Lokmanya Tilak Jankalyan Shikshan Santha's

Lokmanya Tilak College of Engineering

Sector 4, Vikas Nagar, Koparkhairane, Navi Mumbai 400709

An Autonomous Institute Affiliated to University of Mumbai

Department of Electrical Engineering

CURRICULUM STRUCTURE

For

THIRD YEAR ENGINEERING

(BASED ON NEP 2020)

w.e.f. A.Y. 2026-27

Approved by Board of Studies on 29/04/2026

Approved by Academic Council on22/05/2026

Department of Electrical Engineering

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Preface

Lokmanya Tilak College of Engineering (LTCE) is founded by a Nagpur-based trust known as Lokmanya Tilak Jankalyan Shikshan Sanstha (LTJSS). The Sanstha was established in 1983, by Honourable Dr. Satish Chaturvedi. At present, there are 28 educational institutes run by the Sanstha in Nagpur. The Sanstha derives its philosophy from the magnanimous mathematician, educationist, social reformer Lokmanya Bal Gangadhar Tilak, who dedicated his life for the cause of Swaraj. Lokmanya Tilak College of Engineering was established in 1994, approved by the All-India Council for Technical Education, New Delhi, recognised by the Govt. of Maharashtra, accredited by NAAC with 'A' grade and is affiliated to the University of Mumbai. Within the span of 30 years of its inception, LTCE has grown leaps and bounds in terms of popular courses being offered at U.G., P.G.and Ph.D. level. Four of its branches viz., Computer, Mechanical, Electrical and Electronics and Telecommunications Engg. have been accredited by NBA. The Institute runs the Under-graduate Programmes in Mechanical Engineering, Computer Engineering, Electronics & Telecommunication Engineering, Electrical Engineering, Computer Science & Engineering (Data Science), Computer Science & Engineering (Artificial Intelligence & Machine Learning) and Computer Science & Engineering (IoT & Cyber Security Including Blockchain Technology). Institute also offers Doctoral Programmes in Mechanical Engineering and Computer Engineering. LTCE stands steadfast in its mission of continuing efforts for the betterment of its students and society.

The National Education Policy 2020, recently implemented by the Government of India, envisions providing quality education to all young people, with the primary goal of nurturing well-rounded, thoughtful, and creative individuals. NEP 2020 also emphasizes the importance of developing character, ethical values, constitutional principles, intellectual curiosity, scientific temper, creativity, and other related virtues. The Government of Maharashtra has instructed autonomous colleges to update their curriculum and begin implementing the National Education Policy (NEP) 2020. We are fully committed to ensuring the effective and meaningful adoption of NEP 2020 in its true essence. At "Lokmanya Tilak College of Engineering", the holistic development of learners has always been our top priority and central focus. LTCE embraced the NEP philosophy as early as 2022 wherein we have introduced the concept of Honors and Minors programs on emerging fields as per the guidelines of University of Mumbai and in 2024, we proudly graduated our first batch under this holistic curriculum. The autonomous curriculum for 2024-28 is structured in line with the recommendations of NEP 2020, AICTE, and UGC. It now includes courses in emerging technologies and multidisciplinary areas to ensure relevance to industry and practical applications. Greater focus has been placed on experiential learning to move away from rote memorization.

Sd/-	Sd/-	Sd/-
Dr. Madhwi Kumari	**Dr. Sheeba P. S.**	**Dr. Subhash K. Shinde**
BoS Chairman, Electrical Engineering	**Dean, Academics & Research**	**Principal**

Illustrative Semester wise Credit distribution structure for Four Year UG Engineering Program – One Major, One Multidisciplinary Minor as per Maharashtra State Govt. Resolution:

Courses		Semester								Total Credits
		I	II	III	IV	V	VI	VII	VIII	
Basic Science Course	BSC/ESC	6-8	8-10							14-18
Engineering Science Course		8-10	4-6							12-16
Programme Core Course (PCC)	Program Courses		2	8-10	8-10	10-12	8-10	4-6	4-6	44-56
Programme Elective Course (PEC)						4	8	2	6	20
Multidisciplinary Minor (MD M)	Multidisciplinary Courses			2	2	4	2	2	2	14
Open Elective (OE) Other than a particular program				4	2	2				8
Vocational and Skill Enhancement Course (VSEC)	Skill Courses	2	2		2		2			8
Ability Enhancement Course (AEC -01, AEC-02)	Humanities Social Science and Management (HSSM)	2			2					4
Entrepreneurship/Economics/ Management Courses				2	2					4
Indian Knowledge System (IKS)			2							2
Value Education Course (VEC)				2	2					4
Research Methodology	Experiential Learning Courses								4	4
Comm. Engg. Project (CEP)/Field Project (FP)				2						2
Project									4	4
Internship/ OJT								12		12
Co-curricular Courses (CC)	Liberal Learning Courses	2	2							4
Total Credits (Major)		**20-22**	**20-22**	**20-22**	**20-22**	**20-22**	**20-22**	**20-22**	**20-22**	**160-176**

Definition of Credit:

1 Hr. Lecture (L) per week	1 Credit
1 Hr. Tutorial (T) per week	1 Credit
2 Hr. Practical (P) per week	1 Credit
1 Hr. Practical (P) per week	0.5 Credit

Credit Requirements for Award of Degree:

a) A total of 167 credits are required for a student to be eligible for the award of an **Undergraduate Degree in Engineering**, including a Multi-Disciplinary Minor, in accordance with the Government of Maharashtra GR dated 04/06/2024.

b) A student shall be eligible for the award of an **Undergraduate Degree** with **Honours/Minor** in Emerging Areas upon earning an additional **18 credits**.

Multiple Exits:

Students will have the flexibility to enter a programme in odd semesters and exit a programme after the successful completion of even semesters as per their future career needs.

Level	Exit After Semester	Minimum Credits Required	LTCE Credits	Qualification Title	Additional Credit requirements
4.5	II (First Year)	40	44	One Year **UG Certificate** in relevant discipline	**8 credits** through Skill-based vocational courses (4 Credits) and Internship/ Apprenticeship/ Project (4 Credits).
5.0	IV (Second Year)	80	86	Two Years **UG Diploma** in relevant discipline	**8 credits** through Skill-based vocational courses (4 Credits) and Internship/ Apprenticeship/ Project (4 Credits).
5.5	VI (Third Year)	120	127	Three Years **B. Voc.**in the relevant Discipline	**8 credits** through Skill-based vocational courses (4 Credits) and Internship/ Apprenticeship/ Project (4 Credits).
6.0	VIII (Fourth Year)	160	167	**B.Tech**. in major discipline with multidisciplinary minor	-----
6.0	VIII (Fourth Year)	160+18= 178	167+18= 185	**B.Tech**. in major discipline with double minor (Multidisciplinary and Emerging minor)	--------

Distribution of Credits:

Type of Course	Course Code	No. of Credits as per Maharashtra Govt.	No. of credits as per LTCE
Basic Science Course	BSC	14-18	**16**
Engineering Science Course	ESC	12-16	**14**
Programme Core Course	PCC	44-56	**49**
Programme Elective Course	PEC	20	**19**
Multidisciplinary Minor	MDM	14	**14**
Open Elective (OE) Other than a particular program	OE	8	**08**
Vocational and Skill Enhancement Course	VSEC	8	**10**
Ability Enhancement Course (AEC -01, AEC-02)	AEC	4	**03**
Entrepreneurship/Economics/ Management Courses	EEMC	4	**04**
Indian Knowledge System (IKS)	IKS	2	**02**
Value Education Course (VEC)	VEC	4	**04**
Research Methodology	ELC	4	**03**
Comm. Engg. Project (CEP)/Field Project (FP)	ELC	2	**02**
Project	ELC	4	**04**
Internship/ OJT	ELC	12	**12**
Co-curricular Courses (CC)	CC	4	**03**
Total Credits (Major)		**160-176**	**167**
Total Credits (Major+Honors/Minors)		**178-194**	**167+18=185**

Abbreviations:

AEC	Ability Enhancement Course
AEL	Ability Enhancement Laboratory
BSC	Basic Science Course
BSL	Basic Science Laboratory
CEP	Common Engineering Project
CC	Co-curricular courses
CIE	Continuous Internal Evaluation
ESC	Engineering Science Course
ESE	End Semester Exam
ESL	Engineering Science Laboratory
IKS	Indian Knowledge System
L	Lecture
MDM	Multidisciplinary Minor
MSE	Mid Semester Exam
OE	Open Elective
P	Practical
PCC	Programme Core Course
PCL	Programme Core Laboratory
PEC	Programme Elective Course
T	Tutorial
VEC	Value Education Course
VSEC	Vocational and Skill Enhancement Course

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Third Year Engineering Scheme: Semester V (w.e.f. AY 2026-27)

Course Code	Course Name	Teaching Scheme		Credit Assigned		Total Credits	Examination Scheme					
							Internal Assessment		End Semester Exam		Oral &/ Practica	Total
		L	P	L	P		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)	Marks	Duration (Hrs		
EEPCC501	Control System	3		3		3	20	20	60	2		100
EEPCC502	Electrical Machine-I	3		3		3	20	20	60	2		100
EEPCC503	Power System Transmission and Distribution	3		3		3	20	20	60	2		100
EEPEC501	Program Elective Course-I	3		3		3	20	20	60	2		100
XXMDM501	Multidisciplinary Minor Course II	3		3		3	20	20	60	2		100
EEVSEC	Computer Aided Electrical Workshop		2*+2		2	2		50			25	75
EEPCL501	Control System -Lab		2		1	1		25			25	50
EEPCL502	Electrical Machine and Power System Lab		2		1	1		25			25	50
EEPECL501	Program Elective Lab		2		1	1		25			25	50
XXMDML501	Multidisciplinary Minor Course II Lab				1	1		25				25
Total		**15**	**12**	**15**	**6**	**21**	**100**	**250**	**300**	**10**	**100**	**750**

2*Indicate 2 (L) Hours theory lecture per week for the entire class.

EEPEC501X: Program Elective Course I	**EEPEC5011**:Renewable Energy and Energy Storage.	**EEPEC5012**:Utilisation of Electrical Energy.	**EEPEC5013**:Power Plant Technology.
EEPEL501X: Program Elective Lab I	**EEPEL5011**:Renewable Energy and Energy Storage Lab	**EEPEL5012**:Utilisation of Electrical Energy Lab.	**EEPEL5013**:Power Plant Technology Lab

Department of Electrical Engineering

Third Year Engineering Scheme: Semester VI (w.e.f. AY 2026-27)

Course Code	Course Name	Teaching Scheme		Credit Assign		Total Credits	Examination Scheme					
							Internal Assessment		End Semester Exam		Oral &/ Practical	Total
		L	P	L	P		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)	Marks	Duration (Hrs)		
EEPCC601	Power Electronics	3		3		3	20	20	60	2		100
EEPCC602	Electrical Machine -II	3		3		3	20	20	60	2		100
EEPEC601	Program Elective Course II	3		3		3	20	20	60	2		100
EEPEC602	Program Elective Course III	3		3		3	20	20	60	2		100
XXMDM601	Multidisciplinary Minor Course III	3		3		3	20	20	60	2		100
EEPCL601	Power Electronics Lab		2		1	1		25			25	50
EEPCL602	Electrical Machine -II Lab		2		1	1		25			25	50
EEPEL601	Program Elective Lab		2		1	1		25				25
XXMDM601	Multidisciplinary Minor Course III Lab		2		1	1		25				25
EECEP601	Mini Project II		2		1	1		25			25	50
Total		**15**	**10**	**15**	**5**	**20**	**100**	**225**	**300**	**10**	**75**	**700**

EPEC601X: Program Elective Course II	**EEPEC6011**:Control System Design.	**EEPEC6012**: Analog and Digital Communication.	**EEPEC6013**:Electrical Machine Design.
EEPEC602X: Program Elective Course III	**EEPEC6021**:Electric and Hybrid Electric Vehicle Technology.	**EEPEC6022**: Special Electrical Machines and Its Applications.	**EEPEC6023**:Micro Grid and Smart Grid.
EEPEL601: Program Elective Lab II	**Electrical Engineering Application design and Simulation Lab**		

Multidisciplinary Minor (MDM) (14 Credits)

Semester	Computer Engineering (CE)	Electronics & Telecommunication Engineering (ET)	Artificial Intelligence & Robotics (AR)	Internet of Things (IT)	Mechanical Engineering (ME)	Electrical Engineering (EE)
IV	CEMDM401: Data Structure and Algorithms	ETMDM401: Microprocessor and Microcontroller	ARMDM401: Artificial Intelligence	ITMDM401: Internet of Things and Applications	MEMDM401: Basics of Mechanical Engineering	EEMDM401: Elements of Electrical System
	CEMDML401: Data Structure and Algorithms Lab	ETMDML401: Microprocessor and Microcontroller Lab	ARMDML401: AI Lab	ITMDML401: Internet of Things Lab	MEMDML401: Mechanical Engineering Lab	EEMDML401: Elements of Electrical System Lab
V	CEMDM501: Database Management System	ETMDM501: Digital Communication & Sensor Technology	ARMDM501: Mechatronics	ITMDM501: Sensors, Actuators and Transducers	MEMDM501: Conventional & Renewable Energy Sources	EEMDM501: Special Machines and Smart grid
	CEMDML501: Database Management System Lab	ETMDML501: Digital Communication & Sensor Technology Lab	ARMDML501: Mechatronics Lab	ITMDML501: Sensors, Actuators and Transducers Lab	MEMDML501: Renewable Energy Sources Lab	EEMDML501: Special Machines and Smart grid Lab
VI	CEMDM601:AI & Soft Computing	ETMDM601: Digital Image Processing	ARMDM601: Robotics	ITMDM601: Microcontrollers and Application	MEMDM601: Automobile System	EEMDM601: Electric Vehicle Technology
	CEMDML601:AI & Soft Computing Lab	ETMDML601: Digital Image Processing Lab	ARMDML601: Robotics Lab	ITMDML601: Microcontrollers Lab	MEMDML601: Automobile Lab	EEMDML601: Electric Vehicle Technology Lab
VII	CEMDML701: Web Design Lab	ETMDML701: Mobile Computing Lab	ARMDML701: Predictive Maintenance Lab	ITMDML701: Industrial Automation Lab	MEMDML701: 3D Printing Lab	EEMDML701: Design Management Auditing of Electrical System Lab

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Third Year Engineering Curriculum: Semester V

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
EEPCC501	Control System Engineering	20	20	60	1	2	100	

Prerequisite: Circuit Theory, Laplace transform, mathematics for Electrical Engineering-I	
Course Objectives: The course aims to	
1	Modelling of electrical ,mechanical, electrotechnical system, transfer function, block diagram, state variables
2	Analyse and design system parameters to meet transient and steady state error, performance specifications.
3	Learn time response analysis and demonstrate their knowledge to frequency response
4	Learn stability analysis of systems using Root locus, bode plot, polar plot, and Nyquist plot.
Course Outcomes: Learners will be able to	
1	Explain and derive transfer functions of various system
2	Apply the block diagram reduction technique and SFG
3	Describe Stability, transient and steady state performance of second order system
4	Derive the various state space representation of control system
5	Draw the root locus and define stability
6	Draw the bode, polar and Nyquist plots and define stability

Module	Detailed Contents	Hrs.	CO Mapping
01	**Introduction to Control System**		

	Introduction to Control System: Elements of control systems, concept of open loop and closed loop systems, Examples and application of open loop and closed loop systems. Concept of feedback and Automatic control, Effects of feedback, Transfer function of electrical, mechanical (translational and rotational) System. Force Voltage and Force Current analogies.	6	**CO1**
02	**Mathematical Model of Physical System** Block diagram reduction technique and signal flow graph, Mason's rule, Signal flow graph of electrical network. Conversion of BDR to SFG and vice versa. **Self Learning topic:** Transfer function model of AC & DC servomotor, potentiometer & tacho-generator	6	**CO2**
03	**Time Domain Analysis**		
	Time Domain Analysis: Time domain analysis of a standard second order closed loop system. Concept of un-damped natural frequency, damping, overshoot, rise time and settling time. Dependence of time domain performance parameters on natural frequency and damping ratio. Step and Impulse response of first and second order systems. Effects of Pole and Zeros on transient response. Stability by pole location. Routh-Hurwitz criteria and applications. Error Analysis: Steady state errors in control systems due to step, ramp and parabolic inputs. Concepts of system types and error constants.	8	**CO3**
04	**State Variable Analysis** Introduction to state variable, General state space representation, State space representation of Electrical and Mechanical systems. Conversion between state space and transfer function. Alternative representations in state space: (Phase variable, canonical, parallel & cascade). Similarity transformations, diagonalizing a system matrix. **Self Learning Topic:**Laplace Transform solution of state equation, stability in state space	7	**CO4**
05	**Root locus Techniques** Definition and properties of root locus, rules for plotting root locus, stability analysis using root locus.	6	**CO5**
06	**Frequency Domain Analysis** Polar plots, Bode plot, stability in frequency domain. Nyquist stability criterion. Gain margin and phase margin via Nyquist diagram and Bode plots. **Self Learning Topic**: Nyquist plots, stability via Nyquist Plot	9	**CO6**

Text Books:-

1. Control System Engineering by Norman Nise
2. Control System Engineering by Nagrath and Gopal, 5th to latest edition , Wiley Eastern
3. Modern Control System Engineering by K. Ogata, Prentice Hall
4. Modern Control Systems, Twelfth edition, by Richard C Dorf, Robert H Bishop, Pearson.
5. Gopal, M., Digital Control System, Wiley Eastern (1986).

