SCHEME OF INSTRUCTION & EXAMINATION
B.E. (Electronics and Instrumentation Engineering) III – SEMESTER

S. No	Course Code	Course Title	Scheme of Instruction				Scheme of Examination			Credits
			L	T	P/D	Contact Hrs/Wk	CIE	SEE	Duration In Hrs	
Theory Courses										
1	ES302CE	Engineering Mechanics	3	1	-	3	30	70	3	4
2	BS205MT	Mathematics – III	3	1	-	3	30	70	3	4
3	PC436EE	Network Analysis	3	-	-	3	30	70	3	3
4	PC402EE	Electromagnetic Fields	3	-	-	3	30	70	3	3
5	PC437EE	Transducers Engineering	3	-	-	3	30	70	3	3
6	PC403EC	Analog Electronic Circuits	3	-	-	3	30	70	3	3
Practical / Laboratory Courses										
7	PC453EE	Networks Analysis Lab	-	-	2	2	25	50	3	1
8	PC454EE	Computer Aided Instrumentation Drawing Lab	-	-	2	2	25	50	3	1
9	PC453EC	Analog Electronic Circuits Lab	-	-	2	2	25	50	3	1
Total			**18**	**2**	**6**	**24**	**255**	**570**	**-**	**23**

HS: Humanities and Social Sciences BS: Basic Science ES: Engineering Science
MC: Mandatory Course PC: Professional Core PE: Professional Elective
L: Lecture T: Tutorial P: Practical D: Drawing
CIE: Continuous Internal Evaluation SEE: Semester End Evaluation (Univ. Exam) EE: Electrical Engg.

Note:

1. Each contact hour is a clock hour.
2. The duration of the practical class is two hours, however it can be extended wherever necessary, to enable the student to complete the experiment.

Course Code	Course Title						Core/Elective
ES302ME	**Engineering Mechanics**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**1**	**-**	**-**	**30**	**70**	**4**

Course Objectives

The objectives of this course is to impart knowledge of

- Resolution of forces, equilibrium of force systems consisting of static loads
- Obtaining centroids and moments of inertia for various regular and irregular areas.
- Various forces in the axial force members, and to analyse the trusses using various methods,
- Concept of friction for single and connected bodies.
- Basic concepts of dynamics, their behavior, analysis and motion bodies
- Work energy principles and impulse momentum theory and applications to problem solving

Course Outcomes

After completing this course, the student will be able to:

1. Apply the fundamental concepts of forces, equilibrium conditions for static loads.
2. Determine the centroid and moment of inertia for various sections.
3. Analyse forces in members of a truss using method of joints and method of sections, analyse friction for single and connected bodies.
4. Apply the basic concepts of dynamics, their behavior, analysis and motion bodies.
5. Solve problems involving work energy principles and impulse momentum theory.

UNIT – I

Introduction to Engineering Mechanics: Basic Concepts

System of Forces: Coplanar Concurrent Forces, Components in Space – Resultant of coplanar and spatial systems, Moment of Force and Couple and its Application to coplanar system

Equilibrium of Systems of Forces: Free Body Diagrams, Equations of Equilibrium and applications to Coplanar System.

UNIT – II

Centroid: Centroid of simple areas (from basic principles), Centroid of Composite areas.

Area Moment of Inertia: Definition, Moment of inertia of simple areas (from basic principles), Polar Moment of Inertia, Transfer formula, Moment of Inertia of Composite areas.

Centre of Gravity & Mass moment of Inertia: Centre of gravity and Mass moment of inertia of simple bodies (from basic principles).

UNIT-III

Friction: Theory of friction, Laws of friction, Friction connected to single and connected bodies. Wedge friction.

Analysis of Perfect Frames: (Analytical Method) Types of Frames, Assumptions for forces in members of perfect frame, Method of joints and Method of sections for Cantilever Trusses, simply supported Trusses.

UNIT –IV

Kinematics: Introduction, Motion of particle, Rectilinear and Curvilinear motions, Velocity and Acceleration, Types of Rigid body, Angular motion, Fixed axis rotation.

Kinetics: Introduction, fundamental equation of kinetics for a particle, D' Alembert's principle for particle motion, connected system and Fixed Axis Rotation.

UNIT – V

Work - Energy Method: Introduction, Equations for Translation, Work-Energy Applications to Particle Motion, Connected System and Fixed Axis Rotation.

Impulse Momentum Method: Linear impulse momentum, law of conservation of momentum, coefficient of restitution, Elastic impact.

Suggested Readings:

1. Ferdinand L. Singer, *Engineering Mechanics*, Collins, Singapore, 1994.
2. Reddy Vijay Kumar K. and K. Suresh Kumar, Singer's Engineering Mechanics, 2010.
3. S.S Bhavakatti, *Engineering Mechanics*, New age International publishers.
4. Rajeshakharam, S. and Sankarasubrahmanyam, G., *Mechanics,* Vikas Publications, 2002.
5. Junarkar, S.B. and H.J. Shah., *Applied Mechanics*, Publishers, 2001.
6. Shah., *Applied Mechanics*, Publishers, 2001.

Course Code	Course Title						Core/Elective
BS205MT	**Mathematics – III (Probability & Statistics)**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**1**	**-**	**-**	**30**	**70**	**4**

Course Objectives

- To introduce the solution methodologies for second order Partial Differential Equations with applications in engineering
- To provide an overview of probability and statistics to engineers

Course Outcomes

After completing this course, the student will be able to:

1. Solve field problems in engineering involving PDEs.
2. They can also formulate and solve problems involving random variables and apply statistical methods for analysing experimental data.

UNIT-I: Introduction of Probability, Conditional probability, Theorem of Total probability, Baye's Theorem and its applications, Random variables, Types of random variables, Probability mass function and Probability density function, Mathematical expectations.

UNIT-II: Discrete probability distributions: Binomial and Poisson distributions, Mean, variance, moment generating function and evaluation of statistical parameters for these distributions, Moments, Skewness and Kurtosis.

