP IoT Architectural Overview : Building an IoT architecture, Main design principles and needed capabilities, IoT Architecture Outline ;	8	15%
SECOND INTERNAL EXAMINATION			
V	Embedded Design for IoT : CPU, I/O devices, clock, memory, address and data buses, Tristate Logic ,Embedded System Definition & Real time applications ,CISC vs. RISC, OS vs. RTOS, Application Software vs. Embedded Software (Drivers & BSPs)	8	20%
VI	Case Study & Advanced IoT Applications: Sensors and sensor Node and interfacing using any Embedded target boards (Raspberry Pi / ARM Cortex/ Arduino) Internet of Things SMART Applications : Energy management, Traffic management, IoT for Home ,Cities , Smart Energy and Smart Grid , Smart Logistics and Retails	8	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks: 100 Exam Duration: 3Hourrs.

Part A: 8 compulsory questions.

One question from each module of Modules I - IV; and two each from Module V & VI.

Student has to answer all questions. (8 x5)=40

Part B: 3 questions uniformly covering Modules I & II. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part C: 3 questions uniformly covering Modules III & IV. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part D: 3 questions uniformly covering Modules V & VI. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Course code	Course Name	L-T-P - Credits	Year of Introduction
EE474	ENERGY MANAGEMENT AND AUDITING	3-0-0-3	2016

Prerequisite : Nil

Course Objectives

- To enable the students to understand the concept of energy management and energy management opportunities
- To understand the different methods used to control peak demand
- To know energy auditing procedure
- To understand the different methods used for the economic analysis of energy projects.

Syllabus

General principles of Energy management and Energy management planning - Peak Demand controls - Energy management opportunities in electrical systems and HVAC systems – Reactive power management – Energy audit – cogeneration system – Economic analysis of energy projects

Expected outcome .

- The students will be able to understand the different methods used to reduce energy consumption

Data Book (Approved for use in the examination):

References:

1. Albert Thumann, William J. Younger, Handbook of Energy Audits, CRC Press, 2003.
2. Charles M. Gottschalk, Industrial energy conservation, John Wiley & Sons, 1996.
3. Craig B. Smith, Energy management principles, Pergamon Press.
4. D. Yogi Goswami, Frank Kreith, Energy Management and Conservation Handbook, CRC Press, 2007
5. G.G. Rajan, Optimizing energy efficiencies in industry -, Tata McGraw Hill, Pub. Co., 2001.
6. IEEE recommended practice for energy management in industrial and commercial facilities,
7. IEEE std 739 - 1995 (Bronze book).
8. M Jayaraju and Premlet, Introduction to Energy Conservation And Management, Phasor Books, 2008
9. Paul O'Callaghan, Energy management, McGraw Hill Book Co.
10. Wayne C. Turner, Energy management Hand Book - - The Fairmount Press, Inc., 1997.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	General principles of Energy management and Energy management planning. Peak Demand controls, Methodologies, Types of Industrial Loads, Optimal Load scheduling-Case studies.	6	15%
II	Energy management opportunities in Lighting and Motors. Electrolytic Process and Electric heating, Case studies.	8	15%
	FIRST INTERNAL EXAMINATION		
III	Types of boilers, Combustion in boilers, Performances evaluation, Feed water treatment, Blow down, Energy conservation opportunities in boiler.		

	Properties of steam, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system, Identifying opportunities for energy savings. Classification, General fuel economy measures in furnaces, Excess air, Heat Distribution, Temperature control, Draft control, Waste heat recovery.	8	15%
IV	HVAC system: Coefficient of performance, Capacity, Factors affecting Refrigeration and Air conditioning system performance and savings opportunities. Classification and Advantages of Waste Heat Recovery system, analysis of waste heat recovery for Energy saving opportunities	7	15%
SECOND INTERNAL EXAMINATION			
V	Energy audit -Definition, Need, Types of energy audit, Energy audit Instruments. Cogeneration-Types and Schemes, Optimal operation of cogeneration plants- Case study. Computer aided energy management.	7	20%
VI	Economic analysis methods-cash flow model, time value of money, evaluation of proposals, pay-back method, average rate of return method, internal rate of return method, present value method, life cycle costing approach, Case studies.	6	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks: 100 Exam Duration: 3Hourrs.

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One question from each module of Modules I - IV; and two each from Module V & VI.

Student has to answer all questions. (8 x5)=40

Part B: 3 questions uniformly covering Modules I & II. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part C: 3 questions uniformly covering Modules III & IV. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.

Part D: 3 questions uniformly covering Modules V & VI. Student has to answer any 2 from the 3 questions: (2 x 10) =20. Each question can have maximum of 4 sub questions (a,b,c,d), if needed.