Reference Books:-

1. Linear Control system Analysis and design with MATLAB, by J.J. Azzo, C. H. Houpis S.N. Sheldon, Marcel Dekkar
2. Feedback control of Dynamic System, G.F. Franklin, Pearson higher education,
3. Control System Engineering, Shivanagraju s. Devi L., New Age International
4. Control Systems Technology, Curtis Johnson, Heidar Malki, Pearson
5. Control Systems Engineering, S. K. Bhattacharya, Pearson.
6. Control Systems, Theory and applications, Smarajit Ghosh, Pearson

Web Reference /Video Courses

1. NPTEL Course: Control Engineering By Prof. Ramkrishna Pasumarthy, Department of Electrical Engineering, IIT Madras :-Web link- https://nptel.ac.in/courses/108/106/108106098/
2. NPTEL Course: Control Systems By Prof. C.S. Shankar Ram, Department of Design Engineering, IIT Madras :- Web link- https://nptel.ac.in/courses/107/106/107106081/
3. NPTEL Course: Control Engineering By Prof. S.D. Agashe, Department of Electrical Engineering, IIT Bombay :-Web link- https://nptel.ac.in/courses/108/101/108101037/

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester V

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					
EEPCC502	Electrical Machine-I	20	20	60	1	2	100	3

Prerequisite: Students should be able to have a solid foundation in basic electrical principles, including AC circuits, magnetism, and electro mechanical energy conversion.	
Course Objectives: The course aims to	
1	Concepts of energy conversion,Concepts of DC machines and their applications.
2	Impart the knowledge of working principle, operations, performance and applications of single phase and three phase Transformers.
Course Outcomes: Learners will be able to	
1	Understand working principle of autotransformer
2	Illustrate working principle and performance of single phase transformer under different operating conditions
3	Analyze various types of connections and performance of three phase transformer under various conditions. .
4	Understand and analyze the significance of the DC machines performance parameters.
5	Illustrate working principle and performance of stepper motor
6	Illustrate working principle and performance of switched reluctance motor

Module	Detailed Contents	Hrs.	CO Mapping
01	**Electro mechanical Energy Conversion:** 1.1 Principle, Energy stored in magnetic field. 1.2 Field and co energy, Force and torque equations. 1.3 Torque in singly and doubly excited systems. **Auto Transformer:** 1.4 Working, Types. 1.5 Isolation Transformer working. 1.6 Applications.	06	CO1

	Self Learning Topic: Concept of field and co-energy.		
02	**Single phase Transformer**: 2.1 Review of working principle. 2.2 EMF equation and Equivalent Circuit. 2.3 Phasor diagram (Resistive, Inductive and capacitive load). 2.4 voltage regulation, Losses and Efficiency, Condition for Maximum Efficiency 2.5 Parallel Operation: No load Operation. 2.6 On load Operation: Equal Voltage Operation and Unequal Voltage Operation. 2.7 Testing of Transformer: OC and SC test, Sumpner's Test. **Self-Learning Topic:**Applications of parallel operation	**07**	**CO2**
03	**Three Phase Transformer:** 3.1 Constructional details. 3.2 Principle of operation, Connections and Phasor groups. 3.3 Parallel operation, Excitation Phenomenon in transformers. 3.4 Harmonics in three phase transformers, Suppression of harmonics. 3.5Oscillating neutral phenomenon, Switching intransient phenomenon. 3.6 Open delta or V - connection, Three phases to two phase conversion (Scott connection). **Self-Learning Topic:**. Three phase Transformer Connections and Phasor groups,	**08**	**CO3**
04	**DC Machines** 4.1 construction,working principle. 4.2 types, characteristics, starting,Necessity of starter,losses and efficiency. 4.3 Armature reaction, Process of commutation. 4.4 Testing of DC Motor Retardation, Swinburne, Hopkinson's and field test. **Self Learning Topic:** concept of back EMF, torque equation,speed-torque characteristic of series, shunt,compound.	**07**	**CO4**
05	**Stepper motor:** 5.1 Introduction, Construction, Types. 5.2 Operating Principles, Step angle, Resolution, Direction of rotation, Holding torque. 5.3 Pull-in torque and pull-out torque. 5.4 Excitation Methods: Single-phase excitation. 5.5 Two-phase excitation, Drive Circuits and Control, Stepper motor drivers, Pulse generation techniques, Open-loop control, Closed-loop control. 5.6 PWM control basics. **Self-Learning Topic:** Control and Interfacing, Performance Characteristics	**07**	**CO5**
06	**Switched Reluctance Motor** 6.1 Introduction,Construction,Working. 6.2 Types, Torque Production in SRM. 6.3 Converter and Drive Circuits.		**CO6**

	6.4 Control Techniques of SRM, Characteristics. 6.5 Applications of SRM 6.6 **BLDC) Motor:** Introduction, construction, working principle, types of BLDC motors.	**07**	
	Self-Learning Topic Recent developments and future scope of SRM technology		

Text Books:

1. Bimbhra P.S., Electric Machinery , Khanna Publisher
2. Bimbhra P.S., Generalized Machine Theory, Khanna Publisher
3. V. K. Mehta, Principles of Electrical Machines, S Chand Publication
4. https://onlinecourses.nptel.ac.in/noc19_cs47/preview

References:

1. M. G. Say,Performance and Design of Alternating Current Machines, CBS Pub.
2. Ashfaq Husain, Electric Machines, Dhanpat Rai and Co.
3. A.E. Fitzgerald, Kingsly, Stephen., Electric Machinery, Tata McGraw Hill

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester V

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
EEPCC503	Power System Transmission and Distribution	20	20	60	1	2	100	

Prerequisite: Basics of Electrical and Electronics Engineering and Elements of Electrical System.	
Course Objectives: The course aims to	
1	Learn the basic structure of electrical power systems, different components of the power system network.
2	Acquire knowledge of mechanical and electrical design of transmission systems.
3	Learn the representation of transmission systems for performance evaluation.
4	Acquire knowledge of different distribution network models.
Course Outcomes: Learners will be able to	
1	Illustrate the different types of conductors and evaluate the parameters of different types of ac transmission lines.
2	Evaluate the parameter of different types of ac transmission lines.
3	Analyze the performance of transmission lines using a power circle diagram.
4	Analyze the mechanical and electrical design aspects of overhead transmission lines.
5	Analyze and design the different distribution network models.
6	Understand the detailed construction of underground cables and fundamentals of the earthing system.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Transmission Line Parameters (Resistance and Inductance)**	08	CO1
	Introduction to overhead and underground transmission and distribution systems. **Conductors:** Comparison of conductor materials in overhead and underground system, concept of composite and bundle conductor. Economic choice of voltage and conductor size. **Resistance** of transmission line, skin effect, proximity effect, **Definition of inductance**, internal and external flux linkage of single conductor, Flux linkages of one conductor in an array, inductance of single phase two wire line, inductance of three phase three wire line with symmetrical and unsymmetrical spacing, concept of GMR and GMD, inductance of three phase double circuit line, inductance of bundled conductor lines **(Numerical)**.		
	Self-Learning Topic: HTLS conductor. Dynamic Line Rating.		
02	**Transmission Line Parameter (Capacitance)**	05	CO2
	Capacitance of transmission line, capacitance of single phase line, capacitance of three phase line with symmetrical and unsymmetrical spacing, effect of earth on transmission line capacitance **(single phase only) (Numerical)**.		
	Self-Learning Topic: Electrostatic Field of Conductors.		
03	**Characteristics and Performance of Transmission Lines**	08	CO3
	Introduction, Short and medium transmission lines, Charging currents, Calculation by nominal-T, nominal-π and end-condenser method, Regulation and efficiency, **Evaluation and Estimation** of generalized circuit constants (ABCD parameters) for short and medium line, long transmission line. Power circle diagram, Ferranti effect, Surge impedance and surge impedance loading. Corona and its impact. **(Numerical).**		
	Self-Learning Topic: Reactive power flow. Transmission network in India.		
04	**Mechanical Design of Overhead Lines**	08	CO4
	Types of Line supports, Types of steel towers, cross arms, Span conductor configurations, spacing and clearances, Sag and Tension calculations **(Numerical)**, support at same level, ice and wind effect, Total length of conductor, Equivalent Span. **Insulators:** Type of insulators, potential distribution across insulator string, String efficiency, methods for improving string efficiency **(Numerical).**		
	Self-Learning Topic: Right of way issues. Modern Transmission line construction techniques.		
05	**Classification and Design of Distribution Systems**	08	CO5
	Comparison of various Distribution Systems, AC 3-phase 4- wire Distribution, Type of Primary Distribution Systems, Type of Secondary Distribution Systems, Voltage Drop in AC Distributors, Kelvin's Law, Limitation of Kelvin's Law. **General Design Considerations**, Load Estimation, Design of Primary Distribution, Secondary Distribution Design, and Economical Design of Distributors **(Numerical)**.		
	Self-Learning Topic: Distribution loss reduction techniques. Reactive power compensation.		

06	**Underground Cables and Power System Earthing** **Electric Cable**: Classification and construction of cable, insulation resistance of cable, capacitance of single core and three core cable, grading of cable, inter-sheath grading, capacitance grading. **Earthing System**: Fundamentals (soil resistivity, step and touch potentials, grid voltage); measurement of earth resistance, power system neutral grounding and its methods, earthing techniques and types. **Self-Learning Topic:** Advanced cable insulation technologies.	05	**CO6**

Text Books:

1. B.R. Gupta, Power System Analysis and Design, S.Chand.
2. Electric Power Distribution Engineering, Turan Gonen, CRC Press, 3rd Edition, 2014.
3. Electric Power Distribution, A.S. Pabla, Tata Mc Graw Hill (India) Pvt. Ltd., 6 th Edition, 2011.
4. I.J Nagrath & D.P. Kothari, "Modern Power System Analysis", Tata McGraw Hill, 4th Edition, 2011.
5. Arun Ingole, "Power Transmission and Distribution", Pearson, 1st Edition, 2018.
6. Ashfaq Hussain, "Electric Power Systems", CBS Publisher & Distributors, 5th Edition, 2017.

References:

1. S.L Uppal & S.Rao, "Electrical Power Systems", Khanna Publishers, 15th Edition, 2018
2. C.L. Wadhwa, "Electric Power System", New Age International Publishers, 6th Edition, 2010.
3. W. D. Stevenson, "Element of Power System Analysis", McGraw Hill, 4th Edition, 1982.
4. NPTEL/ Swayam Course:Power System Analysis, By Prof. Debapriya Das (IIT Kharagpur) **https://onlinecourses.nptel.ac.in/noc22_ee120/preview**

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Industrial Visit to Power Plant/Sub-Station (Report): 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester V

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
EEPEC5011	Renewable Energy Energy Storage and smart grid	20	20	60	1	2	100	3

Prerequisite: Basic Electrical and Electronics Engineering	
Course Objectives: The course aims to	
1	Introduce the basic knowledge of solar thermal energy applications and solar photovoltaic systems.
2	Introduce the working,construction of Wind Energy system
3	Give the students basic knowledge of fuel cell system operation, working and other renewable energy sources.
4	Introduce Energy Storage
5	Introduce the need, definition of smart grid.
6	Understand Renewable Energy System Integration and Control
Course Outcomes: Learners will be able to	
1	Describe the basic knowledge of solar thermal energy applications and solar photovoltaic systems.
2	Describe the basic knowledge, working,construction of Wind Energy system
3	Describe fuel cell system operation, working,construction and other renewable energy sources.
4	Describe the significance of various energy storage technology
5	Describe the need and fundamentals of smart grid.
6	Describe Renewable Energy System Integration and Control

Module	Detailed Contents	Hrs.	CO Mapping
1	**Solar Energy- Solar Photovoltaic System** 1.1 Review of solar thermal applications-solar thermal conversion devices and storage applications. 1.2 Solar cell: characteristics, losses, model of a solar cell,	08	CO1

	1.3 Solar PV modules, mismatch in module, hot spots, bypass diode. 1.4 PV module: I-V and power curve, effect of variation in temperature and solar radiations, MPPT. 1.5 Types,different algorithms for electrical MPPT,distributed MPPT, MPPT converters. 1.6 Types of PV systems: standalone, grid connected systems. 1.7 BOS of PV system, Battery charge controllers, Power Conditioning Unit. 1.8 Solar PV Micro-inverters,Solar Plant design: mounting of PV panels supporting structures. 1.9 Calculation and Design methodology of standalone PV system and grid connected system. **Self-Learning Topic:** Emerging technologies, Regulatory standards, Net-metering.		
02	**Wind Energy System** 2.1 Review of wind energy systems and its components. 2.2 Types of wind turbines, characteristics, power generation and control. 2.3 Wind energy systems performance parameters and calculations 2.4 Topologies of WES, WES with rectifier / inverter system, 2.5 Power Converters for Doubly Fed Induction Generators (DFIG) in Wind Turbines. 2.6 Cost and environmental impact. **Self-Learning Topic: Revision of wind energy system**	07	CO2
03	**Fuel Cell and Other sources** 3.1 Fuel cell principle of operation, thermodynamics and types 3.2 Performance and Polarisation Curves-Voltage loss, Nernst equation, efficiency. 3.3 Topologies of fuel cell and applications. 3.4 Hydrogen as Fuel, P2G Application 3.5 Other sources: Tidal, Ocean Thermal, Geothermal, and Micro-hydro. 3.6 Cost and environmental impact. **Self-Learning Topic:** Recent development and Regulations	07	CO3
	Energy Storage		

04	4.1 Characteristics and performance of Batteries, Ultra-Capacitors, Flywheels, Superconducting magnetic energy storage (SMES), pumped hydro energy storage systems. 4.2 Energy storage- Battery sizing for stand-alone applications; Small scale application, Portable storage systems; (Numerical), 4.3 Hybrid Energy storage systems-configurations and applications. 4.4 Energy Storage-Charging methodologies, SoC, SoH, SoS estimation techniques. **Self-Learning Topic:** Case Studies on Energy Storage	07	CO4
05	**Smart-grid** 5.1 Concept, Need and function of Smart-Grid. 5.2 Concept of Resilient & Self-Healing Grid. 5.3 Micro grids and role in smart-grid scenario. 5.4 Intelligent Electronic Devices(IED) and Smart Substations **Self-Learning Topic:** Smart Grid Technologies	06	CO5
06	**Renewable Energy System Integration and Control** 6.1Architecture and configuration of integrated renewable energy systems 6.2 Operating modes and control: Centralised/Decentralised,Grid/Islanded 6.3 Load Following and Cycle Charging 6.4 Intermittency in operation and management 6.5 Power Quality, Synchronisation and Stability control **Self-Learning Topic: I**nverters in system integration.	07	CO6

Text Books:

1. Chetan Singh Solanki , Solar Photo Voltaics , PHI Learning Pvt Ltd., New Delhi,2009.
2. J.F. Manwell and J.G. McGowan, Wind Energy Explained, Theory Design and Applications.
3. Leo J.M.J. Blomen and Michael N. Mugerwa, "Fuel Cell System", New York, Plenum Press, 1993
4. Robert Huggins, Fundamentals, Materials and Applications Second Edition, Springer, 2016
5. J. C. Sabonnadière and N. Hadjsaïd, Smart Grids, John Wiley & Sons and ISTE, 2012
6. A. Keyhani, M. N. Marwali, M. Dai, Integration of Green and Renewable Energy in Electric Power Systems,Wiley, 2009

References:

1. S. Kalaiselvam and R. Parameshwaran , Thermal Energy Storage Technologies for Sustainability Systems Design, Academic Press, 2014
2. Trevor M. Letcher, Storing Energy with Special Reference to Renewable Energy Source, Elsevier,

2016
3. Frank S. Barnes and Jonah G. Levine, Large Energy Storage Systems Handbook, CRC Press, 2011
4. D. D. Hall and R. P. Grover, Biomass Regenerable Energy, John Wiley, New York, 1987.