UNIT-III: Continuous probability distributions, Uniform, Exponential and Normal distributions, Mean, variance, moment generating function and evaluation of statistical parameters for these distributions.

UNIT-IV: Curve fitting by the method of least squares: Fitting of straight lines, second degree parabolas and more general curves, Correlation, regression and Rank correlation. Test of significance: Large sample test for single proportion, difference of proportions, single mean, difference of means, and difference of standard deviations.

UNIT-V: Test for single mean, difference of means and correlation coefficients, test for ratio of variances, Chi-square test for goodness of fit and independence of attributes.

Suggested Readings:

1. R.K. Jain & Iyengar, "Advanced Engineering Mathematics", Narosa Publications.
2. B.S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 2000.
3. P. Sivaramakrishna Das & C.Vijaya Kumar, "Engineering Mathematics", Pearson India Education Services Pvt. Ltd.
4. N.P. Bali & M. Goyal, "A Text Book of Engineering Mathematics", Laxmi Publications, 2010.
5. S.C. Gupta & V.K.Kapoor, "Fundamentals of Mathematical Statistics" , S.Chand Publications.
6. P. G. Hoel, S. C. Port & C. J. Stone, "Introduction to Probability Theory", Universal Book Stall, 2003.
7. W. Feller, "An Introduction to Probability Theory and its Applications", Vol.1, Wiley, 1968.

Course Code	Course Title						Core/Elective
PC436EE	**Network Analysis**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To acquire knowledge in circuits and to understand the fundamentals of derived circuit laws.
- To understand theorems, steady state and transient analysis of single phase and 3-phase circuits.
- To analyse the two port networks and to acquire the knowledge of coupled circuits.

Course Outcomes

At the end of this course students will be able to:

1. Classify the circuit elements and also evaluate the current, voltage in DC network with & without network theorems.
2. Analyze the DC steady state & transient responses of R, L, C circuits.
3. Evaluate the AC steady state response of R, L, C networks and explain the different configuration of AC circuits.
4. Explain the Resonance in the circuits, coupled circuits and different 3-phase system, also measure the power in 3-phase system.
5. Analyze the Two port networks.

UNIT -I

Network Elements: Active elements, dependent and independent sources, passive elements –RLC and Magnetic Energy stored in inductance and capacitance. D.C. Circuit analysis. Superposition theorem. Thevenin's and Norton's theorem. Maximum Power transfer theorem. Star-delta transformation.

UNIT-II

Response of RLC Circuits: Formulation of integro differential equations in RLC networks, I duality, Initial conditions. Response of RL, RC, RLC networks subjected to internal energy. Response of networks to impulse, step, ramp, exponential and sinusoidal excitations. Transient and steady state response. Response to arbitrary inputs by convolution.

UNIT - III

Steady state response of RLC networks: Average and RMS value of periodic time function. Steady state sinusoidal response of RL, RC, RLC network notation, vector l i representation, series, parallel and series parallel network. Active and reactive power.

UNIT-IV

Resonance: Series parallel resonance, Bandwidth, Q-factor. Coupled circuit -Analysis of circuits with mutual inductance. Three phase circuits. Generation of 3 phase voltages, star - delta connections -solution of 3 phase balanced circuits. Power measured by two wattmeter method.

UNIT V

Two port parameters: Impedance, Admittance, transmission -Hybrid parameters of two port passive networks. Their inter relationships. Terminated two ports. Inter connection of two ports.

Suggested Reading:

1. Van Valkenburg-Network Analysis-Prentice Hall of lndia-3rd Edition.
2. H. Hayt. E Kimmerley-Engineering Circuit Analysis-McGraw Hill, 5th Edition.
3. Sudhakar, Shyam Mohan S Palli, Network Analysis, Tata McGraw Hill.
4. Robert L Boylested, “Introductory Circuit Analysis”, Pearson Education, 2018.

Course Code	Course Title						Core/Elective
PC402EE	**Electromagnetic Fields**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- Review of Vector Calculus
- Application and apply the various laws of static electrical and magnetic fields
- Understand the time varying the electrical and magnetic fields
- Understand the propagation of EM waves

Course Outcomes

At the end of the course students will be able to

1. Understand the vector calculus for electromagnetism.
2. Obtain the electric fields for simple configurations under static conditions.
3. Analyse and apply the static magnetic fields.
4. Understand Maxwell's equation in different forms and different media.
5. Understand the propagation of EM waves

In this course, most of the students find difficult to visualize electric and magnetic fields. Instructors may demonstrate various simulation tools to visualize electric and magnetic fields in practical devices like transformers, transmission lines and machines

UNIT-I

Review of Vector Calculus: Vector algebra-addition, subtraction, components of vectors, scalar and vector multiplications, triple products, three orthogonal coordinate systems (rectangular, cylindrical and spherical). Vector calculus-differentiation, partial differentiation, integration, vector operator del, gradient, divergence and curl, integral theorems of vectors. Conversion of a vector from one coordinate system to another.

UNIT-II

Static Electric Field: Coulomb's law, Electric field intensity, Electrical field due to point charges. Line, Surface and Volume charge distributions. Gauss law and its applications. Absolute Electric potential, Potential difference, Calculation of potential differences for different configurations. Electric dipole, Electrostatic Energy and Energy density

Conductors, Dielectrics and Capacitance: Current and current density, Ohms Law in Point form, Continuity of current, Boundary conditions of perfect dielectric materials. Permittivity of dielectric materials, Capacitance, Capacitance of a two wire line, Poisson's equation, Laplace's equation, Solution of Laplace and Poisson's equation, Application of Laplace's and Poisson's equations with single variable.

UNIT-III

Static Magnetic Fields: Biot-Savart Law, Ampere Law, Magnetic flux and magnetic flux density, Scalar and Vector Magnetic potentials. Steady magnetic fields produced by current carrying conductors.

Magnetic Forces, Materials and Inductance: Force on a moving charge, Force on a differential current element, Force between differential current elements, Nature of magnetic materials, Magnetization and permeability, Magnetic boundary conditions, Magnetic circuits, inductances and mutual inductances.

UNIT-IV

Time Varying Fields and Maxwell's Equations: Faraday's law for Electromagnetic induction, Displacement current, Point form of Maxwell's equation, Integral form of Maxwell's equations, Motional Electromotive forces. Electrical and Magnetic boundary conditions.

UNIT-V

Electromagnetic Waves: Derivation of Wave Equation, Uniform Plane Waves, Maxwell's equation in Phasor form, Wave equation in Phasor form, Plane waves in free space and in a homogenous material. Wave equation for a conducting medium, Plane waves in lossy dielectrics, Propagation in good conductors, Skin effect. Poynting theorem.

Suggested Readings:

1. M. N. O. Sadiku, "Elements of Electromagnetics", Oxford University Publication, 2014.
2. A. Pramanik, "Electromagnetism - Theory and applications", PHI Learning Pvt. Ltd, New Delhi, 2009.
3. A. Pramanik, "Electromagnetism-Problems with solution", Prentice Hall India, 2012.
4. W.J. Duffin, "Electricity and Magnetism", McGraw Hill Publication, 1990.
5. B. D. Popovic, "Introductory Engineering Electromagnetics", Addison-Wesley Educational Publishers, International Edition, 1971.
6. W. Hayt, "Engineering Electromagnetics", McGraw Hill Education, 2012.

Course Code	Course Title						Core/Elective
PC437EE	**Transducer Engineering**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

The objectives of the course are to impart knowledge of the:

- To be able to understand different types of Transducers, their characteristics and applications.
- To learn and understand the standards of calibration of measuring devices.

Course Outcomes

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

1. Describe various static and dynamic characteristics of measuring system
2. Classify transducers.
3. Use inductive and capacitive transducer for various sensing applications
4. Discuss temperature and pressure standards for calibrations
5. Use temperature and pressure transducer for various sensing applications

UNIT-I

Introduction to measurement system (MS) static characteristics of MS: linearity, Hysteresis, Threshold, Repeatability, Reliability and maintainability, Span, Calibration. Dynamic characteristics of M.S. - Zero order, first order instruments and their responses for impulse, step, ramp & sinusoidal Inputs and frequency response of above Instruments.

UNIT-II

Resistive Transducer: Classification of transducers, Basic requirements of transducers, Variable resistance transducers; Potentiometers, Strain gauge (SG), types of SG, derivation of gauge factor, Bridge Configuration, compensation, Application of SGs.

UNIT-III

Variable capacitive transducers: Capacitance, Principles, Capacitance displacement transducers, Capacitive hygrometer, and capacitive proximity transducers.

Variable inductive transducers: Linear variable differential transformer, Rotary variable differential transformer.

UNIT-IV

Measurement of temperature: Standards for calibration of temp. Temperature measuring devices, types of filled in system thermometers — liquid in glass, vapour pressure, bimetallic on solid rod thermometer Resistance temperature detectors, thermistor thermocouple, pyrometers, IC temp. Detectors.

UNIT-V

Measurement of pressure: various elastic elements for pressure measurement. Diaphragms — flat and corrugated type — deflection of diaphragm due to pressure — Bourdan tube — bellows — capsule — Transduction method — Potentiometric, SG, variable reluctance type, LVDT type transducers for measuring pressure. Non-electrical type of measurements — dead weight gauges and manometers force balance transducers, High pressure measurements, vacuum measurements, MC Leod gauge, Ktudcn gauge, thermal conductivity gauge & Ionization gauge.

Suggested Reading:

1. C.S.Rangan, G.R. Sarma, V.S.V. Mani, Instrumentation Devices Systems, Tata McGraw Hill Publication, 1983.Mani Sharma.
2. DVS Murthy, Transducers and Instrumentation, Prentice Hall of India (P) Ltd., 2000.
3. A.K.Sawhney, ACourse in Electrical &Electronics Measurement and Instrumentation, Dhanpat Rai & Co., Delhi, 1999.
4. B.Nakra and Chowdary, Instrumentation Measurement and Analysis Tata Mc-Graw Hill Publication, 2nd Edition, 2003.

Course Code	Course Title						Core/Elective
PC223EC	**Analog Electronics**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- Study the characteristics of diode in forward and reverse bias and applications of diodes.
- Describe the construction and working of Bipolar Junction Transistor in various modes and JFET.
- Familiarize with feedback concepts and identify various types of feedback amplifiers.
- Study the importance of power amplifiers and Oscillators.
- Understand the operation and applications of op-amps.

Course Outcomes

At the end of the course students will be able to

1. Interpret the characteristics and apply diode models to analyse various applications of diodes
2. Discriminate the BJT configurations to recognize appropriate transistor configuration for any given application and design the biasing circuits with good stability
3. Analyse and compare feedback amplifiers.
4. Distinguish various classes of Power Amplifiers.
5. Analyse the operation of OPAMP and its applications

UNIT-I

P-N junction characteristics , V-I characteristics , Avalanche breakdown , Zener diode, Applications of Diodes as rectifiers. Filters (L, C), LED, photodiode. Basic Clipping and clamping circuits using diodes. (One level only)

UNIT-II

Bipolar Junction Transistor - V-I characteristics, JFET - I-V characteristics, and various configurations (such as CE/ CS, CB/CG, CC/CD) and their features. Small signal models of BJT and JFET. Analysis of BJT as an amplifier, estimation of voltage gain, current gain, input resistance, output resistance.

Transistor Biasing: Fixed bias, collector to base bias, self-bias, thermal stability, heat sinks **UNIT**

UNIT-III

Concept of Feedback - positive and negative, Feedback topologies : Voltage series, current series, voltage shunt, current shunt, effect of feedback on gain, bandwidth etc., and concept of stability. (Qualitative treatment only)

UNIT-IV

Oscillators: Barkhausen criterion, RC oscillators (phase shift, Wien bridge), LC oscillators (Hartley, Colpitts), CRYSTAL Oscillator. (Qualitative treatment only)

Power Amplifiers: Various classes of operation (Class A, B, and AB), their power efficiency and distortion (Qualitative treatment only)

UNIT-V

OP-AMP Block diagram, Ideal OP-AMP, DC and AC Characteristics, Inverting and Non-Inverting Amplifiers, Adder/ Subtracter, Integrator, Differentiator, Comparator, Zero crossing detector, Square and Triangular wave generators, Peak detector, Sample and Hold circuit and Precision Rectifiers.