Web Reference /Video Courses

1. NPTEL Course: Introduction to Smart Grid, By Prof. N. P. Padhy & Prof. Premalata Jena, IIT Roorkee
2.NPTEL Course: Energy Resources & Technology By Prof. S. Banerjee, IIT Kharagpur:- Web link- https://nptel.ac.in/courses/108/105/108105058/
3.NPTEL Course: Non-Conventional Energy Systems By Prof. L. Umanand, IISC Bangalore:- Web link- https://nptel.ac.in/courses/108/108/108108078/

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester V

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
EEPEC5012	Utilization of Electrical Energy	20	20	60	1	2	100	3

Prerequisite:Basics of Electrical Engineering	
Course Objectives: The course aims to	
1	Impart the knowledge of various types of lamps used and fittings accessories.
2	Impart knowledge of principles of electrical traction and different types of drives used.
3	Increase the awareness of latest developments in electric heating and welding.
4	Impart the basic knowledge of some domestic electric appliances.
Course Outcomes: Learners will be able to	
1	Explain the functioning of illumination methods and fitting accessories.
2	Analyse different type of traction systems
3	Illustrate and analyse the performance of various traction motors and drives
4	Describe the concept of electrical heating and welding and their application.
5	Explain different methods of cooling systems used in domestic electric appliances.
6	Describe and analyse the power factor for improving the quality of supply.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Illumination system** Definition of various illumination terminology, Laws of Illumination-Inverse square and Lombert's Cosine law, Photometry, Various types of lamps-High Mercury vapour lamp, Sodium vapour lamps, Metal Halide Lamps, various lighting schemes, features and application, Method of lighting calculations (numericals) Domestic and industrial lamp fittings. **Self Learning Topic:** Photo cells, working of Compact fluorescent lamp(C.F.L)	06	**CO1**
02	**Electric Traction**	10	

	Requirement of an ideal traction system. Types of Traction system. System of Track electrification- DC system, single phase, three phase, composite system (Kando system), single phase AC to DC system. Different accessories for track electrification- overhead wire, conductor rail system, current collector- pantograph types, Types of services, speed time curve, trapezoidal and quadrilateral speed time curves, power and energy output from driving axles, average and schedule speed (numerical), specific energy consumption, factors affecting specific energy consumption, dead weight, accelerating weight and adhesive weight. **Self Learning Topic:** AC and DC power system comparison**.**		**CO2**
03	**Electric Traction Motors and Controls** Desirable characteristics of traction motors, AC series motors, linear induction motor for traction. chopper controlled motor, Control of Traction motors- Requirement, starting and speed control by using rheostat control, series parallel method, transition from series to parallel(numericals) (shunt transition, bridge transition), thyristor control method, Breaking-Requirement of breaking system, mechanical breaking, electrical breaking, rheostatic breaking, regenerative breaking. Mechanical breaking. **Self Learning Topic: C**haracteristics of DC motors, DC series motors, 3phase induction motor characteristics.	08	**CO3**
04	**Electric Heating and Welding** Electric Heating, Resistance ovens, Radiant Heating, Induction Heating, High frequency Eddy Current Heating, Dielectric Heating, The Arc Furnace, Heating of Buildings, Electric Welding, Modern Welding Techniques. **Self Learning Topic:** Modes of heat transfer, Welding, process of welding.	06	**CO4**
05	**Power Tariff and Power factor Improvement** Requirement of tariff, two/three part tariff, WRD, spot pricing, (Numerical) Comparison between Private Generating plant and Public supply, Advantages and methods of Power factor improvement **Self Learning Topic: B**asic tariff methods, power factor	06	**CO5**
06	**Other application of Electrical Energy** Electrical circuit of a Refrigerator **,**Refrigeration cycle, Vapour compression type, vapour absorption type,Room Air conditioner window type and split type. Elevators- Functions, application types, its motors and safety. **Self Learning Topic:** Study ratings of home appliances.	06	**CO6**

Text Books:

1. Utilization of Electric Energy by J. B. Gupta, SK Kataria & Sons.
2. Utilization of Electric Energy by R. K. Rajput, Laxmi Publications (P) Ltd.
3. Generation, Distribution and Utilization of Electric Energy by C.L.Wadhwa, Wiley Eastern Ltd.

Reference Books:

1. Art, Science of Utilization of Electric Energy by H. Pratap, Dhanpat Rai & Sons
2. Electric Traction by H. Pratap, Dhanpat Rai & Sons
3. Designing with light- A Lighting Handbook by Anil Valia, Lighting System
4. Generation and Utilization of Electric Energy by S. Sivanagaraju, Pearson Eduction India

5. M. Ehsani, Y. Gao,S.E.Gay and Ali Emadi, *Modern Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design,* CRC Press. 2005.
6. “Lamps and lighting” by M.A.Cayless, J.R.Coaton and A.M.Marsden
https://onlinecourses.nptel.ac.in/noc19_cs47/preview

Internal Assessment (20 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester V

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
EEPEC5013	Power Plant Technology	20	20	60	1	2	100	3

Prerequisite: Basic Electrical Engineering	
Course Objectives: The course aims to	
1	Provide fundamental knowledge of basic working principles and components used in various conventional power plants for electricity generation.
2	Develop an understanding of a plant performance and efficiency analysis.
3	Introduce various operational aspects and recent technological advancements in power generation systems.
4	Analyze the economic aspects of power generation, including cost estimation and optimal operation of plant performance for sustainable operation.
Course Outcomes: Learners will be able to	
1	Understand and analyses the working of thermal power plant
2	Understand and analyses the working of nuclear power plant
3	Understand and analyses the working of gas turbine power plant
4	Understand and analyses the working of diesel engine power plant
5	Understand and analyses the working of hydro electric power plant
6	Analyze and evaluate the economical aspects of power generation

Module	Detailed Contents	Hrs.	CO Mapping
01	**Thermal Power Plant** Layout and Working of a Thermal Power Plant. Burning and Handling of Fuel, Ash and Draught. Boiler Types, Mountings, and Accessories. Steam Turbines and Condensers. Feed Water Treatment and Steam Piping, Cooling Towers. Performance and Efficiency Analysis. **Self Learning Topic:** Supercritical, Ultra-supercritical and Advanced Ultra-Super Critical (AUSC) Boilers/Turbines.	09	**CO1**
02	**Nuclear Power Plant**	06	**CO2**

	Layout and Working of a Nuclear Power Plant. **Reactors:-**Pressurized Water (PWR) , Boiling Water (BWR), Gas Cooled, Liquid Metal Fast Breeder, Heavy Water, Fusion Power, Molten Salt. Control of Reactor. Performance and Efficiency Analysis.		
	Self Learning Topic: Safety Systems for Pressurised Heavy Water Reactors, Atomic Energy Regulatory Board, Govt of India .		
03	**Gas Turbine Power Plant**	06	**CO3**
	Layout and Working of a Gas Turbine Power Plant. **Cycles** :-Brayton, Open, Close, Integrated Gasification Combined Cycle. Governing System. Gas and Steam Combined Cycle Operation. Performance and Efficiency Analysis.		
	Self Learning Topic: Turbine Blade Material, Coating and Cooling.		
04	**Diesel Engine Power Plant**	06	**CO4**
	Layout and Working of a Diesel Electric Power Plant.Governing System. Alternative fuel Operation.Performance and Efficiency Analysis.		
	Self Learning Topic: Emission Norms for Diesel Generator Sets in India (CPCB Stage V).		
05	**Hydro Electric Power Plant**	06	**CO5**
	Layout and Working of a Hydro Electric Power Plant.**Classification and Types**:-Run off River, Storage River, Pumped Storage. Turbines and governing System. Performance and Efficiency Analysis.		
	Self Learning Topic: Micro Hydro Power Generation and Scope in India		
06	**Economics of Power Generation**	09	**CO6**
	Power Plant Fundamental Terms. Load and Impact of Various Factors. Selection of Plant, Location, Equipment Size and Number of Units. Optimal Operation of Plant. Cost of Electricity and its Components.Various Tariffs. Life-Cycle Cost and Asset Management.		
	Self Learning Topic: Heat Rate Improvement Programs by NTPC		

Text Books:

1. Arora, Domkundwar, "A Course in Power Plant Engineering",Dhanpat Rai & CO. Private Limited .
2. P K Nag, "Power Plant Engineering", McGraw Hill Education(India) Private Limited.
3. M. M. EI Wakil " Powerplant Technology", McGraw Hill Education(India) Private Limited.

References:

1. Fredrick T Morse, Power Plant Engineering, East-West Press Private Limited..
2. Mahesh Verma, Power Plant Engineering, Metrolitan Book CO Private Limited..
3. George W Sutton-(Editor), Direct Energy Conversion, Lathur University, Electronic Series Vol 3, McGraw Hill.
4. NPTEL Course, " Power Plant Engineering", https://nptel.ac.in/courses/112107291.

Internal Assessment (40 Marks)
A. Mid Semester Exam (20 Marks)
Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)
A. Assignment: 5 Marks
B. Quiz/Open book test/Presentation: 10 Marks

C. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weight age.

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester V

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2*+2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					2
EEVSEC 501	**Computer Aided Electrical Workshop**	-	50	25	-	-	75	

Prerequisite:	
Course Objectives: The course aims to	
1	Bridge the gap between industry and institute
2	Develop skill of electric circuit design
3	Develop skill of PCB design
4	Develop Skill of Electrical CAD
5	Develop Skill of circuit analysis through Simulation.
Course Outcomes: Learners will be able to	
1	Design and develop circuit board for simple electrical circuit
2	Make PCB schematic and PCB board
3	Make electrical circuit using CAD tool
4	Analyze electrical circuit through Simulation
5	Enhance the technical skill and employability

Content

Prerequisite: AutoCAD, Electrical Workshop, Circuit Theory

Module 1	**Electric circuit Board design:**	**7 hours**	**CO Mapping**

	A small electrical circuit board can be developed which may be utilized to perform some experiment in lower semester such as circuit board for testing the KVL, KCL, resonance, first order, second order circuit, RLC series parallel circuit etc. Students should be given the knowledge of materials used in making the trainer kits, circuit making and simulation in any circuit simulation software and fabrication of the circuit on a board and develop the final product. Visit to the nearby Industrial Training Institute.		**CO1, CO5**
	Self Learning: Certified training program in circuit building		
Module 2	**PCB Making** PCB board of single layer or double layer of any control circuit Using IC, Transistors and electronic components. Any open source PCB design software can be used.	7	CO2, CO5
Module 3	**Electrical circuit using CAD tool** Use of Autocad and Electrical Autocad to make electrical circuit, single line diagram, power system diagrams	7	CO3, CO5
Module 4	**Electrical circuit through Simulation** System analysis through simulation with the use of various Matlab Simulink toolboxes such as SIMPOWERSYSTEM, CONTROLSYSTEM, SIMSCAPE, SIMDRIVELINE, SIMELCTRONICS and others.	7	CO4, CO5

Certification Course:
1. NPTL/MOOCS/Coursera/SWAYAM etc certification Course
2. Training in any Skill Development institute during the semester.
3. Workshop in PCB design, Arduino programming/ Raspberry pi or any other area which will develop the technical skill of students.
4. Course Project

Lab work should be done as a group of Maximum 4 students.

Term Work: At least one circuit board designed and tested, one PCB developed and tested, Two CAD work, two simulations on Simulink, one certificate course/ workshop/ training in skill development centre are compulsory to grant the term.

Continuous Internal Evaluation (25 Marks)
1. Lab Performance: 10 Marks
2. Certification course/ Course project: 25 Marks
3. In-Semester Practical Exam during lab session: 10 Marks
4. Regularity and Attendance: 5 Marks

Oral & Practical Exam (25 Marks)
An Oral exam will be held based on the entire syllabus.

Department of Electrical Engineering

Second Year Engineering Curriculum: Semester IV

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hours
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
EEPCL501	Control System -Lab	-	25	25	-	-	50	

Course Objectives: The course aims to	
1	Study basic concepts of control system
2	Familiarize with the modelling of dynamical systems and the characteristics of control components like AC servo motor, DC servo motor, DC position control system and synchro
3	Employ time domain analysis to predict and diagnose transient performance parameters of the system for standard input functions
4	Ascertain the required dynamic response from the system
Course Outcomes: Learners will be able to	
1	Understand Basic control system
2	Illustrate the functioning of various components of the control system.
3	Analyse the response of the physical system for various inputs.
4	Analyse and interpret stability of the system through Root Locus, Bode plot and Nyquist plots
5	Execute time response analysis of a second order control system using MATLAB
6	Describe the system in state space using Matlab

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
1	**Syllabus: Same as EEC503: Control Systems** **Suggested List of Laboratory Experiments: Minimum four from Group (A) and four from Group (B), in all minimum eight experiments need to be performed.** Laboratory Experiments 1. Study of AC Servomotor	**CO1, CO2, CO3**

	2. Study of DC Servomotor 3. Study of potentiometer as an error detector 4. Study of Synchros as an error detector 5. Study of AC position control system 6. Study of DC position control system 7. Obtain time response of first order to step ramp and parabolic input 8. Obtain time response of second order system to step input. 9. open loop and closed loop control system 10. type of system	
2	Simulation Based Experiments (on Simulation Platform like MATLAB/SCILAB or Python Programming tool) 1. a) Simulation of a typical second order system and determination of step response and evaluation of time domain specifications b) Evaluation of the effect of additional poles and zeroes on time response of second order system c) Evaluation of effect of pole location on stability d) Effect of loop gain of a negative feedback system on stability 2. Draw the Root loci for a given transfer function and verification of breakaway point and imaginary axis crossover point. 3. Obtain the phase margin and gain margin for a given transfer function by drawing bode plots and verify the same. 4. Draw the Nyquist plot for a given transfer function 5. Obtain State model from Poles and zero and also from transfer function 6. Determination of step, ramp & impulse response of a state model Any other experiment based on syllabus which will help students to understand topic / concept. **Note: Students and teachers are encouraged to use the virtual labs whose links are as given below The remote access to Labs in various disciplines of Science and Engineering is available. Students can conduct online experiments which would help them in learning basic and advanced concepts through remote experimentation.** **Virtual Lab Website Reference** 1. http://vlab.co.in/broad-area-electrical-engineering 2. http://vlab.co.in/broad-area-electronics-and-communications	**CO4, CO5, CO6**

Lab Performance:
Minimum 08 experiments to be performed. Any other experiments related to the course content can be performed.

Continuous Internal Evaluation (25 Marks):

1. Lab Performance: 10 Marks
2. Mid Semester Oral & Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Oral/Practical Exam(ESE)(25): Oral exam of 25 marks to be conducted at end of the semester on entire syllabus of Control System Engineering (EEPCC501) including the lab work and assignments

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester V

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
EEPCL502	**Electrical Machine and Power System Lab**	-	25	25	-	-	50	

Prerequisite: Basic Electrical and Electronics, Electrical Machines, Power System Transmission and Distribution	
Course Objectives: The course aims to	
1	Provide practical knowledge of the operation, characteristics, and speed control methods of DC and induction motors.
2	Develop the ability to evaluate and analyze the performance of electrical machines such as DC machines, induction motors, and transformers through laboratory experiments.
3	Impart knowledge of different transmission and distribution systems, its modeling and enable students to analyze the performance.
4	Develop practical understanding of underground cables and earthing systems, including performance analysis and measurement techniques used in power systems.
Course Outcomes: Learners will be able to	
1	Illustrate different methods of speed control of DC and Induction motors.
2	Evaluate the performance of DC and Induction motors.
3	Analyze the performance of the transformer.
4	Calculate and analyze the performance of various transmission line models.
5	Calculate and analyze the performance of different distribution networks.
6	Calculate and analyze the performance of cables and earthing systems.

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
1	To perform speed control of DC series motor	CO1
2	To perform speed control of DC shunt motor	CO1
3	To perform speed control of an induction motor by V/F method.	CO1
4	To perform speed control of an induction motor by pole changing method.	CO1
5	To perform load test of DC series motor	CO2
6	To perform load test on DC shunt motor	CO2
7	To perform Swinburn's test on a DC motor.	CO2

8	To perform load test on slip ring induction motor.	CO2
9	To perform load Test on three phase squirrel cage induction motor	CO2
10	To perform Sumpner's test on single phase transformer	CO3
11	To perform OC and SC on single phase transformers.	CO3
12	To perform parallel operation of transformers.	CO3
13	To perform Scott connection of the transformer.	CO3
14	To perform Open Delta (V) connection of the transformer.	CO3
15	To perform load test on 3 phase transformer	CO3
16	To compute ABCD parameters of different transmission lines.	CO4
17	To compute voltage regulation and efficiency parameters of different transmission line models.	CO4
18	To calculate resistance, inductance,capacitance of different conductor configurations of a transmission line.	CO4
19	To calculate performance parameters of mechanical design of transmission lines.	CO4
20	To calculate performance parameters of various AC distribution network configurations.	CO5
21	To calculate performance parameters of various DC distribution network configurations.	CO5
22	To measure performance parameters of a cable.	CO6
23	To measure the resistivity of soil.	CO6

Virtual Lab Website Reference:

1. http://vlab.co.in/broad-area-electrical-engineering

2. http://vlab.co.in/broad-area-electronics-and-communications

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Lab Performance: At least eight experiments must be conducted, with a minimum of four experiments each from the Machines and Power Systems domains. Additionally, experiments beyond the suggested list may be undertaken, provided they are relevant to the subject content.

Oral & Practical Exam (25 Marks)

An Oral & Practical exam will be held based on the lab work and the respective theory courses.

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester V

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					
EEPECL 5011	Renewable Energy Energy Storage and Smart Grid Lab	-	25	25	-	-	50	1

Prerequisite: To understand Basics of Renewable energy Sources	
Course Objectives: The course aims to	
1	Understand the operating principles, modeling, and control of DC–DC and DC–AC converters used in DC and AC microgrid applications.
2	Develop and simulate voltage mode and current mode control strategies for DC–DC converters and inverters to ensure stable power conversion and regulation.
3	Design and analyze grid-connected inverter systems including synchronization, active/reactive power control, and grid integration techniques.
4	Implement and evaluate power sharing techniques among multiple DC–DC converters and inverters for reliable operation of DC and AC microgrids.
5	Model and simulate renewable energy systems including Solar PV with MPPT, Solar PV–Battery hybrid systems, Fuel cell based two-stage systems, and wind energy conversion systems.
6	Apply simulation and emulation tools such as MATLAB/Simulink to study smart grid technologies microgrid operation, and system performance under dynamic conditions.
Course Outcomes: Learners will be able to	
1	Analyze the operation and develop simulation models of unidirectional and bidirectional DC–DC converters for DC microgrid applications.
2	Design and simulate DC–AC converters (inverters) using voltage mode and current mode control techniques for AC microgrid applications.
3	Develop grid-connected inverter models with synchronization, voltage/frequency regulation, and active/reactive power control for AC microgrids.
4	Implement and evaluate power sharing techniques among multiple DC–DC converters in DC microgrid systems for stable load distribution.
5	Analyze parallel operation and power sharing between multiple inverters in AC microgrids to ensure reliable and balanced power delivery.
6	Apply simulation tools such as MATLAB/Simulink to study converter performance, control strategies, and microgrid stability under dynamic operating conditions.

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
01	Simulation of DC-DC Converters (unidirectional /Bidirectional) with Voltage mode control / current mode control for DC Microgrid application.	CO1
02	Simulation of DC-AC Converter (Inverter) with Voltage / current mode control for AC Microgrid application.	CO1
03	Simulation of DC-AC Converter (Inverter) with grid connected mode operation for AC Microgrid application.	CO1
04	Simulation of power sharing between two (or more) DC-DC Converters in DC Microgrid scenario.	CO1
05	Simulation of power sharing between two Inverters in AC Microgrid scenario.	CO1
04	Simulation of Solar PV MPPT (P&O or Incremental conductance) based characterization under different operating conditions	CO2
05	Simulation of Solar PV MPPT converter with VSI	CO2
06	Simulation of Back to back converter for Wind Energy Application	CO3
07	Simulation of Fuel cell based Two stage (DC-DC converter and VSI) power supply for AC loads	CO4
08	Simulation of Solar PV MPPT (P&O or Incremental conductance) based characterization under different operating conditions	CO5
09	Simulation of Solar PV and Battery hybrid energy source	CO6

Lab Performance:
Minimum 08 experiments to be performed. Any other experiments related to the course content can be performed.

Continuous Internal Evaluation (25 Marks)
1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Oral & Practical Exam (25 Marks)
An Oral exam will be held based on entire syllabus of EEPECL5011 - **Renewable** Energy &Energy Storage and smart grid Lab

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester V

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
EEPECL5012	Utilization of Electrical Energy Lab	-	25	25	-	-	50	

Prerequisite:	
Course Objectives: The course aims to	
1	Observe working of various types of illumination lamps.
2	Observe the working of various electric drives used in Traction/Elevators.
3	Observe the working of Furnaces and electric welding methods.
4	Use safety equipment for economic development.
5	Apply the knowledge of tariff calculation on electricity bills.
Course Outcomes: Learners will be able to	
1	Measure illumination at different places for various lamps using lux meters.
2	Identify the various electrical drives operation in traction.
3	Identify various components required for various types of heating furnaces.
4	Analyse the power factor improvement methods.
5	Analyse the tariff methods used in domestic and industrial sites.
6	Analyse the use of various home appliances used in day to day life.

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
01	To measure voltage, current and power for various types of illumination lamps.	CO1
02	To measure the intensity of light using a lux meter for different lamps.	CO1
03	Visit a loco shed or monorail to observe various components and working of electric locomotives used in Electric Traction.	CO2
04	To observe the working of anyone industrial drive, with characteristics.	CO2
05	Report on various types of heating furnaces.	CO3
06	Improve the power factor of available inductive load using a static capacitor.	CO4
07	Prepare a technical report after visiting an industry, various power factor improvement devices used.	CO4
08	Prepare a comparative chart of two different manufacturing companies in India for any two Lift/Elevator with technical data.	CO5
09	Prepare a report based on comparative study of various tariff structures of Maharashtra.	CO5
10	Prepare Energy Bill based on energy consumption of residence/commercial building	CO5
11	To observe the components of air conditioning, refrigerators etc.	CO6
12	To study/Visit any refrigeration plant and make a report.	CO6

Lab Performance:

Minimum 08 experiments to be performed. Any other experiments related to the course content can be performed.

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Oral Exam (25 Marks)

An Oral exam will be held based on the entire UEE EEPEC5012 syllabus and practical.

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester V

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	02 Hrs
		Internal Assessment		Oral	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					01
EEPECL5013	Power Plant Technology Lab	-	25	25	-	-	50	

Prerequisite: Basic Electrical Engineering	
Course Objectives: The course aims to	
1	Apply fundamental principles to analyse the performance of various power plants using computational tools.
2	Analyze the effects of various operating parameters on the performance of various power plants using computational tools.
3	Evaluate different power plant configurations and compare their performance metrics using computational tools.
4	Optimize performance models to improve the operational efficiency and sustainability of various power plants.
Course Outcomes: Learners will be able to	
1	Illustrate and analyse the performance of thermal power plants.
2	Illustrate and analyse the performance of nuclear power plants.
3	Illustrate and analyse the performance of gas turbine power plants.
4	Illustrate and analyse the performance of diesel engine power plants.
5	Illustrate and analyse the performance of hydro power plants.
6	Illustrate and analyse the tariff fixation process.

Suggested List of Experiments

Sr. No	List Of Experiments	CO Mapping
1	Simulation and Analysis of Coal Required Per Hour in Thermal Power Plant	CO1
2	Simulation and Analysis of Cooling Water Required Per Hour in Thermal Power Plant	CO1
3	Simulation and Analysis of Reactor in Nuclear Power Plant	CO2

4	Simulation and Analysis of Specific Energy Release Rate in Nuclear Power Plant	CO2
5	Simulation and Analysis of Thermal Efficiency of Gas Turbine Power Plant	CO3
6	Simulation and Analysis of Drop in Pressure for Gas Turbine Power Plant	CO3
7	Simulation and Analysis of Sampling Valve Control of Diesel Engine	CO4
8	Simulation and Analysis of Output of the Hydro Generating Station	CO5
9	Simulation and Analysis of Rate at which the Water Fall in the Reservoir	CO5
10	Hand Calculation for Generation Tariff Fixation as per Regulatory Commission	CO6

Lab Performance:
Minimum 08 experiments to be performed. Any other experiments related to the course content can be performed.

Text Books:
1. V Ganeshan, "Scilab Textbook Companion for Gas Turbines".
2. S. C. Arora, S. Domkundwar, A. V. Domkundwar, "Scilab Textbook Companion for A Course In Power Plant Engineering".
3. NTPC Useful Downloads

Continuous Internal Evaluation (25 Marks):
1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Oral & Practical Exam (25 Marks)
An Oral exam will be held based on the entire sy

Department of Internet of Things Engineering
Third Year Engineering Curriculum: Semester V

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
ITMDM501	Sensors Actuators and Transducers	20	20	60	1	2	100	

Prerequisite: Students should be able to implement the fundamental knowledge of the IoT system.	
Course Objectives: The course aims to	
1	To understand the working principles and classifications of sensors, actuators, and transducers.
2	To learn micro and MEMS sensors and actuators for IoT systems.
3	To study electrical interfacing, signal conditioning, and calibration techniques.
4	To design IoT-based systems using real-time sensing and actuation.
Course Outcomes: Upon successful completion of this course, the learner will be able	
1	Explain operating principles and classifications of sensors, actuators, and transducers.
2	Identify and select appropriate sensors for various IoT applications.
3	Describe actuator types and their control techniques.
4	Explain transduction mechanisms and their practical implementation.
5	Design and implement IoT-based systems integrating sensors, actuators, and transducers.
6	Understand the concept of Advanced transducers and their IoT integration

Module	Detailed Contents	Hrs.	CO Mapping
01	**Fundamentals and Classification of Sensors:** **1.1** Introduction to sensors and measurement systems. **1.2** Sensor characteristics: sensitivity, resolution, accuracy, range, hysteresis, drift, and linearity. **3.** Classification: active/passive, analog/digital, contact/non-contact sensors. **4.** Types of sensors for measurement of : flow, temperature, pressure, proximity, force/strain, speed/velocity, displacement/position,	08	CO1

	acceleration/motion, sound, vibration, humidity, gas, biosensor, pH, infrared, image/vision **5.** Selection criteria and standards for sensors. **1.6** Overview of smart sensors and IoT sensor nodes. **1.7** Applications**:** Home automation, smart lighting, temperature monitoring		
	Self-Learning Topic: Application for moisture measurement		
02	**Micro and MEMS Sensors for IoT:**	**06**	**CO2**
	2.1 Introduction to MEMS and micro-sensors. **2.2** MEMS fabrication techniques (lithography, etching, deposition, packaging) **2.3** Micro-sensors: • Accelerometer, gyroscope, pressure, flow, temperature, and humidity sensors • Biosensors and chemical sensors **2.4** Integration of MEMS sensors in IoT platforms (smartphones, wearables, vehicles) **2.5** Sensor calibration, signal conditioning, and interfacing.		
	Self- Learning Topic: Case Study: MPU6050 IMU, BMP280 environmental sensor, DHT11		
03	**Fundamentals of Actuators and Drive Mechanisms**	**08**	**CO3**
	1. Introduction to actuators – principle, classification, and characteristics **3.2** Electrical actuators: • DC motor, stepper motor, servo motor • Control techniques (PWM, H-bridge) **3.** Pneumatic and hydraulic actuators – basic operation and control valves. **4.** Mechanical actuators- operation and types and control circuit. **5.** Smart actuators and drive circuits for IoT. **6.** Thermal actuators- basic operation and control circuit. **7.** Magnetic actuator-basic operation and control circuit **8. Applications:** Smart door locks, automatic fans.		
	Self-Learning Topic: Application in robotic arms		
04	**Micro-Actuators and Intelligent Actuation Systems**	**06**	**CO4**
	4.1 MEMS micro-actuators: electrostatic, piezoelectric, thermal, and magnetic types. **4.2** Shape memory alloy (SMA) actuators. **4.3** Micro-pumps, micro-valves, and micro-grippers. **4.4** Interfacing actuators with microcontrollers and IoT boards (Arduino, ESP32, Raspberry Pi)		
	Self-Learning Topic: Case studies: micro-actuators in biomedical devices and robotics		
05	**Transducer Fundamentals and Signal Conditioning:**	**07**	**CO5**
	1. Concept of transduction and transducers **2.** Types of transduction mechanisms: resistive, inductive, capacitive, piezoelectric, and optical. **3.** Conversion principles and energy domains. **4.** Static and dynamic characteristics of transducers. **5.** Signal conditioning: amplification, filtering, isolation, ADC/DAC, noise reduction. **6. Applications:** Strain measurement, pressure.		
	Self-Learning Topic: Application in force detection.		

06	**Advanced Transducers and IoT Integration** **1.** Optical fiber, ultrasonic, and photoelectric transducers. **2.** Smart and digital transducers. **3.** Wireless transducer networks and IoT interfacing. **4.** Calibration, compensation, and error analysis. **5.** Data acquisition systems and sensor fusion. **6.** Cloud-based monitoring (Thing Speak, Blynk, MQTT). **Self -Learning Topic: Case Studies:** Smart agricultural sensing system and IoT-enabled vibration and air-quality transducer networks.	**07**	**CO6**

Text Books

1. **D. Patranabis**, *Principles of Industrial Instrumentation*, Tata McGraw Hill
2. **Arshdeep Bahga & Vijay Madisetti**, *Internet of Things: A Hands-On Approach*
3. **Clarence W. de Silva**, *Sensors and Actuators: Engineering System Instrumentation*, CRC Press

References:

1. **Franky Hillenbrand**, *MEMS Sensors and Actuators*, Springer
2. **John G. Webster**, *Measurement, Instrumentation, and Sensors Handbook*
3. **Misra, A Mukharjee, A Roy, " Introduction to IoT**", Cambridge University Press
4. **A. Mukharjee, C. Roy , Sudip Misra, "Introduction to Industrial Internet of Things and Industry 4.0",**

Website Reference / Video Courses:

1. **NPTEL Course: Introduction to Industrial Internet of Things and Industry 4.0** By Prof. S. Misra , Dept. of Computer Science and Engineering, IIT Kharagpur.:- Web link-

   https://onlinecourses.nptel.ac.in/noc21_cs20/preview

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Internet of Things Engineering
Third Year Engineering Curriculum: Semester V

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
ITMDML501	Sensors, Actuators and Transducers Lab	-	25	-	•	-	25	

Prerequisite:	
Course Objectives: The course aims to	
1	Implement, test and characterize sensors (analog/digital/MEMS) used in IoT.
2	Design simple signal-conditioning circuits and ADC interfacing.
3	Control actuators (DC/stepper/servo/relay/solenoid) from microcontrollers.
4	Calibrate sensors, perform error analysis and document results.
Course Outcomes: Learners will be able to	
1	Implement, test and characterize sensors (analog/digital/MEMS) used in IoT.
2	Implement, test and characterize transducers used in IoT.
3	Implement, test and characterize micro sensors used in IoT.
4	Implement, test and characterize actuators (DC/ stepper/servo/relay/solenoid) used in IoT.

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
01	Study of analog and digital temperature sensors	CO1
02	Interfacing MEMS accelerometer (MPU6050) with Arduino	CO2
03	Interfacing servo and stepper motors using PWM	CO4
04	Interfacing DC motor with H-bridge driver circuit	CO4
05	Study of piezoelectric transducer	CO2
06	Signal conditioning for sensor data (amplifier + filter)	CO3
07	IoT data acquisition using ESP32/ESP8266 and cloud platform	CO3
08	Calibration and performance evaluation	CO2,3,4
09	Mini project using sensors and actuators	CO1,2,3,4
10	Measurement of temperature using DHT11, thermistor, thermocouple, LM35	CO2,
11	Measurement of pressure using Piezoelectric sensor, Bourdon tube, Strain-gauge pressure sensor, BMP180, MPX5010	CO2

12	Demonstration of IR sensor for proximity sensing	CO3
13	Automatic lighting system using LDR	CO3
14	Motion detection using MEMS Accelerometer (ADXL335, MPU6050), Gyroscope	CO3,4

Reference Websites

- https://www.arduino.cc
- https://randomnerdtutorials.com
- https://thingspeak.com
- https://blynk.io
- https://www.mems-exchange.org

Lab performance: Minimum 8 experiments must be conducted to keep the term valid. Any other experiment may be conducted on the related topics of the theory course.

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Department of Electronics and Telecommunication Engineering

Third Year Engineering Curriculum: Semester V

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
CEMDM501	Database Management System	20	20	60	1	2	100	

Course Objectives: The course aims to	
1	Learn and practice data modelling using the entity-relationship and developing database designs.
2	Implement the use of Structured Query Language (SQL) and learn SQL syntax.
3	Illustrate the needs of database processing and learn techniques for controlling the consequences of concurrent data access
4	Analyse the concept of database security and privacy
Course Outcomes: Learners will be able to	
1	Describe the fundamentals of database systems
2	Implement the different data models and design issues in database.
3	Design ER diagram, relational schemas, apply concepts of normalization to relational database design.
4	Analyse the basics model of relational Algebra, calculus.
5	Experiment views, triggers and querying the database using SQL.
6	Implement transaction management, concurrency control. database security and privacy

Module	Detailed Contents	Hrs.	CO Mapping
01	**Introduction to Databases**	4	CO1
	Introduction to databases, History of database system, Benefits of Database system over traditional file system, relational databases, three tier database architecture, Data independence		
02	**Data Models**	3	

	The importance of data models, Introduction to various data models (hierarchical, Network, Relational, Entity relationship and object model), Basic building blocks, Business rules, Degrees of data abstraction		**CO2**
03	**Database Design, ER-Diagram and Unified Modelling Language**	10	**CO3**
	Database design and ER Model: overview, ER-Model and its Constraints, ER-Diagrams, ERD Issues, weak entity sets Codd's rules, Relational Schemas, Introduction to UML Relational database model: Logical view of data, keys, integrity rules. Relational Database design: features of good relational database design, atomic domain		
04	**Relational Algebra and Calculus**	10	**CO4**
	Relational algebra: Introduction, Selection and projection, set operations, renaming, Joins, Division, syntax, semantics. Operators, grouping and ungrouping, relational comparison. Calculus: Tuple relational calculus, Domain relational Calculus, calculus vs algebra, computational capabilities. Normalization methods : 1NF, 2NF, 3NF, BCNF, 4NF, 5NF		
05	**Constraints, Views and SQL**	10	**CO5**
	What is constraints, types of constrains, Integrity constraints, SQL: data definition, aggregate function, Null Values, nested sub queries, Joined relations. Triggers. Views: Introduction to views, data independence, security, updates on views, comparison between tables and views SQL Tools : MySQL, ORACLE 10G, POSTGRESQL		
06	**Transaction management and Concurrency control**	5	**CO6**
	Transaction management: ACID properties, serializability and concurrency control, Lock based concurrency control (2PL, Deadlocks), Time stamping methods, optimistic methods, database recovery management. Database Security and privacy: Issues, Access Control based on grant and revoke privileges		
	Total	**42**	

Text Books:

1. Silberschatz, H Korth, S Sudarshan, "Database System and Concepts‖", Fifth Edition McGraw-Hill
2. Rob, Coronel, "Database Systems", Seventh Edition, Cengage Learning.
3. Ramez Elmasri, Shamkant B. Navathe, "Fundamentals of Database System‖", Seventh Edition, Person.
4. 4. G. K. Gupta, "Database Management Systems‖", McGraw – Hill.