Suggested Readings:

1. Jacob Millman, Christos C. Halkias, and Satyabrata Jit, Electronic Devices and Circuits, 3rd ed.,McGraw Hill Education, 2010.
2. S Salivahanan, N Kumar, and A Vallavaraj, Electronic Devices and Circuits, 2nd ed., McGraw HillEducation, 2007.
3. Jacob Milliman and Herbert Taub, "Pulse, Digital and Switching Waveforms",3rd Edition.
4. A.Anand Kumar "Pulse and Digital circuits".
5. Ramakanth A. Gayakwad, "Op-Amps and Linear Integrated Circuits" Pearson,2018, 4th edition

Course Code	Course Title						Core/Elective
PC453EE	**Network Analysis Lab**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
PC436EE	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

- To Train the Students for acquiring practical knowledge in time response and frequency response of series / parallel RC, RL and RLC Circuits.
- To prepare the students for finds out parameters of a given two port network.
- To make the students for understanding the verification of theorems.

Course Outcomes

At the end of the course students will be able to

1. Evaluate the time response and frequency response character sties of R,L, C Series and parallel circuits.
2. Able to validate the network theorems.
3. Able to find various parameters of a two-port network.
4. Able to simulate electrical circuits using spice.
5. Able to synthesize networks from a given transfer function.

List of Experiments:

1. Charging and Discharging Characteristics of RC and RL series circuits.
2. Verification of Thevenin's and Norton's theorems.
3. Verification of Superposition theorem
4. Verification of Maximum power transfer theorem
5. Frequency Response of a Series RLC Circuits.
6. Frequency Response of a Parallel RLC Circuits.
7. Impedance and Admittance Parameters of two port network.
8. ABCD and Hybrid Parameters of two port network.
9. Series, parallel and cascaded connection of two port networks.
10. Power measurement using Two Wattmeter method.
11. Simulation and transient analysis of series RLC circuits using PSPICE.
12. Network Synthesis.
13. Characteristics of Linear, Non-Linear and Bilinear Elements.

Note: At least ten experiments should be conducted in the Semester.

Suggested Readings:

1. Van Valkenburg M.E., Network Analysis, Prentice Hall of India, 3rd Edition, 2000.
2. William Hayt H, Kimmerly Jack E, Steven Durbin M, Engineering Circuit Analysis, McGraw Hill, 6th Edition, 2002.
3. Jagan N.C, Lakshrninarayana C., Network Analysis, B.S. Publications, 3rd Edition, 2014.

Course Code	Course Title						Core/Elective
PC454EE	**Computer Aided Instrumentation Drawing**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives:

- To understand the terminology of electrical circuit with components and Process Instrumentation (P&ID) diagram.
- To be able to familiarize with P and ID symbols.
- To acquire knowledge on various Electrical and Instrumentation Engineering Software's.

Course Outcomes

At the end of this course the students will be able to:

1. Identify and draw different components of electrical and Instrumentation systems
2. Draw different control and wiring diagrams.
3. Draw PI diagrams of process instrumentation system.

Drawing of the following using Electrical CADD / Corel Draw / MS Word / PPT/Visio

List of Experiments:

1. Lines, Arcs, Curves, Shapes, Filling of objects, Object editing & Transformation.
2. Electrical, Electronic & Electro – mechanical symbols.
3. House – wiring diagrams and layout.
4. Simple power and control circuit diagrams.
5. P& ID symbols (seven main groups are: equipment, piping, vessels, heat exchangers, pumps, instruments, and valves)
6. A typical Flow control system
7. A typical Pressure control system.
8. A typical Temperature control system.
9. A typical Level control system
10. Instrument Line Symbols for: Instrument and device connections at process measurement points/ Connections to instrument power supplies/ Signals between measurement and control instruments and functions.

Suggested Reading:

1. KB. Raina, S.K. Bhattacharya, *Electrical Design, Estimating and Costing*, Wiley Eastern Ltd., 1991.
2. Nagrath, Kothari, *Electrical Machines*, Tata McGraw Hill Publishing Company Ltd., 2000.
3. A.K. Sawhney, *A Course in Electrical Machines Design*, Dhanpat Rai and Sons, 1996.
4. B. G. Liptak, Instrument Engineers Handbook: Process measurement and Analysis Volume 1, CRC Publication, 2003.

Course Code	Course Title						Core/Elective
PC253EC	**Analog Electronics Lab**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

- Designing basic circuits of rectification with and without filters using diodes
- Designing wave shaping circuit using diodes.
- Designing of single and multistage amplifier circuits.
- Demonstrate negative feedback in amplifier circuits and positive feedback in Oscillators
- Design of P, PI and PID controllers.

Course Outcomes

At the end of the course students will be able to

1. Calculate ripple factor, efficiency and % regulation of rectifier circuits
2. Analyse feedback amplifiers and op-amp oscillator circuits
3. Design single, and multi-stage amplifier, wave shaping and controller circuits
4. Understand the characteristics of electronics devices
5. Design of P, PI and PID controllers using op-amps.