References:

1. Peter Rob and Carlos Coronel, "Database Systems Design, Implementation and Management", Thomson Learning, 5th Edition.
2. P.S. Deshpande, "SQL and PL/SQL for Oracle 11g, Black Book", Dreamtech Press
3. Mark L. Gillenson, Paulraj Ponniah, "Introduction to Database Management", Wiley
4. Raghu Ramkrishnan and Johannes Gehrke, "Database Management Systems", TMH

5. Debabrata Sahoo “Database Management Systems‖ Tata McGraw Hill, Schaum
6. https://www.w3schools.in/dbms/
7. https://www.tutorialspoint.com/dbms/index.htm
8. https://www.studytonight.com/dbms/

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Electronics and Telecommunication Engineering

Third Year Engineering Curriculum: Semester V

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
CEMDML501	Database Management System Lab	-	25	-	-	-	25	

Course Objectives: The course aims to	
1	Explore design and develop of relational model 2 3
2	Present SQL and procedural interfaces to SQL comprehensively
3	Introduce the concepts of transactions and transaction processing
4	Design of different queries.
Course Outcomes: Learners will be able to	
1	Design ER /EER diagram and convert to relational model for the real world application.
2	Apply DDL, DML, DCL and TCL commands
3	Apply simple and complex queries
4	Explore PL / SQL Constructs.
5	Learn simple and complex queries
6	Demonstrate the concept of Views, Trigger

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
1	Identify the case study and detail statement of problem. Design an Entity-Relationship (ER) / Extended Entity-Relationship (EER) Model	1
2	Mapping ER/EER to Relational schema model.	1
3	Create a database using Data Definition Language (DDL) and apply integrity constraints for the specified System	2
4	Apply DML Commands for the specified system	2
5	Perform Simple queries, string manipulation operations and aggregate functions.	3

6	Implement various Join operations.	4
7	Perform Nested and Complex queries	5
8	Perform DCL and TCL commands	2
9	Implement procedure and functions	5
10	Implementation of Views and Triggers	6

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Third Year Engineering Curriculum: Semester V

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
ARMDM501	Mechatronics	20	20	60	1	2	100	

Prerequisite: Fundamentals of Electrical & Electronics Engineering, Basics of Sensors & Instrumentation	
Course Objectives: The course aims to	
1	Study key elements of the Mechatronics system.
2	Familiarise with concepts of sensor characterisation, actuators and their interfacing with microcontrollers.
3	Introduce ADC/DAC conversion and basic signal filtering concepts
4	Study the design of pneumatic and hydraulic circuits.
5	Study and understand electropneumatic circuits and PLC Design
6	Demonstrate system reliability, communication interfaces and real mechatronic system integration.
Course Outcomes: Learners will be able to	
1	Explain elements of the mechatronics systems and the mechatronics design process
2	Identify the suitable sensor and actuator for a mechatronics system
3	Analyze ADC/DAC processes and apply suitable signal filtering techniques for measurement systems.
4	Design & develop pneumatic/hydraulic circuits.
5	Design and develop electropneumatic circuits and PLC ladder logics.
6	Interpret system reliability aspects, communication interfaces and industrial case studies of mechatronic systems.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Introduction to Mechatronics** 1. Definition, scope and evolution of Mechatronics, Key elements of Mechatronic system (mechanical structure, sensors, actuators, electronics, control unit, software),	05	CO1

	2. Integrated design approach in Mechatronics vs conventional design, Mechatronics design process (problem identification, modelling, simulation, prototyping, implementation) **Self-Learning Topic:** Real-life mechatronic system identification (elevator, printer, washing machine, etc.		
02	**Selection of Sensors & Actuators** 1. Sensors: Criteria for selection of sensors based on requirements, principle of measurement, sensing method, performance chart, etc. (Displacement, temperature, acceleration, force/pressure) based on static and dynamic characteristics. 2. Actuators: Selection of actuators based on principle of operation, performance characteristics, maximum loading conditions, safety, etc. Principle and selection of mechano-electrical actuators, i) DC motors, ii) Stepper Motors, iii) Solenoid Actuators, iv) Servo Motors, v) BLDC **Self-Learning Topic:** Examples of sensors used in household appliances (fridge, washing machine, AC), Comparison of DC motor vs Stepper motor in simple applications, Selection of an actuator for a small robotic arm	**07**	**CO2**
03	**Data Acquisition, Signal Conditioning & Microcontroller System Theory** 1. Concept of Bit accuracy/width and Sampling speed, sampling theorem, aliasing, Nyquist criteria, ADC (Analog to Digital Converter), Successive approximation method and sample and hold circuitry, DAC (Digital to Analog Converter), R-2R circuit and DAC resolution **2.** Signal Filters: Low pass, High Pass and Band Pass with circuit diagrams for simple cases **Self-Learning Topic:** Use of low-pass filter in removing noise from a sensor signal, Applications of band-pass filters	**07**	**CO3**
04	**Design of Pneumatic & Hydraulic Circuits** 1. Design of Pneumatic Sequencing Circuits using the Cascade method and the shift register method (up to 2 cylinders) 2. Basic Hydraulic Circuits: Meter in, meter out, and bleed off circuits; Intensifier circuits, Regenerative Circuit, Counterbalance valve circuit and sequencing circuits. **Self-Learning Topic:** Identification of hydraulic circuits used in industry (press machines, lifting systems), Simple case study of meter-in vs meter-out control in hydraulic actuators, Safety precautions in handling hydraulic and pneumatic systems	**08**	**CO4**
05	**Design of Electro-pneumatic Circuits**		

	1. Electro-pneumatic Circuits Design of Electro-Pneumatic Circuits using single solenoid and double solenoid valves, with and without grouping. 2. PLC Discrete Control Systems Design of Pneumatic circuits using PLC Control (ladder programming only) up to 2 cylinders, with applications of Timers and Counters and concept of Flag and latching.	**08**	**CO5**
	Self-Learning Topic: Identification of electro-pneumatic components used in industrial machines, Real-life examples of pneumatic systems in automation, Safety rules and precautions when working with pneumatic circuits		
06	**Reliability, communication, and Case studies** 1. Reliability, maintainability, safety, and fault diagnosis in mechatronic systems 2. Communication Protocols (overview only), CAN, UART, SPI, I2C (basics only) **3.** Case Studies: Automotive ABS, CNC feed drive system, Pick & place robot, Smart manufacturing cell	**07**	**CO6**

Text Books:

1. Applied Mechatronics- A. Smaili and F. Mrad, OXFORD university press
2. Mechatronics System Design, Shetty and Kolk, Cengage Learning, India Edition
3. Introduction to Mechatronics, AppuKuttan K.K., OXFORD Higher Education
4. Pneumatic Circuits and Low-Cost Automation by Fawcett JR
5. Electromechanical Design Handbook, Walsh, McGraw-Hill
6. Electro-mechanical Engineering - An Integrated Approach, Fraser and Milne
7. Frank Petruzella," Programmable Logic Controllers", McGraw-Hill Education; 4 edition

References:

1. Industrial Hydraulics: Pippenger
2. Vickers Manual on Hydraulics
3. Hydraulic Valves and Controls: Pippenger
4. Fundamentals of pneumatics: Festo series
5. Mechatronics, NitaigourMahalik, Tata McGraw-Hill
6. Mechatronics, HMT
7. John W Webb and Reis, Ronald A., "Programmable Logic Controllers: Principles & Applications", Prentice Hall.

NPTEL/SWAYAM courses:

a. https://onlinecourses.nptel.ac.in/noc21_me27/preview
b. https://nptel.ac.in/courses/117105082

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks

2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to the Mid Semester Examination (MSE), carrying 20% to 30% weightage, and the syllabus covered from MSE to ESE, carrying 70% to 80% weightage.

Third Year Engineering Curriculum: Semester V

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
ARMDML501	Mechatronics Lab	-	25	-	-	-	25	

Prerequisite: Basic knowledge of electrical and mechanical systems, control theory, and microcontroller programming.	
Course Objectives: The course aims to	
1	Understand fundamentals of mechatronic systems, sensors, and actuators.
2	Interface and control electrical and mechanical devices using microcontrollers
3	Identify and analyze dynamic characteristics of actuators.
4	Apply automated controls using pneumatic and pneumatic. systems.
5	Implement PLC programs for automation applications.
Course Outcomes: Learners will be able to	
1	Demonstrate the interfacing and control of sensors and actuators using microcontrollers.
2	Demonstrate the interfacing of different electrical/mechanical devices (motors, heaters, etc.) with microcontrollers.
3	Identify dynamic characteristics of an actuator through experimental system identification.
4	Demonstrate use of automated controls using pneumatic systems.
5	Demonstrate use of automated controls using hydraulic systems.
6	Implement a program on the PLC system and demonstrate its application.

Suggested List of Experiments

Sr. No.	List of Experiments:	CO Mapping
1	Interfacing of Stepper Motor with microcontroller and its programming for Rotational or XY table (It is suggested to program to vary the position of the rotary or XY table and compare the positioning accuracy using a standard calibrated angular or linear sensor).	CO1

2	Interfacing of DC Motor with microcontroller and its programming for characterization of DC motor setup (It is suggested to program to vary the speed of DC motor and determine its load-speed characteristics).	**CO2**
3	System Identification of any one of the actuators.	**CO3**
4	Designing a sequential operation for two cylinders using electro-pneumatic circuits.	**CO4**
5	Simulation of basic pneumatic and electro-pneumatic circuits (using software like Festo, AutoSim , etc.).	**CO4**
6	Simulation of hydraulic and electro-hydraulic circuits (using software like Festo, AutoSim, etc).	**CO5**
7	Designing a sequential operation for two cylinders using electro-hydraulic circuits. a) Designing sequential operation for two cylinders using electro-hydraulic circuits. or b) Designing sequential operation for two cylinders using electro-pneumatic circuits.	**CO5**
8	Experiments on Ladder programming on PLC for simple on-off control, timers, counters, two motor system, and simple control applications with logic/ timers/counters.	**CO6**
9	Experiments on Ladder programming for Mechatronics systems (e.g. bottle filling plant, control of electro-pneumatic or electro-hydraulic systems).	**CO6**

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Oral & Practical Exam (25 Marks)

An oral and practical exam will be held based on the entire syllabus.

Department of Electrical Engineering

Second Year Engineering Curriculum: Semester V

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
EEMDM501	Special Machines and smart grid	20	20	60	1	2	100	

Prerequisite: Basic Electrical Engineering, Electric Machine	
Course Objectives: The course aims to	
1	Understand how to integrate renewable energy sources, such as solar and wind, into both existing and future power grids.
2	Learn the construction, principle of operation, and performance characteristics of various special machines.
3	Identify and understand the applications of special machines and smart grid in modern technology.
Course Outcomes: Upon successful completion of this course, the learner will be able to	
1	Describe the construction, principle of operation, performance characteristics and control schemes of stepper motors.
2	Describe the construction, principle of operation, performance characteristics and control schemes of switched reluctance, motors.
3	Describe the construction, principle of operation, performance characteristics and control schemes of BLDC motor .
4	Describe the construction, principle of operation, performance characteristics and control schemes of PMSM motors.
5	Analyze the necessity and architectures of smart grid.
6	Understand the concept of distributed generation and its operation.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Stepper Motors:** 1.1 Construction and working principle. 1.2 Types: Variable Reluctance, Permanent Magnet, and Hybrid Stepper Motors. 1.3 Torque–angle characteristics, static and dynamic performance	07	CO1

	1.4 Drive and control circuits (unipolar/bipolar, open-loop and closed-loop control) 1.5 Microcontroller or Arduino-based stepper control 1.6 Applications**:** CNC machines, robotics and printers		
	Self Learning Topic: Application in positioning system		
02	**Switched Reluctance Motors (SRM)**	**07**	**CO2**
	2.1 Construction and operating principle 2.2 Torque production and control methods 2.3 Converter topologies for SRM drives 2.4Sensor and sensorless control techniques 2.5 Design and performance considerations 2.6 Applications: Electric vehicles and renewable energy systems		
	Self Learning Topic: Applications in industrial drives		
03	**Brush less DC Motors (BLDC)**	**07**	**CO3**
	3.1 Brush less dc motor drive for servo applications. 3.2 Low cost brush less dc motor drives 3.4 Important features 3.5 Applications: Home appliances, EVs		
	Self Learning Topic: Use of PMBLDC in aerospace systems.		
04	**Permanent Magnet Synchronous Motors (PMSM)**	**07**	**CO4**
	Construction and principle of operation 4.1 Types: Surface-mounted and Interior PMSMs 4.2 EMF and torque equations 4.3 Vector control (FOC) and direct torque control (DTC) principles **Applications:** Servo systems, robotics, aerospace, traction drives		
	Self Learning Topic: comparison between synchronous motor and PMSM motor.		
05	**Introduction to smart grid :**	**07**	**CO5**
	5.1 Conventional power systems and Smart grid, definition of smart grid, need for smart grid, 5.2 Smart grid architecture, smart grid domains, enablers of smart grid, 5.3 Communication architecture and protocols for smart grid, smart grid priority standards and regulation.		
	Self Learning Topic: smart-grid activities in India.		
06	**Distributed Generation and communication in Smart Grid:**	**07**	**CO6**
	6.1 Renewable-based Distributed generations, Introduction to energy storage devices, 6.2 Different types of energy storage technologies, 6.3 Battery management system (BMS): concept, types and applications, 6.4 smart grid communication technologies.		
	Self Learning Topic: need of renewable energy sources.		

Text Books

1. K. Venkataratnam, *Special Electrical Machines*, Universities Press.
2. E. G. Janardanan, *Special Electrical Machines*, PHI Learning.
3. Microgrids architectures and control Edited by Nikos Hatziargyriou, Wiley, IEEE Press, 2014.

4. 2. A. Keyhani, M. N. Marwali, M. Dai, Integration of Green and Renewable Energy in Electric
5. Power Systems, Wiley, 2009.
6. 3. Antonio Carlos Zambroni de Souza, Miguel Castilla, Microgrids Design and Implementation,
7. Springer 2019.
8. 4. James Momoh, —Smart Grid: Fundamentals of Design and Analysis,‖ IEEE Press and Wiley
9. Publications, 2015.
10. 5. J. C. Sabonnadière, N. Hadjsaïd, —Smart Grids‖, Wiley Blackwell.

References:

1. T. J. E. Miller, *Brushless Permanent Magnet and Reluctance Motor Drives*, Clarendon Press.
2. R. Krishnan, *Electric Motor Drives – Modeling, Analysis and Control*, Prentice Hall.
3. D. P. Kothari and I. J. Nagrath, *Electric Machines*, Tata McGraw Hill.
4. G. K. Dubey, *Fundamentals of Electrical Drives,* Narosa Publications
5. Yezdani, and Reza Iravani, Voltage Source Converters in Power Systems: Modeling, Control
6. and Applications, John Wiley Publications, 2010.
7. Dorin Neacsu, Power Switching Converters: Medium and High Power, CRC Press, 2006.
8. J. Ekanayake, N. Jenkins, K. Liyanage, J. Wu, A. Yokoyama, Smart Grid: Technology and
9. Applications, Wiley, 2012.
10. IEEE standards —IEEE-1547-2003: IEEE Standard for Interconnecting Distributed Resources
11. with Electric Power Systems IEEE standards 2003.
12. IEEE standards —IEEE 1547-4-2011: IEEE Guide for Design Operation & Integration of
13. Distributed Resources Island System with Electric Power System.
14. Consortium for Electric Reliability Technology Solutions (CERTS) white paper on Integration
15. of Distributed Energy Resources: The CERTS Microgrid Concept‘ 2002.
16. NPTEL Course: DC Microgrid and Control System, Prof. Avik Bhattacharya, IIT
17. Roorkee.

Website Reference / Video Courses:

1. **NPTEL Course: Special Electromechanical Systems** By Prof. S. S. Murthy, Yogesh Hote, Dept. of Electrical Engineering, IIT Delhi.:- Web link- https://nptel.ac.in/courses/108102156
2. **NPTEL Course: Introduction to Smart Grid**, By Prof. N. P. Padhy & Prof. Premalata Jena, IIT Roorkee

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Electrical Engineering

Second Year Engineering Curriculum: Semester V

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
EEMDML501	**Special Machines and smart grid Lab**	-	25	-	-	-	25	

Prerequisite: Students know the construction, working principle and operation of DC machines, transformers and Induction motors	
Course Objectives: The course aims to	
1	Introduce various special electrical machines beyond conventional DC and AC machines.
2	Explain the construction, working principles, and control techniques of stepper, reluctance, and permanent magnet motors.
3	Highlight applications of special motors in industrial automation, robotics, and electric vehicles.
4	Explore various control implementation incorporated in smartgrid in simulation or with hardware.
Course Outcomes: Learners will be able to	
1	Exemplify the working of Stepper motor and its control.
2	Demonstrate the functioning of SRM motor and its control
3	Illustrate the working of BLDC motor and its control
4	Illustrate the operational features of PMSM motor and its control
5	Identify and study the various smart grid components.
6	Understand the modelling of renewable resources such as PV, Wind, and fuel cell.

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
01	Study of Smart Grid components.	CO5
02	Simulation on Modelling of PV system using MATLAB.	CO6
03	Simulation on Modelling of DFIG based wind power system.	CO6
04	Simulation of Grid connected PV MPPT single stage. CO1	CO6
05	To measure and analyze the power quality parameters with and without compensation. (voltage, THD, pf and current)	CO5
06	Simulation/Emulation of DC Microgrid with steady state/transient	CO5

	performance analysis	
07	Simulation/ Emulation of AC Microgrid with steady state/transient performance analysis.	CO5
08	Study of solar PV charateristics	CO6
09	Study of constructional features and working principle of different special motors (Stepper, SRM, BLDC, PMSM, LIM).	CO1 to CO4
10	Speed control of a Stepper Motor using Arduino or Microcontroller Interface.	CO1
11	Determination of Step Angle and Resolution of Stepper Motor.	CO1
12	Characteristics of Switched Reluctance Motor (SRM).	CO2
13	Speed control of SRM using a power converter.	CO2
14	Study of Permanent Magnet Synchronous Motor (PMSM).	CO4
15	Experimental setup of PMSM drive using inverter and controller.	CO4
16	Study of BLDC motor and its characteristics.	CO3
17	Integration of special motor with sensor and control module for application (e.g., robotic arm / conveyor).	CO3

Virtual Lab Website Reference:
1. http://vlab.co.in/broad-area-electrical-engineering
2. https://www.vlab.co.in/broad-area-mechanical-engineering - Energy Storage Labs, Solar Energy lab, Wind Energy Lab

Virtual Lab Website Reference:

1. http://vlab.co.in/broad-area-electrical-engineering

Term Work: Minimum 8 experiment/simulation must be done for satisfactory completion of the term.

Continuous Internal Evaluation (25 Marks)
1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. **Regularity and Attendance: 5 Marks**

Third Year Engineering Curriculum: Semester V

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
MEMDM501	Conventional & Renewable Energy Sources	20	20	60	1	2	100	

Prerequisite: Knowledge of Thermal Engineering	
Course Objectives: The course aims to	
1	To study working principles of various renewable energy sources and their utilities
2	To study working principles of various Thermal & Hydro Electric Power plants.
3	To study economics of harnessing energy from renewable energy sources
Course Outcomes: Learners will be able to	
1	Analyze the various energy sources & its availability in India & world.
2	Describe the operating principle of Thermal & hydel power plants.
3	Describe the operating principle of nuclear power plants.
4	Analyze different solar collectors using geometrical parameters and photovoltaics for generation of solar energy & its application
5	Identify and analyze various wind turbine energy harnessing techniques.
6	Identify various Mini & Micro Hydro Electric Plants & wind turbine energy harnessing techniques

Module	Detailed Contents	Hrs.	CO Mapping
01	Introduction to Energy Types of Energy, energy scenario in India & world, Energy demand & supply & consumption trend.	05	CO1
02	**Thermal & hydroelectric Power.** Fossil fuels: coal, natural gas formation & use Thermal power generation: basic layout & working., hydro power plants:	10	CO2

	principal, types & components. Advantages, disadvantages & environmental impacts. **Self-Learning Topic: Hydrology**		
03	**Nuclear Energy** Nuclear fission, fusion, components & layout of Nuclear Power plants, Site Selection. Safety & waste disposal **Self-Learning Topic: Nuclear Materials**	06	**CO3**
04	**Module Title:** Solar Energy Solar Radiation, Sun Earth Angle, Solar Measurement Devices, Solar Energy Collectors. Application of Solar Energy	08	**CO4**
05	**Wind Energy** Resources of Wind, Classification of Wind Mills, Wind Energy Conversion System (WECS), Performance Characteristics of Wind Mill, Application of wind energy & Site Selection.	07	**CO5**
06	**Other Renewable Energy Sources.** Mini & Micro Hydro Electric Plants, Application & Site Selection. Hybrid Energy, Economic Environmental & Regulatory Aspects of Renewable Sources. **Self-Learning Topic: Hydrology**	06	**CO6**

Text Books:

1. "Non-conventional Energy Sources", G.D. Rai, 6th Edition, Khanna Publishers, ISBN: 978-81-7409-073-7
2. "Solar Energy: Principles of Thermal Collection and Storage", SP Sukhatme and J K Nayak, 4th Edition, Tata McGraw Hill Publishing Co. Ltd.
3. "Renewable Energy Sources", J W Twidell& Anthony D. Weir, 3rd Edition 2015,ELBSPub, ISBN: : 978-1-315-76641-6
4. Power Plant Engineering by Prof, V M Domkundwar
5. Power Plant Engineering by Prof Rajput

References:

1. https://nptel.ac.in/courses/103103206
2. https://nptel.ac.in/courses/103107157
3. https://nptel.ac.in/courses/115105127

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Quiz/Open book test/Presentation: 15 Marks
2. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Mechanical Engineering

Third Year Engineering Curriculum: Semester V

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
MEMDML501	Renewable Energy Sources Lab	-	25	--	-	-	25	

Prerequisite: Thermal Engineering	
Course Objectives: The course aims to	
1	To study working principles of various renewable energy sources and their utilities
2	To study working principles of various Thermal & Hydro Electric Power plants.
3	To study economics of harnessing energy from renewable energy sources
4	
Course Outcomes: Learners will be able to	
1	Analyze the various energy sources & its availability in India & world.
2	Describe the operating principle of Thermal & hydel power plants.
3	Describe the operating principle of nuclear power plants.
4	Analyze different solar collectors using geometrical parameters and photovoltaics for generation of solar energy & its application
5	Identify and analyze various wind turbine energy harnessing techniques.
6	Identify various Mini & Micro Hydro Electric Plants & wind turbine energy harnessing techniques

Suggested List of Experiments (Any Five from Following List.)

Sr. No.	List of Experiments	LO Mapping
01	Demonstration on Solar Cooker	4
02	Demonstration on Solar Panel Test Rig.	4
03	Case Study on Wind Mill.	5
04	Study of Components of Wind Mill.	5
05	Study of Components & layout of thermal power plants.	2
06	Study of Component & layout of hydroelectric power plant.	2

07	Study of Mini & Micro Hydro Electric Plants	6
08	A case study on Energy Scenario & pattern of consumption of fossil fuel in Indian scenario.	1
09	Study of Components & layout of nuclear power plants.	3
10	Compulsory Visit to Any Renewable Source installation or conventional power plant.	1-6

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
EEPCC601	Power Electronics	20	20	60	1	2	100	

Prerequisite: Basic operation and characteristics of Power Semiconductor Devices	
Course Objectives: The course aims to	
1	Impart knowledge about various power semiconductor devices related to its characteristics, ratings, protection and to select semiconductor devices for various applications
2	Introduce different power conversion topologies such as ac to dc, dc to dc, dc to ac, ac to ac and the underlying principles of converter operation aiding to analyse their performance.
3	Keep abreast with the latest technologies and research going on in different areas related to power electronics
Course Outcomes: Learners will be able to	
1	Explain the basic operation and characteristics of various semi controllable and fully controllable device
2	Analyse various single phase and three phase power converter circuits and understand their applications.
3	Analyse dc to ac converter circuits and their applications
4	Analyse dc to dc and ac to ac converter circuits and their applications
5	Apply the basic concepts to select devices and converters for various applications
6	Identify and describe various auxiliary circuits and requirements in power electronics applications such as Gate driver circuit, and snubber circuits along with electrical isolation and heat sinks

Module	Detailed Contents	Hrs.	CO Mapping
01	**Power Semiconductor Devices**		

	Basic operation of silicon-controlled rectifier (SCR), Static characteristics, two transistor analogy, Dynamic characteristics, Firing circuits (R,RC, Ramp triggering using UJT), Commutation circuits, Protection circuit of SCR. Basic operation and characteristics of power BJTs, power MOSFETs, IGBTs, Safe Operation Area (SOA) for each device, Silicon Carbide (SiC) and GaN devices, Comparison of devices, selection of devices for various applications.	08	**CO1**
	Self-Learning Topic: Other devices of Thyristor family, Conduction and switching losses.		
02	**Controlled Rectifiers**	07	**CO2**
	Single phase half wave controlled rectifiers, full wave rectifiers (mid-point and bridge configuration) for R and R-L load, freewheel diode, Rectification and inversion mode of single phase fully controlled rectifier, single phase dual converter, Three phase semi converter and full converter with R load, Applications, calculation of output voltage, single phase PWM rectifier, basic working principle and applications.		
	Self-Learning Topic: RMS and Average value of different waves.		
03	**Inverter**	07	**CO3**
	Principle of operation, Performance parameters, Single phase voltage source bridge Inverters, Three phase VSI (120° and 180° conduction mode), control of inverter output voltage, PWM techniques-Single PWM, Multiple PWM, Sinusoidal PWM, Introduction to Space vector modulation, Current source inverters, comparison of VSI and CSI, Applications.		
	Self Learning Topic: Classification of Inverters based on source and power level.		
04	**DC to DC Converter**	06	**CO4**
	Introduction, Switching mode regulators-Buck, Boost, Buck-Boost, bidirectional dc to dc converters, all with resistive load and only CCM mode. Numerical included.		
05	**AC voltage controllers**	06	**CO5**
	On-Off and phase control, Single phase AC voltage controllers with R and RL loads. Cyclo converters, Matrix converter: Basic working principle		
	Self Learning Topic: Bidirectional switches like diac and triac.		
06	**Auxiliary Circuits and Applications**	08	**CO6**
	Types of drivers-level shifters, bootstrap drivers, isolated drivers, Gate Drive circuitry for Power Converters, methods of current and voltage measurement, snubber circuits and heat sinks. D.C. Motor Speed control, A.C. Drives: variable frequency drives. AC Voltage Regulators. Power Factor Correction Circuits, LED lamp driver.		
	Self-Learning Topic: Basics of Control Circuit		

Text Books:

1. "Power Electronics", M.D Singh and Khanchandani, Tata McGrawhill
2. "Power Electronics" M.H.Rashid, Prentice-Hall of India
3. "Power Electronics", Ned Mohan, Undeland, Robbins, John Wiley Publication
4. "Power Electronics", P.C Sen, Tata McGrawhill
5. "Power Electronics: Devices, Circuits and Matlab Simulations" by Alok Jain, Penram International
6. "Power Electronics", V.R Moorthi, Oxford University press
7. "Thyristors & their applications", Ramamurthy

8. “Silicon Carbide Power Devices” B. Jayant Baliga

References:

1. “Power Electronics”, P.S Bhimbra, Khanna Publishers
2. “Power Electronics for Technology”, Ashfaq Ahmed, Pearson
3. “Power Electronics”, Landers, McGraw Hill
4. “Elements of power electronics” Philip T Krein, Oxford University Press
5. “Silicon Carbide, Volume 2: Power Devices and Sensors,” Peter Friedrichs, Tsunenobu Kimoto, Lothar Ley and Gerhard Pensl , Wiley
6. “Power Electronics Converters and Regulators,” Dokić, Branko L. and Blanuša, Branko
7. “Modern Power Electronics & AC Drives”, B. K. Bose, Prentice Hall India
8. http://nptel.iitm.ac.in: “Power Electronics” web-course

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
EEPCC601	Power Electronics	20	20	60	1	2	100	

Prerequisite: Basic operation and characteristics of Power Semiconductor Devices	
Course Objectives: The course aims to	
1	Impart knowledge about various power semiconductor devices related to its characteristics, ratings, protection and to select semiconductor devices for various applications
2	Introduce different power conversion topologies such as ac to dc, dc to dc, dc to ac, ac to ac and the underlying principles of converter operation aiding to analyse their performance.
3	Keep abreast with the latest technologies and research going on in different areas related to power electronics
Course Outcomes: Learners will be able to	
1	Explain the basic operation and characteristics of various semi controllable and fully controllable device
2	Analyse various single phase and three phase power converter circuits and understand their applications.
3	Analyse dc to ac converter circuits and their applications
4	Analyse dc to dc and ac to ac converter circuits and their applications
5	Apply the basic concepts to select devices and converters for various applications
6	Identify and describe various auxiliary circuits and requirements in power electronics applications such as Gate driver circuit, and snubber circuits along with electrical isolation and heat sinks

Module	Detailed Contents	Hrs.	CO Mapping
01	**Power Semiconductor Devices**		

	Basic operation of silicon-controlled rectifier (SCR), Static characteristics, two transistor analogy, Dynamic characteristics, Firing circuits (R,RC, Ramp triggering using UJT), Commutation circuits, Protection circuit of SCR. Basic operation and characteristics of power BJTs, power MOSFETs, IGBTs, Safe Operation Area (SOA) for each device, Silicon Carbide (SiC) and GaN devices, Comparison of devices, selection of devices for various applications.	08	**CO1**
	Self-Learning Topic: Other devices of Thyristor family, Conduction and switching losses.		
02	**Controlled Rectifiers**	07	**CO 2**
	Single phase half wave controlled rectifiers, full wave rectifiers (mid-point and bridge configuration) for R and R-L load, freewheel diode, Rectification and inversion mode of single phase fully controlled rectifier, single phase dual converter, Three phase semi converter and full converter with R load, Applications, calculation of output voltage, single phase PWM rectifier, basic working principle and applications.		
	Self-Learning Topic: RMS and Average value of different waves.		
03	**Inverter**	07	**CO 3**
	Principle of operation, Performance parameters, Single phase voltage source bridge Inverters, Three phase VSI (120° and 180° conduction mode), control of inverter output voltage, PWM techniques-Single PWM, Multiple PWM, Sinusoidal PWM, Introduction to Space vector modulation, Current source inverters, comparison of VSI and CSI, Applications.		
	Self Learning Topic: Classification of Inverters based on source and power level.		
04	**DC to DC Converter**	06	**CO 4**
	Introduction, Switching mode regulators-Buck, Boost, Buck-Boost, bidirectional dc to dc converters, all with resistive load and only CCM mode. Numerical included.		
05	**AC voltage controllers**	06	**CO5**
	On-Off and phase control, Single phase AC voltage controllers with R and RL loads. Cyclo converters, Matrix converter: Basic working principle		
	Self Learning Topic: Bidirectional switches like diac and triac.		
06	**Auxiliary Circuits and Applications**	08	**CO6**
	Types of drivers-level shifters, bootstrap drivers, isolated drivers, Gate Drive circuitry for Power Converters, methods of current and voltage measurement, snubber circuits and heat sinks. D.C. Motor Speed control, A.C. Drives: variable frequency drives. AC Voltage Regulators. Power Factor Correction Circuits, LED lamp driver.		
	Self-Learning Topic: Basics of Control Circuit		

Text Books:

9. "Power Electronics", M.D Singh and Khanchandani, Tata McGrawhill
10. "Power Electronics" M.H.Rashid, Prentice-Hall of India
11. "Power Electronics", Ned Mohan, Undeland, Robbins, John Wiley Publication
12. "Power Electronics", P.C Sen, Tata McGrawhill
13. "Power Electronics: Devices, Circuits and Matlab Simulations" by Alok Jain, Penram International
14. "Power Electronics", V.R Moorthi, Oxford University press
15. "Thyristors & their applications", Ramamurthy
16. "Silicon Carbide Power Devices" B. Jayant Baliga

References:

9. "Power Electronics", P.S Bhimbra, Khanna Publishers
10. "Power Electronics for Technology", Ashfaq Ahmed, Pearson
11. "Power Electronics", Landers, McGraw Hill
12. "Elements of power electronics" Philip T Krein, Oxford University Press
13. "Silicon Carbide, Volume 2: Power Devices and Sensors," Peter Friedrichs, Tsunenobu Kimoto, Lothar Ley and Gerhard Pensl , Wiley
14. "Power Electronics Converters and Regulators," Dokić, Branko L. and Blanuša, Branko
15. "Modern Power Electronics & AC Drives", B. K. Bose, Prentice Hall India
16. http://nptel.iitm.ac.in: "Power Electronics" web-course

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

4. Assignment: 5 Marks
5. Quiz/Open book test/Presentation: 10 Marks
6. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
EEPEC 6011	Control System Design	20	20	60	1	2	100	