List of Experiments:

1. Characteristics of Silicon, Germanium and Zener Diode in forward bias and reverse bias
2. Application of diode as a full wave rectifier with and without filters. Calculation of Ripple factor,voltage regulation and efficiency with various loads
3. Static characteristics of BJT in CE configuration
4. Static characteristics of MOSFET in CS configuration
5. Frequency response of Single and two stage BJT amplifier in CE configuration
6. Frequency response of Single and two stage MOSFET amplifier in CS configuration
7. Inverting amplifier using op-amp.
8. Non-inverting amplifier using op-amp.
9. Instrumentation amplifier.
10. Design of integrator and differentiator using op-amp.
11. RC Phase Oscillator and Wein Bridge Oscillator using op-amp.
12. A/D converters.
13. Clipping circuits
14. Clamping Circuits.
15. Monostable Multivibrator using op-amp.
16. Generation of triangular and square wave using op-amp.
17. Design of P, PI and PID controller using op-amp.
18. Design of Lead/lag compensator using op-amp

Note: At least ten experiments should be conducted in the Semester

Suggested Readings:

1. Paul B. Zbar, Albert P. Malvino, Michael A. Miller, Basic Electronics, A text- Lab Manual, 7thEdition. Mc- Graw- Hill Higher Education 2001.
2. D Roy Chaudhary, Shail B Jain, Linear Integrated circuits, New Age International Publishers, 2007.

SCHEME OF INSTRUCTION & EXAMINATION
B.E. (Electronics and Instrumentation Engineering) IV – SEMESTER

S. No	Course Code	Course Title	Scheme of Instruction				Scheme of Examination			Credits
			L	T	P/D	Contact Hrs/Wk	CIE	SEE	Duration In Hrs	
Theory Courses										
1	HS102EG	Effective Technical Communication in English	2	-	-	2	30	70	3	2
2	PC438EE	Instrumentation Systems	3	-	-	3	30	70	3	3
3	ES305ME	Energy Sciences and Engineering	2	-	-	2	30	70	3	2
4	PC439EE	Power Plant Instrumentation	3	-	-	3	30	70	3	3
5	PC410EE	Digital Electronics and Logic Design	3	-	-	3	30	70	3	3
6	PC411EE	Power Electronics	3	-	-	3	30	70	3	3
Practical / Laboratory Courses										
7	PC458EE	Transducers Engineering Lab	-	-	2	2	25	50	3	1
8	PC456EE	Power Electronics Lab	-	-	2	2	25	50	3	1
9	PC457EE	Digital Electronics and Logic Design Lab	-	-	2	2	25	50	3	1
Total			**16**	**00**	**06**	**22**	**255**	**570**	**-**	**19**

HS: Humanities and Social Sciences BS: Basic Science ES: Engineering Science
MC: Mandatory Course PC: Professional Core PE: Professional Elective
L: Lecture T: Tutorial P: Practical D: Drawing
CIE: Continuous Internal Evaluation SEE: Semester End Evaluation (Univ. Exam) EE: Electrical Engg.

Note:

1. Each contact hour is a clock hour.
2. The duration of the practical class is two hours, however it can be extended wherever necessary, to enable the student to complete the experiment.

Course Code	Course Title						Core/Elective
HS102EG	**Effective Technical Communication in English**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

To expose the students to:

- Features of technical communication
- Types of professional correspondence
- Techniques of report writing
- Basics of manual writing
- Aspects of data transfer and presentations.

Course Outcomes

On successful completion of the course, the students would be able to:

1. Handle technical communication effectively
2. Use different types of professional correspondence
3. Use various techniques of report writing
4. Acquire adequate skills of manual writing
5. Enhance their skills of information transfer and presentations

UNIT I

Definition and Features of Technical communication: Definition and features of technical communication (precision, relevance, format, style, use of visual aids), Differences between general writing and technical writing, Types of technical communication (oral and written)

UNIT II

Technical Writing-I (Official correspondence): Emails, IOM, Business letters, Business proposals.

UNIT III

Technical writing-II (Reports): Project report, Feasibility report, Progress report, Evaluation report.

UNIT IV

Technical writing- III (Manuals): Types of manuals, User manual, Product manual, Operations manual.

UNIT V

Information Transfer and Presentations: Non-verbal (bar diagram, flow chart, pie chart, tree diagram) to verbal (writing), Verbal (written) to non-verbal, Important aspects of oral and visual presentations.

Suggested Readings:

1. Raman, Meenakshi & Sharma, Sangeeta. (2015). *Technical Communication: Principles and Practice* (3rd ed.). New Delhi, OUP.
2. Rizvi, Ashraf, M. (2017). *Effective Technical Communication* (2nd ed.). New Delhi, Tata McGraw Hill Education.
3. Sharma, R. C., & Mohan, Krishna. (2017). *Business Correspondence and Report Writing: A Practical Approach to Business & Technical Communication* (4th ed.). New Delhi, Tata McGraw Hill Education.
4. Tyagi, Kavita &Misra, Padma. (2011). *Advanced technical communication*. New Delhi, PHI Learning.
5. Jungk, Dale. (2004). *Applied writing for technicians*. New York, McGraw-Hill Higher Education.

Course Code	Course Title						Core / Elective
PC438EE	**Instrumentation Systems**						Core
Prerequisite	Contact Hours per Week				CIE	SEE	
	L	T	D	P			Credits
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To expose the students to various sensors and transducers for measuring mechanical quantities.
- To understand the specifications of sensors and transducers.
- To learn the basic conditioning circuits for various sensors and transducers.
- To introduce advances in sensor technology

Course Outcomes

On successful competition of this course students will be able to

1. Explain the working of different displacement, acceleration and speed techniques.
2. Explain the working of different force, torque measuring techniques and describe thermocouple for measurement of temperature.
3. Explain the different transducers used for flow measurement.
4. Explain the working of various methods used for measurement of liquid level and humidity.
5. Calculate different sound levels used for measuring sound and compare different microphones.

UNIT -I

Measurement of Motion: Angular Velocity/Speed Measurement-Electrical methods DC and AC Tachogenerators Eddy Current-Drag Cup Tachometers- Stroboscopic method. Acceleration measurements-Seismic displacement/velocity/acceleration- pick-ups. Electromagnetic and electro dynamic velocity transducers, Piezoelectric transducers, Deflection type accelerometer-bonded strain gauge accelerometer, Piezo-electric accelerometers.

UNIT-II

Measurement of force and Torque: Basic methods of force and measurement-characteristics of elastic force transducers-load cells. Various types of Torque measurement-absorption, transmission, stress, deflection type. Measurement of Temperature: Laws of thermocouples-Thermocouple circuits-reference junction considerations ice bath reference junction-Special materials, configurations and techniques-cooled thermocouples-pulsed thermocouples-multifunction thermocouples-radiation thermometers

UNIT - III

Measurement of flow: Classification of flow meters-Head flow meters-Orifice plate-Venturi tube-flow nozzle and pilot tube-Rotameter-Electromagnetic flow meter-Positive displacement meters-Hot wire Hot Film Anemometer Mass Flow measurements-Rotor torque mass flow meter

UNIT-IV

Measurement of liquid level: Electrical methods-Resistive, inductive and capacitive methods-Capacitive variable area method- Capacitive voltage divider method-Capacitive variable dielectric constant method-Measurement of liquid level using Gamma Rays-Ultrasonic method- Measurement of liquid level using float. Measurement of humidity: Absolute Humidity-Relative humidity-Hygrometers-Resistive Hygrometers-capacitive hygrometer-Microwave refractometer - Aluminum oxide Hygrometers-Measurement of PH Electrodes-Station Glass and Calomel Electrodes-Installation of PH meters.

UNIT V

Measurement of sound: Sound level Meter-Microphones-Types-Carbon and capacitive microphone-Dynamic microphone-Inductive microphone-Piezo-electric microphone-Pressure response of capacitive microphone Measurement of sound using microphones.

Suggested Reading:

1. C.S.Rangan, G R Sarma & V S N Mani, *Instrumentation Devices and Systems*-TMH, 2nd Edition 2004
2. B.Nakra & Chowdhari, *Instrumentation Measurement and Analysis*, TMH, 2nd Edition 2003
3. D.V.S.Murthy, *Transducers and Instrumentation,* PHI, 1995.
4. 4. John P. Bentley, Principles of Measurement Systems, 3rd Edition, Pearson Education, 2000.
5. Doebelin E.O, *Measurement Systems - Application and Design*, 4th Edition, McGraw-Hill, New
6. Patranabis D, *Principles of Industrial Instrumentation*, 2nd Edition, Tata McGraw Hill, New Delhi, 1997.

Course Code	Course Title						Core/Elective
ES305ME	**Energy Sciences and Engineering**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**2**	**1**	**-**	**-**	**30**	**70**	**3**

Course Objectives

The objectives of this course is to impart knowledge of

- Able to identify various sources of energy.
- Understand the difference between Conventional and renewable energy sources.
- Identify various storage devices of Energy.
- Able to estimate the costing of power plant.

Course Outcomes

After completing this course, the student will be able to:

1. Understand the basics of various sources of energy
2. Analyze the present status of conventional energy sources.
3. Understand the working principles of Renewable Energy systems
4. Design and develop waste heat recovery systems.
5. Relate energy economics, standards and future challenges.

UNIT-I

Introduction: Various sources of energy, relative merits and demerits, Statistics and prospects of conventional and Renewable energy sources.

UNIT-II

Conventional Energy Sources: Fossil Fuels: Power generation using steam turbine and gas turbine power plants, Nuclear Fuels: Parts of reactor core, Nuclear power plant outline, Methods to dispose radioactive waste. Hydro Energy: Spillways, Hydroelectric power plant outline.

UNIT-III

Renewable Energy Systems: Solar Energy – Types of collectors and concentrators, Solar Photo Voltaic Cell. Wind Energy – Types of Wind Turbines and their working, geothermal power plant, Biomass conversion, Wave Energy power plant, Tidal Energy power plant, Ocean thermal energy power plant.

UNIT-IV

Storage: Methods to store Mechanical Energy, Electrical Energy, Chemical Energy and Thermal Energy. Co-generation &Tri-generation: Definition, application, advantages, classification, saving Potential. Energy waste, waste heat recovery classification, advantages and applications, commercially viable waste heat recovery devices.

UNIT-V

Power Plant Economics and Environmental Considerations: Costing, Estimation of power production - Pollutants and Pollution Standards -Methods of pollution control. Energy Efficiency rating and BEE standards, Future energy needs and challenges.

Suggested Reading:

1. Wakil MM, *Power Plant Technology*, McGraw Hill Publishers.
2. P.K. Nag, *Power Plant Engineering*, McGraw-Hill Publishers.
3. G.D. Rai, *Non-Conventional Energy Sources,* Khanna Publishers.
4. Mili Majumdar, *Energy Efficient Buildings in India,* Ministry of Non-Conventional Energy Sources.

Course Code	Course Title						Core / Elective
PC439EE	**Power Plant Instrumentation**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	
	L	T	D	P			Credits
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To acquire good knowledge of power generation using various methods.
- To acquire good knowledge of Instrumentation involved in Power generation.
- To know the basics of Turbine supervisory Instrumentation and control.

Course Outcomes

At the end of the course students will be able to

1. Describe power generation using various methods and explain the working of Thermal power plant in detail. Decode P & I diagrams for process control systems.
2. Explain the techniques for measurement and control of four basic parameters like level, temperature, pressure and flow for power station as well as general process control systems.
3. Describe the Instrumentation and control associated with boilers in TPP, and apply the knowledge gained for identifying and eliminating the redundancy in formulating the boiler control loops.
4. Explain the prime mover supervision and control mechanism and describe the turbine supervisory instrumentation used in TPP.
5. Explain the power generation using NPP, Hydro–Electric, Wind Power and combined cycle power plant with its associated Instrumentation.

UNIT-I

Overview of Power Generation: Method of power generation in thermal power plant s, building blocks – Boiler – types, feed water systems, steam circuits, combustion process, products of combustion process, fuel systems, treatment of flue gases, condensate systems, feed water conditioning, P&I diagram of boiler, Importance of instrumentation in power generation.

UNIT-II

Metal temperature measurement in boilers, piping system for pressure measuring devices, smoke and dust monitor, flame monitoring. Introduction to turbine supervising system, pedestal vibration, shaft vibration measurement. Non-contact type transducers for speed measurement, LVDT for measurement of shell expansion.