Prerequisite: Students should be able to establish a quantitative foundation to the design and analysis of Control systems.	
Course Objectives: The course aims to	
1	Impart knowledge and skill on compensator design.
2	Understand the concept of state–space analysis, to design the compensator in time and frequency domain.
3	Study basics of digital control system and design of digital compensator.
Course Outcomes: Upon successful completion of this course, the learner will be able to	
1	Understand the basic concept of design of various compensators and their requirements.
2	Understand and Implement the design of compensators using root locus techniques.
3	Understand and Implement the design of compensators using frequency response technique.
4	Design modern controllers based on the state space techniques.
5	Understand the basics of digital control systems.
6	Understand the design of digital compensators.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Introduction to the Compensator:** **1.1** Basic concept of compensator design, its requirement, **1.2** Cascade compensator, feedback compensator, gain compensation, lag, lead and lag-lead compensator, **1.3** Proportional, derivative, integral Compensation, **1.4** Physical realization of compensator with passive and active components, **1.5** Basic block diagrams of a compensated closed loop control system. **Self-Learning Topic:** Case study on physical system realization using active and passive controllers.	**04**	**CO1**

02	**Design of Compensators using Root Locus Technique:** **2.1** Introduction, improving steady state error by gain compensation, **2.2** Transient response improvement by cascade compensation, **2.3** Improving steady state and transient response. **Self-Learning Topic:** PID controller and lag-lead controller design using root locus.	**08**	**CO2**
03	**Design of Compensators using Frequency Response Technique (Bode Plot):** **3.1** Introduction, Relation between closed-loop time response parameters of peak time, settling time, and percent overshoot with the open-loop frequency response parameters, **3.2** Transient response improvement by gain adjustment, Lag compensation, Lead compensation, Lag-lead compensation **Self-Learning Topic:** physical realization of lead- lag compensators using frequency response	**08**	**CO3**
04	**Design of Compensators using State variable approach:** **4.1** Introduction, pole placement topology, controller design by pole placement topology in phase variable form, **4.2** Controllability, controllability matrix, controllability by inspection, alternative approach to controller design, controller design by transformation. **4.3** Introduction to Observer / estimator, observability, observability matrix, observability by inspection, observer design by pole placement, alternative approach to Observer design. **4.4** Steady state error design using integral control. **Self-Learning Topic: application of the controllability and observability**	**08**	**CO4**
05	**Digital control System:** **5.1** Introduction, advantage of digital control, components of digital control system, **5.2** Derivation of digital/ pulse transfer function, block diagram reduction, **5.3** Stability of digital system on Z-plane, bilinear transformation, **5.4** Steadystate error and error constants. **Self-Learning Topic:** implementation of digital control system	**08**	**CO5**
06	**Design of Digital Compensators:** **6.1** Transient response on the Z-plane, **6.2** Gain design on Z plane for transient response using root locus, stability design by root locus, **6.3** Cascade compensation (design of digital lead, lag compensator) of digital system using s-plane, **6.4** Implementing the digital compensator. **Self-Learning Topic**: implementation of Lag-lead compensator	**06**	**CO6**

Text Books:

1. Control system engineering by Norman Nise 7 th Edition.
2. Digital Control Systems by Benjamin C. Kuo, Oxford series 2nd to latest Edition.
3. Control Engineering: An Introductory Course by Wilkie J., Johnson M., Katebi R., Palgrave MacMillan.
4. Industrial Control Electronics: Devices, Systems and Applications by Bartelt, Delmar Thomson Learning, 1st Edition.

References:

1. Modern control Engineering by Richard C Dorf, SH Bishop, & Wesley edition, 8 th Edition.
2. Linear Control system Analysis and design with MATLAB, by J.J. Azzo, C. H. Houpis, S.N. Sheldon, Marcel Dekkar, ISBN 0824740386.
3. Control System Engineering, Shivanagraju s. Devi L., New age International latest Edition.
4. Control System engineering by Nagrath and Gopal, 5th to latest edition , Wiley Eastern.
5. Modern control system engineering by K. Ogata, Prentice Hall.
6. Automatic control systems, Basic analysis and Design, William A. Wolovich, Oxford.
7. Process Control principles and applications, Surekha Bharot, Oxford Higher Education.

Website Reference / Video Courses:

1. **NPTEL Course: Advanced Linear Continuous Control Systems** By Prof. Yogesh Hote, Dept. of Electrical Engineering, IIT Roorkee:- Web link- https://nptel.ac.in/courses/108/107/108107115/
2. **NPTEL Course: Industrial Instrumentation** By Prof. Prof. S. Mukhopadhyay and Prof. S.Sen, IIT Kharagpur:- Web link- https://nptel.ac.in/courses/108/105/108105062/

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
EEPEC 6012	Analog and Digital Communication	20	20	60	1	2	100	

Prerequisite: Basic signals and its behavior	
Course Objectives: The course aims to	
1	Introduce the elements of communication systems, describe the generalized block diagram and the types of communication systems.
2	Make students understand analog and digital communication techniques
3	Teach data and pulse communication techniques
4	Introduce source and Error control coding
Course Outcomes: Learners will be able to	
1	Understand theory of noise and the various methods involved in modulation techniques
2	Interpret the concepts in analog communication and differentiate various analog modulation techniques
3	Develop the concepts in digital communication and various digital modulation techniques
4	Apply and integrate various pulsed modulation in digital communication systems
5	Convergent in proposing suitable error controlling and correction algorithms
6	Understand and incorporate the basic knowledge of Optical Fiber communication and Satellite communication.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Introduction to Communication Systems** Need and Importance of Communication, Elements of a Communication System, Types of communication systems (block diagram approach), Electromagnetic Spectrum used in communication, concept of bandwidth and power, Receiver characteristics, Need for modulation Noise: Source of Noise - Types of noise, External Noise- Internal Noise – Noise Calculation, signal to noise ratio	05	CO1
02	**Analog Communication** Theory of Amplitude Modulation (DSBFC, DSBSC) - Evolution and Description of SSB Techniques, Independent sideband (ISB) and Vestigial Side Band (VSB) principles and transmitters Theory of Frequency and Phase Modulation – Comparison of various Analog Communication System (AM, FM, PM)	08	CO2

03	**Digital Communication** Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK) – BPSK – QPSK - Quadrature Amplitude Modulation (QAM) QAM – Bandwidth Efficiency, Comparison of various Digital Communication System (ASK – FSK – PSK – QAM)	08	**C O3**
04	**Sampling Techniques** Sampling theorem, Nyquist criteria, Types of Sampling. Pulse modulation schemes – PAM, PPM and PWM. Generation and detection-Pulse code modulation. Conversion of PWM to PPM., Multiplexing Techniques - FDM and TDM, basic concepts and block diagram, Delta modulation, adaptive delta modulation, principle, generation and detection, Applications of pulse communication	08	**C O4**
05	**Source and Error Control Coding** Entropy -Source encoding theorem – Shannon-fano coding - Huffman coding - mutual information – Channel capacity - Channel coding theorem, Error Control Coding - Linear block codes - Cyclic codes -Convolution codes - Viterbi decoding algorithm	08	**CO5**
06	**Overview** Optical fibre communication, Satellite Communication - Bluetooth	**05**	**C O6**

Text Books:

1. G. Kennedy and B. Davis, “Electronic Communication Systems”, Tata McGraw Hill, 2011
2. Roddy and Coolen, “Electronic Communication”, 4th Edition, Pearson Education 2008
3. Simon Haykin, “Digital Communications”, 2014, 1st edition, John Wiley, India.
4. T.L.Singal, “Analog and Digital Communication”, 2012, 1st edition, Tata McGraw Hill Education
5. Private Ltd, New York

References:

1. Taub and Schilling, “Principles of Communication Systems”, McGraw Hill, Fourth reprint 2009.
2. Wayne Tomasi, “Electronic Communications Systems – Fundamentals Through Advanced", 5th 5thEdition, Pearson Education, 2009.
3. Hweisu and DebjaniMitra, “Analog and Digital Communication: Schaum’s Outline Series”, McGraw Hill Education (India) Pvt Ltd., 3rd Edition 2009.
4. John.G. Proakis, “Digital Communication”, 2014, 5th edition, Pearson Education, Noida, India.
5. Herbert Taub and Donald L Schilling,” Principles of Communication Systems”, 2012,edition)”, Tata McGraw Hill, New Delhi.
6. Bernard Sklar, “Digital Communications: Fundamentals and Applications”, 2016, 2nd edition, Prentice Hall, New Jersey, US**.**

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					03
EEPEC 6013	**Electrical Machine Design**	20	20	60	1	2	100	

Prerequisite: Basic Electrical & Electronics Engineering	
Course Objectives: The course aims to	
1	Understand the fundamental principles and considerations involved in the design of electrical machines, with emphasis on transformers, induction motors, and electromagnets.
2	Identify and select appropriate materials and design parameters required for the construction and efficient performance of transformers and induction motors.
3	Apply analytical methods to design and compute the main dimensions, windings, and magnetic circuits of transformers, induction motors, and electromagnets.
4	Evaluate and analyze the performance characteristics of designed machines to ensure efficiency and compliance with design specifications.
Course Outcomes: Learners will be able to	
1	Select, size various materials required for the design of the transformer and induction motor.
2	Design the main components of the transformer.
3	Compute and analyse the performance parameters of the transformer.
4	Design the main components of the induction motor.
5	Compute and analyse the performance parameters of the induction motor.
6	Design the main components of electromagnet.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Materials**	03	**CO1**
	Philosophy of Machine Design.Selection of Materials:- Magnetic, Electrical, Conducting and Insulating.		
	Self Learning Topic: Recent Development in Engineering Materials.		
02	**Design of Three Phase Transformer**	09	**CO2**
	Construction and Parts of Transformer for Design.Output Equation and Main Dimensions. Selection of Specific Electric and Magnetic Loading. Selection and Design of Core.Selection and Design of LV HV Winding. Selection and Design of Insulation.		

	Self Learning Topic: Design of Energy Efficient Transformers.		
03	**Performance of Transformer**	09	**CO3**
	Computation of Resistance and Leakage Reactance.Computation of Mechanical Forces. Computation of No Load Current.Computation of Tank Size and Tubes/Radiators.		
	Self Learning Topic: IS: 1180, IS: 2026.		
04	**Design of Three Phase Induction Motor**	09	**CO4**
	Construction and Parts of Motor for Design.Output Equation and Main dimensions.Selection of Specific Electric and Magnetic Loading. Design of Stator:-Frame Size, Slots , Size, Winding. Design of Rotor: Airgap, Slots, Size, End Ring, Winding.		
	Self Learning Topic: Design of Energy Efficient Motors.		
05	**Performance of Three Phase Induction Motor**	09	**CO5**
	Computation of Leakage Reactance and Resistance. Computation of Carter's Coefficient. Computation of No Load and Short Circuit Current, Dispersion Coefficient.		
	Self Learning Topic: IS325, IS1231, IEC 60034.		
06	**Design Of Electromagnet**	03	**CO6**
	Construction and Parts of Electromagnet.Design of main Dimension. Computation of Current, Turns, Winding Area and Temperature.		
	Self Learning Topic: Design of Magnetic Clutch.		

Text Books:

1. A.K. Sawhney, "Electrical Machine Design", Dhanpat Rai & Co LTD
2. M.V.Deshpande, "Design and Testing of Electrical Machines", PHI Learning.
3. M.G.Say, "Performance & Design of AC Machines", Pitman

References:

1. BHEL, "Transformers" McGraw Hill Publication
2. Indrajit Dasgupta, "Design of Transformer", McGraw Hill Publication
3. Pvlos S Georgilakis, "Spot Light on Modern Transformer Design" Springer Publication
4. NPTEL, "Computer Aided Design of Electrical Machines",https://onlinecourses.nptel.ac.in/noc24_ee50/preview

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)
Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)
1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)
End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
EEPEC 6021	Electric and Hybrid Electric Vehicles Technology	20	20	60	1	2	100	

Prerequisite: Sustainability and environment, Electrical Machine.	
Course Objectives: The course aims to	
1	Learn the history of electric hybrid electric vehicles (EV & HEV) and emphasize the need and importance of EV-HEV for a sustainable future.
2	Study the fundamental concepts and principles of electric and hybrid electric vehicles Drive train topologies
3	Develop a thorough understanding of the key elements of EV/HEV: Electric Machines For Propulsion Applications and Energy Sources
4	Model, analyze and design electric and hybrid electric vehicles drive train and to Understand energy management strategies
Course Outcomes: Learners will be able to	
1	Identify and describe the history and evolvement of electric & hybrid electric vehicles.
2	Identify and describe the principles of various EV/HEVs drive train topologies.
3	Select electric propulsion system components for EV/HEV drives for the desirable performance and control

4	Compare and evaluate various energy sources and energy storage components for EV/HEV
5	Model, analyze and design EV/HEV drive train with energy management
6	Recognize the need to adapt and engage in operations EV/HEV for sustainable transportation system.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Introduction** Basics of vehicle mechanisms**,** history of electric vehicles (EV) and hybrid electric vehicles (HEV), need and importance of EV and HEV, Power/Energy supplies requirements for EV/HEV applications. State of the art and Indian and global scenario in EV/HEV **Self learning topics: Carbon foot print, Bharat standard for vehicle emission**.	6	**CO1**
02	**Drive-train Topologies** Various electric drive-train topologies, basics of hybrid traction system, various hybrid drive-train topologies, power flow control in drive-train topologies, fuel efficiency analysis.	6	**CO2**
03	**Energy Sources for EV/HEV** Requirements of energy storage in EV/HEV: batteries, fuel cells, flywheels and ultra-capacitors as energy sources for EV/HEV, characteristics and comparison of energy sources for EV/HEV, hybridization of different energy sources. EV battery chargers: AC and DC, Fast chargers and related standards	9	**CO3**
04	**DC and AC Machines for Propulsion Applications** Electric system components for EV/HEV, suitability of DC and AC machines for EV/HEV applications, AC and DC Motor drives.	7	**CO4**
05	**Drive-train Modelling and Design Considerations** Modelling and analysis of EV/HEV drivetrain: Total tractive force calculation, sizing of motor, and design considerations for power electronics drive.	7	**CO5**
06	**Energy Management Strategies and Energy Efficiency** EV/HEV energy management strategies, classification and comparison of various energy management strategies. Basic EV AC and DC Chargers, G2V and V2G concept **<u>Self-study:</u> Testing and Evaluation Standards for EV & HEV available on Automotive Research Association of India (ARAI) website: https://emobility.araiindia.com/standards/**	**7**	**CO6**

Text Books:

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

2. M. Ehsani, Y. Gao, S.E. Gay and Ali Emadi, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, CRC Press. 2005
3. Sheldon Williamsom, *Energy Management Strategies for Electric and Plug-in Hybrid Vehicles*, Springer 2013
4. J. Larminie and J. Lowry, *Electric Vehicle Technology Explained*, Wiley, 2003
5. C. MI, M. Abul and D. W. Gao, *Hybrid Electrical Vehicle Principles and Application with Practical Perspectives*, Wiley 2011

Reference Books:

1. N.Mohan, T.M.Undeland, and W.P Robbins, *Power Electronics, Converters, Applications & Design*, Wiley India Pvt. Ltd., 2003
2. B. K Bose, *Modern Power Electronics and AC Drives*, Pearson Education
2002 3. Robert A. Huggins, *Energy Storage*, Springer 2010

NPTEL/ Swayam Course:

1. Course: Intro. to Hybrid and Electric Vehicles - Prof. Praveen Kumar & Prof. S. Majhi (IIT Guwahati): https://nptel.ac.in/courses/108/103/108103009/
2. Course: Electric Vehicles - Part 1 By Prof. Amit Kumar Jain (IIT Delhi) https://nptel.ac.in/courses/108/102/108102121/

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)
Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)
End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
EEPEC 6022	Special Machines and its Applications	20	20	60	1	2	100	

Prerequisite: knowledge of DC machines, Induction motors, Synchronous machines and Power Electronics.	
Course Objectives: The course aims to	
1	Introduce various special electrical machines beyond conventional DC and AC machines.
2	Explain the construction, working principles, and control techniques of stepper, reluctance, and permanent magnet motors.
3	Familiarize students with modern control and converter interfaces used in electric drives.
4	Highlight applications of special motors in industrial automation, robotics, and electric vehicles.
Course Outcomes: Upon successful completion of this course, the learner will be able to	
1	Exemplify the working of Stepper motor and its control.
2	Demonstrate the functioning of SRM motor and its control
3	Illustrate the working of PMBLDC motor and its control
4	Illustrate the operational features of PMSM motor and its control
5	Illustrate the operational features of other special machines
6	Understand recent trends in control of special machines.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Stepper Motors:**	08	CO1
	1.1 Construction and working principle. **1.2** Types: Variable Reluctance, Permanent Magnet, and Hybrid Stepper Motors. **1.3** Torque–angle characteristics, static and dynamic performance **1.4** Drive and control circuits (unipolar/bipolar, open-loop and closed-loop control)		

	1.5 Microcontroller or Arduino-based stepper control **1.6** Applications**:** CNC machines, robotics and printers		
	Self-Learning Topic: Application in positioning system		
02	**Switched Reluctance Motors (SRM)**	08	CO2
	2.1 Construction and operating principle **2.2** Torque production and control methods **2.3** Converter topologies for SRM drives **2.4** Sensor and sensor-less control techniques **2.5** Design and performance considerations **2.6** Applications: Electric vehicles and renewable energy systems		
	Self-Learning Topic: Applications in industrial drives		
03	**Permanent Magnet Brush less DC Motors (PMBLDC)**	07	CO3
	3.1 Construction, operating principle, and EMF equations. **3.2** Electronic commutation and control techniques (trapezoidal control). **3.3** Speed–torque characteristics. **3.4** Comparison with DC and AC motors. **3.5** Applications: Home appliances, EVs,		
	Self-Learning Topic: Use of PMBLDC in aerospace systems.		
04	**Permanent Magnet Synchronous Motors (PMSM)**	07	CO4
	Construction and principle of operation **4.1** Types: Surface-mounted and Interior PMSMs **4.2** EMF and torque equations **4.3** Vector control (FOC) and direct torque control (DTC) principles **4.4 Applications:** Servo systems, robotics, aerospace, traction drives		
	Self-Learning Topic: comparison between synchronous motor and PMSM motor.		
05	**Other Special Motors and Applications**	07	CO5
	5.1 Linear Induction Motor (LIM): Principle, construction, and applications (maglev trains, conveyors) **5.2 Hysteresis Motor:** Construction, principle, torque characteristics **5.3 Universal Motor:** Operating principle and characteristics **5.4 Reluctance and Synchronous Motors:** Operation and applications **5.5 Piezoelectric and Ultrasonic Motors:** Working principle and emerging uses		
	Self-Learning Topic: Implementation special machines in industry		
06	**Control and Industrial Applications**	05	CO6
	6.1 Microcontroller/DSP-based control of special motors **6.2** Closed-loop speed and position control techniques **6.3** Recent trends in electric drives – Smart motors, IoT-based monitoring, and fault diagnosis		
	Self-Learning Topic: Overview of industrial, aerospace, and EV applications		

Text Books

1. K. Venkataratnam, *Special Electrical Machines*, Universities Press.
2. E. G. Janardanan, *Special Electrical Machines*, PHI Learning.