UNIT-III

Control Loops in Boiler: Combustion control, air/fuel ratio control, furnace draft control, Boiler drum level control- Three element drum level control, Main Steam and reheat steam temperature control, super-heater control, attemperator, de-aerator control, boiler following mode operation, turbine following mode operation.

UNIT-IV

Turbine, Monitoring and Control: lubricant oil temperature control, Hydrogen generator cooling system. Condenser Vacuum control, Gland steam Exhaust pressure control.

UNIT-V

Power generation using other methods – hydro-Electric, layout of hydro -electric power plant, Power generation in nuclear power plant, Importance of Control rods in nuclear power generation, Power generation using solar and wind Energy, Combined cycle power plant.

Suggested Reading:

1. S.C. Aurora and Domkundwar, *Power Plant Engineering,* Dhanpat Rai Publishers.
2. Sravana kumar, and Vijaya Ramanath, *Power plant Engineering*, I.K.Intermational Publishers.
3. David Lindsley, *Boiler Control Systems*, Mcgraw Hill Publishers.

Course Code	Course Title						Core/Elective
PC410EE	**Digital Electronics and Logic Design**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- Understand and apply the Boolean algebra and arithmetic circuits.
- Apply combinational digital circuits for logic functions
- Logic gates, memory, including CMOS gates, flip-flops, arrays, and programmable logic.
- Design tools, both manual and computerized, for design, optimization, and test of logic circuits.

Course Outcomes

At the end of the course students will be able to

1. Understand and apply the Boolean algebra, including CMOS gates and arithmetic circuits.
2. Apply combinational digital circuits for logic functions
3. Use the concepts of Boolean Algebra for the analysis & design of sequential logic circuits
4. Design various A/D and D/A converters
5. Design various logic gates starting from simple ordinary gates to complex programmable logic devices and arrays.

UNIT- I

Fundamentals of Digital Systems and logic families: Digital signals, digital circuits, AND, OR, NOT, NAND, NOR and Exclusive-OR operations, Boolean algebra, examples of IC gates, number systems-binary, signed binary, octal hexadecimal number, binary arithmetic, one's and two's complements arithmetic, codes, error detecting and correcting codes, characteristics of digital lCs, digital logic families, TTL, Schottky TTL and CMOS logic, interfacing CMOS and TTL, Tri-state logic.

UNIT-II

Combinational Digital Circuits: Standard representation for logic functions, K-map representation, simplification of logic functions using K-map, minimization of logical functions. Don't care conditions, Multiplexer, De-Multiplexer/Decoders, Adders, Subtractors, BCD arithmetic, carry look ahead adder, serial adder, ALU, elementary ALU design, popular MSI chips, digital comparator, parity checker/generator, code converters, priority encoders, decoders/drivers for display devices-M method of function realization.

UNIT-III

Sequential circuits and systems: A 1-bit memory, the circuit properties of Bistable latch, the clocked SR flip flop, J, K, T and D-type flip flops, applicationsofflipflops,shiftregisters,applicationsofshiftregisters,serial to parallel converter, parallel to serial converter, ring counter, sequence generator, ripple(Asynchronous) counters, synchronous counters, counters design using flip flops, special counter IC's, asynchronous sequential counters, applications of counters.

UNIT-IV

A/D and D/A Converters: Digital to analog converters: weighted resistor/converter, R-2R Ladder D/A converter, specifications for D/A converters, examples of D/A converter lCs, sample and hold circuit, analog to digital converters: quantization and encoding, parallel comparator A/D converter, successive approximation A/D converter, counting A/D converter, dual slope A/D converter, A/D converter using voltage to frequency and voltage to time conversion, specifications of A/D converters, example of A/D converter ICs.

UNIT-V

Semiconductor memories and Programmable logic devices: Memory organization and operation, expanding memory size, classification and characteristics of memories, sequential memory, read only memory

(ROM), read and write memory (RAM), content addressable memory (CAM), charge de coupled device memory (CCD), commonly used memory chips, ROM as a PLD, Programmable logic array, Programmable array logic, complex Programmable logic devices (CPLDS), Field Programmable Gate Array (FPGA).

Suggested Readings:

1. R. P. Jain, *Modern Digital Electronics*, McGraw Hill Education, 2009.
2. M. M. Mano, *Digital logic and Computer design*, Pearson Education India, 2016.
3. A. Kumar, *Fundamentals of Digital Circuits*, Prentice Hall India, 2016.

Course Code	Course Title						Core/Elective
PC411EE	**Power Electronics**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- Understand the characteristics and performance of various power electronic devices.
- Analyze single and three phase controlled rectifier circuits.
- Understand choppers circuits and AC voltage controllers
- Understand the performance of single phase and three phase inverter circuits.

Course Outcomes

At the end of the course students will be able to

1. Understand the characteristics and performance of various power electronic devices.
2. Analyze single and three phase controlled rectifier circuits.
3. Understand choppers circuits and AC voltage controllers
4. Understand the performance of single phase inverter circuits.
5. Analyse the operation of three phase voltage source inverters.

UNIT-I

Power Switching Devices: Diode, Thyristor, MOSFET, IGBT: static and dynamic Characteristics; Firing circuit for thyristor; Voltage and current commutation of a thyristor; Gate drive circuits for MOSFET and IGBT.

UNIT-II

Thyristor Rectifiers: Single-phase half-wave, full-wave and semi controlled rectifiers with R-load and highly inductive load; Three-phase half wave, full wave and semi controlled bridge thyristor rectifier with R-load and highly inductive load; Input current wave shape and power factor.

UNIT-III

DC-DC Converters: Elementary chopper with an active switch and diode concepts of duty ratio and average voltage, power circuit and operation of buck, boost and buck-boost converters in continuous conduction mode, duty ratio control of output voltage. AC-AC Converter: Power circuit and operation of single-phase AC Voltage Controller with R & RL Load. Basic concepts of Cycloconverter and Matrix converter.

UNIT-IV

Single-phase Inverter: Power circuit and operation of single-phase voltage source inverter in square wave mode, sinusoidal pulse width modulation (Unipolar and bi-polar), relation between modulation index and output voltage. Calculation of performance parameters of inverter.

UNIT-V

Three-phase Inverter: Power circuit and operation of three-phase voltage source inverter in 180^0 and 120^0 modes, Bi-polar sinusoidal pulse width modulation, relation between modulation index and output voltage. Elementary operation of CSI, Comparison of Voltage Source Inverter and Current source Inverter

Suggested Readings:

1. M. H. Rashid, *Power Electronics: Circuits, Devices and Applications*, Pearson Education India, 2009.
2. N. Mohan and T. M. Undeland, *Power Electronics: Converters, Applications and Design*, John Wiley & Sons, 2007.
3. R. W. Erickson and D. Maksimovic, *Fundamentals of Power Electronics*, Springer Science & Business Media, 2007.
4. L. Umanand, *Power Electronics: Essentials and Applications*, Wiley India, 2009.
5. Dr. P.S. Bhimbra, *Power Electronics*, Khanna Publishers, 2009.

Course Code	Course Title						Core/Elective
PC458EE	**Transducers Engineering Lab**						**Core**
Prerequisite	L	T	D	P	CIE	SEE	Credits
PC437EE	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives:

- To experimentally verify the principle and characteristics of various transducers.
- To learn and understand the measurement of non electrical quantities with the use of suitable transducers.

Course Outcomes:

On successful completion of this course student will be able to

1. Measure temperature by RTD, thermistor and Thermocouple.
2. Measure linear and angular displacement using LVDT, capacitive and inductive transducers.
3. Measure speed and toque by using suitable transducers.
4. Demonstrate the performance characteristics of various transducers.

1. Measurement of speed by magnetic pickup
2. Measurement of temperature by (a) Thermistor's (b) Thermocouple
3. Study and calibration of strain gauge
4. Measurement of speed and torque using Opto Electronic Sensor
5. Measurement of pressure by bellows
6. Measurement of Displacement by Capacitive pickup
7. Measurement of Displacement by Light dependent resistor.
8. Level Measuring System
9. Study and Calibration of LVDT
10. Study and Calibration of RTD
11. Measurement of displacement by inductive pickup

Note: At least 10 experiments should be conducted in the semester

Course Code	Course Title						Core/Elective
PC456EE	**Power Electronics Lab**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
PC411EE	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

- To be able to understand various power switching devices, trigger circuits, characteristics and applications by conducting the experiments.
- To learn and understand the rectifiers, choppers and inverters principle operation, characteristics and applications.

Course Outcomes

At the end of the course students will be able to

1. Able to understand speed control of motors by using controlled rectifier
2. Able to understand the applications of cyclo-converters
3. Able to simulate different power electronic devices using software.

List of Experiments:

1. R, RC, UJT Trigger Circuits for SCR's.
2. Design and fabrication of trigger circuits for single phase half and fully controlled bridge rectifiers.
3. Study of SCR chopper.
4. Design and fabrication of trigger circuit for MOSFET chopper.
5. Study of forced commutation techniques of SCRs.
6. Speed control of separately excited DC motor by controlled rectifier.
7. Speed control of universal motors using choppers.
8. Study of single phase half and fully controlled rectifier.
9. Study of single phase and three phase AC voltage controller.
10. Study of single phase dual converter.
11. Study of single phase cyclo converter.
12. IGBT based PWM inverters.
13. Simulation of single phase half and fully controlled rectifier.
14. Simulation of single phase and three phase AC voltage controller.
15. Simulation of single phase inverter & three phase inverter.

Note: At least ten experiments should be conducted in the Semester.

Suggested Readings:

1. Bimbra.P.S., *Power Electronics*, Khanna Publications, 2006.
2. Rashid M.H., *Power Electronics Circuits, Devices and Applications*, PHI, 2004.
3. Singh. M.D., Khanchandani K.B., *Power Electronics*, TMH, 14th reprint, 1999.
4. Mohan, Undeland and Robbins, *Power Electronic Converters. Applications and Design*, John Wiley & Sons, 3rd Edition, 2007.

Course Code	Course Title						Core/Elective
PC457EE	**Digital Electronics and Logic Design Lab**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	L			
PC410EE	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

- Identify the different types of number systems and their use.
- Explain the principle concepts of Digital Logic Design.
- Implement the logic circuits using Combinational Logic IC's.
- Distinguish between the Sequential and Combinational Logic Circuits.
- Reconstruct the Logic Circuits for real time applications with Combinational Circuits
- Formulate the Digital Logic Circuit function.
- Design the Logic Circuit using Combinational and Sequential Circuits

Course Outcomes

At the end of the course students will be able to:

1. Understand working of logic families and logic gates.
2. Design and implement Combinational and Sequential logic circuits.
3. Understand the process of Analog to Digital conversion and Digital to Analog conversion.
1. Use PLCs to implement the given logical problem.
2. Analysis of synchronous and asynchronous counters.

List of Experiments:

1. Study and operation of IC tester, pulse generator and probe.
2. Realization of different logic gates.
3. Realization of inverter using different logic families.
4. Multiplexer application for logic realization and parallel to serial Conversions.
5. Synchronous counters.
6. Asynchronous counters.
7. Half adder, full adder and subtractor and realization of combinational logic.
8. A / D converters.
9. D / A converters.
10. Experiment on Sample and hold circuit.
11. Simulation of error detecting codes using VHDL/Verilog/Multisim
12. Simulation of encoder/decoder using VHDL/Verilog/Multisim
13. Simulation of flip/flops using VHDL/Verilog/Multisim
14. Experiment on programmable logic devices (ROM/RAM/PLA/PAL/FPGA)

Note: At least ten experiments should be conducted in the Semester.

Suggested Readings:

1. R. P. Jain, *Modern Digital Electronics*, McGraw Hill Education, 2009.
2. M. M. Mano, *Digital logic and Computer Design*, Pearson Education India, 2016.
3. A. Kumar, *Fundamentals of Digital Circuits*, Prentice Hall India, 2016.