References:

1. T. J. E. Miller, *Brushless Permanent Magnet and Reluctance Motor Drives*, Clarendon Press.

2. R. Krishnan, *Electric Motor Drives – Modeling, Analysis and Control*, Prentice Hall.

3. D. P. Kothari and I. J. Nagrath, *Electric Machines*, Tata McGraw Hill.
4. G. K. Dubey, *Fundamentals of Electrical Drives*, Narosa Publications

Website Reference / Video Courses:

1. **NPTEL Course: Special Electromechanical Systems** By Prof. S. S. Murthy, Yogesh Hote, Dept. of Electrical Engineering, IIT Delhi.:- Web link- https://nptel.ac.in/courses/108102156

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
EEPEC 6023	Microgrid and Smart grid	20	20	60	1	2	100	

Prerequisite: Renewable Energy System and Energy Storage System	
Course Objectives: The course aims to	
1	Introduce the fundamental concept, various power architectures and control of distributed generation and Microgrids.
2	Review various regulatory standards and state of the art of Microgrids.
3	Understand the Microgrid and Smart Grid deployments for large scale integration of clean energy sources, various technologies, automation and ICT infrastructure requirements.
4	
Course Outcomes: Learners will be able to	
1	Identify and describe the impact of renewable energy integration for mitigating energy crises and sustainable future.
2	Identify and describe the concept of Microgrid and its various topologies, modes of operation control and communication architecture.
3	Identify and study the operation and control of pcus.
4	Study the operation of Microgrid modes, and its protection issues.
5	Identify and describe the concept of Smart Grid, its features and the state of the art.

6	Understand various Smart Grid technologies, automation, resiliency and its adoption in current power system.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Introduction:** Energy crises and sustainable alternatives, review of conventional and non-conventional energy sources and power generation; Comparison of renewable technologies: Solar Photovoltaics, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources. Impact of grid integration of renewable energy resources on existing power system: reliability, stability and power quality issues. **Self Learning Topic: Knowledge of different conventional and non-conventional sources of energy. Block diagram representation and operating principles of all conventional and non-conventional sources of energy. Type of energy storage devices used.**	05	**CO1**
02	**Distributed Generations (DG) and Microgrids:** DG topologies, regulatory standards/ framework: IEEE 1547 series, Limits on operational parameters: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues; Concept of microgrid, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC Microgrids; Control architectures of microgrids: Centralised, decentralised and hierarchical control. Local and system level control functionalities; basics of Power sharing and coordinated control of microgrids	08	**CO2**
03	**Power Conditioning Units (PCUs) for Microgrid Sources:** PCUs in DC and AC microgrids, modes of operation and control of PCUs: Voltage mode control, current mode control. Microgrid functions: black-start and grid synchronisation. **Self Learning Topic: Knowledge of constructional diagrams, waveforms, and operating principles of various power electronic devices. Basic concept of inverters and converters.**	05	**CO3**
04	**Microgrid operations and islanding:** Grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques. Role of energy Storage in Microgrid operations and stability.	08	**CO4**
05	**Introduction to Smart-Grid:** Concept of Smart-Grid, Definitions, Need of Smart-Grid, Functions of Smart-Grid, Opportunities & Barriers of Smart Grid, Concept of Resilient & Self-Healing Grid, Microgrids role in smart-grid scenario. Review of Smart Grid Technologies: Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading(AMR), EV (Vehicle to Grid).	08	**CO5**
06	**Smart Grid Operations and Automation:** Smart Substations, Substation Automation, Feeder Automation. Intelligent Electronic Devices(IED) & their application for monitoring & protection, Wide Area Measurement System(WAMS), Phase Measurement Unit(PMU)	08	**CO6**

	Communication Network for Microgrids & Smart Grid: Home Area Network (HAN), Wide Area Network (WAN), Bluetooth, ZigBee, Wireless Mesh Network, Cyber Security for Smart Grid.		

Text Books:

1. Microgrids architectures and control Edited by Nikos Hatziargyriou, Wiley, IEEE Press, 2014.
2. A. Keyhani, M. N. Marwali, M. Dai, Integration of Green and Renewable Energy in Electric Power Systems, Wiley, 2009.
3. Antonio Carlos Zambroni de Souza, Miguel Castilla, Microgrids Design and Implementation, Springer 2019.
4. James Momoh, ―Smart Grid: Fundamentals of Design and Analysis,‖ IEEE Press and Wiley Publications, 2015.
5. J. C. Sabonnadière, N. Hadjsaïd, ―Smart Grids‖, Wiley Blackwell.

References:

1. Yezdani, and Reza Iravani, Voltage Source Converters in Power Systems: Modeling, Control and Applications, John Wiley Publications, 2010.
2. Dorin Neacsu, Power Switching Converters: Medium and High Power, CRC Press, 2006.
3. J. Ekanayake, N. Jenkins, K. Liyanage, J. Wu, A. Yokoyama, Smart Grid: Technology and Applications, Wiley, 2012.
4. IEEE standards ―IEEE-1547-2003: IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems IEEE standards 2003.
5. IEEE standards ―IEEE 1547-4-2011: IEEE Guide for Design Operation & Integration of Distributed Resources Island System with Electric Power System.
6. Consortium for Electric Reliability Technology Solutions (CERTS) white paper on Integration of Distributed Energy Resources: The CERTS Microgrid Concept‘ 2002.
7. NPTEL Course: DC Microgrid and Control System, Prof. Avik Bhattacharya, IIT Roorkee.
8. NPTEL Course: Introduction to Smart Grid, By Prof. N. P. Padhy & Prof. Premalata Jena, IIT Roorkee.

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Case Study on reasons for Energy crises and its mitigation measures. (Report): 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
EEPCL 601	Power Electronics Lab	-	25	25	- -		50	

Course Objectives: The course aims to	
1	Impart knowledge about various power semiconductor devices related to its characteristics, ratings, protection and to select semiconductor devices for various applications.
2	Introduce different methods of power conversion such as ac to dc, dc to dc, dc to ac the underlying principles of converter operation and hence to analyse different converter circuits for power conversion.
3	Keep abreast with the latest technologies and research going on in different areas related to power electronics.
4	Acquainted with modern tools for analysis of different converters**.**
Course Outcomes: Learners will be able to	
1	Draw V-I characteristics of power electronic devices.
2	Simulate the performance of power electronic conversion systems.
3	Analyse various single phase and three phase power converter circuits and understand their applications
4	Apply the basic concepts of power electronics to design the circuits in the fields of AC and DC drives, power generation and transmission and energy conversion, industrial applications.
5	Identify and describe various auxiliary circuits and requirements in power electronics applications such as Gate driver circuit, and snubber circuits along with electrical isolation and heat sinks.

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
A	**Hardware Based Experiments**	
01	V-I Characteristics of SCR	CO1
02	V-I Characteristics of Power MOSFET	CO1
03	V-I Characteristics of DIAC	CO1
04	V-I Characteristics of TRIAC	CO1
05	Firing Circuit of SCR	CO5
06	Commutation Circuits of SCR	CO5
07	Single phase half /full controlled rectifier circuit.	CO3
08	Three phase half /fully controlled rectifier circuit with R load	CO3
09	Triac - Diac circuit based speed control of single phase motor.	CO4
10	Gate Drive Circuit and snubber circuits (IGBT/MOSFET based)	CO5
11	Single phase Inverter (IGBT/MOSFET based)	CO3
12	Three phase Inverter (IGBT/MOSFET based)	CO3
13	Implementation of PWM techniques.	CO5
14	Buck converter	CO3
15	Boost Converter /Buck-Boost	CO3
16	AC-AC converter	CO3
B	**Applications of Power Electronics Circuits Demonstration**	
17	Closed loop control of DC-DC converter	CO4
18	Power factor correction in converters	CO4
19	LED lamp intensity control	CO4
20	Solar PV based converter / inverter system	CO4
C	**Simulation**	
21	Three phase controlled rectifier including source inductance	CO2
22	PWM Rectifier	CO2
23	Three phase VSI (120° and 180° conduction mode)	CO2
24	Bidirectional DC-DC Converter	CO2
25	Buck Converter	CO2
26	AC voltage controllers: On-Off and phase control	CO2

Lab work shall consist of a total of 10 experiments including at least four Simulations.

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Oral & Practical Exam (25 Marks)

An Oral & Practical exam will be held based on entire syllabus.

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					
EEPCC L602	Electrical Machines -II Lab	-	25	25	-	-	50	

Course Objectives: To impart the knowledge on the following	
1	Practical understanding of Single phase Induction machines and their characteristics
2	Practical understanding of Three phase Induction machines and their characteristics
3	Practical understanding of Synchronous machines and their characteristics
Course Outcomes: Learners will be able to	
1	Analyze the operation of single phase Induction machines
2	Analyze the operation of Three phase Induction machines
3	Analyze different methods of speed control of Three phase Induction motor.
4	Analyze the operation of synchronous machines
5	Determine the voltage regulation of synchronous machines
6	Analyze the synchronization (or parallel operation) of synchronous machines

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
01	To perform no load and blocked rotor test on single phase Induction motor.	CO1
02	To perform load test on Single phase Induction motor.	CO1
03	To perform no load and blocked rotor test on three phase Induction motor.	CO2
04	To perform load test on Three phase Induction motor.	CO2
05	To perform speed control of a three phase slip ring Induction motor.	CO3
06	Constructional details of Synchronous machine	CO4
07	Starting methods of Synchronous motor	CO4
08	Load test on Synchronous motor	CO4
09	'V' and 'inverted V' curves of Synchronous machine	CO4
10	Determination of Xd and Xq of Synchronous machine by Slip test	CO4
11	Use of Synchronous motor as a Synchronous condenser	CO4
12	To determine positive sequence, negative sequence and zero sequence reactance of an alternator	CO4
13	Voltage regulation of Alternator by Direct loading method	CO5
14	Voltage regulation of Alternator by EMF and MMF method	CO5
15	Voltage regulation of Alternator by ZPF and ASA method	CO5
16	Synchronization / Parallel operation of Alternator	CO6

Virtual Lab Website Reference:

1. http://vlab.co.in/broad-area-electrical-engineering
2. http://vlab.co.in/broad-area-electronics-and-communications

Lab work: Lab work should consist of 8 experiments and two simulations.

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Oral & Practical Exam (25 Marks)

An Oral & Practical exam will be held based on the entire syllabus.

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					
EEPECL601	Program Elective Lab(Electrical Engineering Application design and Simulation Lab)	-	25	25	-	-	50	1

Prerequisite: Circuit analysis, fundamentals of control system, power system and Electrical Machine	
Course Objectives: The course aims to	
1	Train students to design, simulate and analyze Electrical systems
2	Train students to use various software tools and industrial applications.
3	Keep abreast with the latest technologies and research going on in different areas related to electrical Engineering.
4	Train students for project development.
Course Outcomes: Learners will be able to	
1	Design and analyze systems in the field of electrical engineering.
2	Simulate and verify the performance of any system .
3	Apply the basic Electrical Engineering knowledge in system development.
4	**Identify and rectify problems in the field of** Electrical Engineering

Note: 1. lab work must be carried out for the program elective courses opted by the students individually.
2. It is advisable to form the batches for lab work as per the program electives courses opted by the students.

Suggested List of Experiments

1.Control System Design

Sr. No.	List of Experiments	CO Mapping
01	To study the effect of P, PI, PD and PID controllers on step response of a feedback control system (Using control engineering trainer/process control simulator). Verify the same by simulation.	CO1, CO2,CO3,CO4
02	Design of a Lead compensator using Root-locus method	CO1, CO2,CO3,CO4
03	Design of a lag compensator using Root-locus method	CO1, CO2,CO3,CO4
04	Design of a lead-lag compensator using Root-locus method	CO1, CO2,CO3,CO4
05	Design of a lead compensator using bode plot method	CO1, CO2,CO3,CO4
06	To draw the frequency response characteristic of a given lag-lead compensating network.	CO1, CO2,CO3,CO4
07	Design of a lag compensator using bode plot method	CO1, CO2,CO3,CO4
08	Design of a lead-lag compensator using bode plot method	CO1, CO2,CO3,CO4
09	Obtain transfer function of a given system from state variable model and vice versa. State variable analysis of a physical system - obtain step response for the system by simulation	CO1, CO2,CO3,CO4
10	Observer design by pole placement using state space approach.	CO1, CO2,CO3,CO4
11	Observer design by alternative approach to Observer design using state space approach.	CO1, CO2,CO3,CO4
12	To understand the concept of controllability, controllability matrix, controllability by inspection method.	CO1, CO2,CO3,CO4
13	Controller design by the method of transformation.	CO1, CO2,CO3,CO4
14	Steady state error design using integral control.	CO1, CO2,CO3,CO4
15	Familiarization with digital control system toolbox	CO1, CO2,CO3,CO4
16	Determination of z-transform, inverse z-transform & pole zero map of discrete systems to study step response of a discrete time system and effect of sampling time on system response.	CO1, CO2,CO3,CO4
17	To explore the Properties of Digital Control Systems. Convert continuous time system to discrete system and vice versa. Root Locus of Digital control system on z-plane.	CO1, CO2,CO3,CO4
18	Gain design on Z plane for transient response using root locus, stability design by root locus.	CO1, CO2,CO3,CO4

Virtual Lab Website Reference:

1. http://vlab.co.in/broad-area-electrical-engineering

2. Analog and Digital Communication

Sr. No.	List of Experiments	CO Mapping
01	AM Modulation and Demodulation	CO1, CO2,CO3,CO4
02	FM Modulation and Demodulation	CO1, CO2,CO3,CO4
03	DSB-SC Modulation and Demodulation	CO1, CO2,CO3,CO4
04	PAM Modulation and Demodulation	CO1, CO2,CO3,CO4
05	PPM Modulation and Demodulation	CO1, CO2,CO3,CO4
06	Sampling Theorem	CO1, CO2,CO3,CO4
07	Frequency Division Multiplexing	CO1, CO2,CO3,CO4
08	Time Division Multiplexing	CO1, CO2,CO3,CO4
09	Delta Modulation and Demodulation	CO1, CO2,CO3,CO4
10	PCM Modulation and Demodulation	CO1, CO2,CO3,CO4
11	BASK Modulation and Demodulation	CO1, CO2,CO3,CO4
12	BFSK Modulation and Demodulation	CO1, CO2,CO3,CO4
13	QPSK Modulation and Demodulation	CO1, CO2,CO3,CO4
14	DPSK Modulation and Demodulation	CO1, CO2,CO3,CO4
15	Pre-emphasis and De-emphasis	CO1, CO2,CO3,CO4
16	Noise power spectral density	CO1, CO2,CO3,CO4
17	Experiments using virtual Lab	CO1, CO2,CO3,CO4
18	Experiments using virtual Lab	CO1, CO2,CO3,CO4

3. Electrical Machine Design Lab

Sr No	List of Experiments	CO Mapping
1	A detail report on Design of Three Phase Transformer	CO1, CO2,CO3,CO4
2	Design of Three Phase Transformer by CAD/ any suitable software	CO1, CO2,CO3,CO4
3	A detail report on Design of Three Phase Induction Motor	CO1, CO2,CO3,CO4
4	Design of Three Phase Induction Motor by CAD/ any suitable software	CO1, CO2,CO3,CO4
5	A detailed report on Design of Electromagnet.	CO1, CO2,CO3,CO4
6	Design of Electromagnet Report by CAD/ any suitable software	CO1, CO2,CO3,CO4

Note:- Design any two components by CAD/ any suitable software and prepare a design report.

4. Electric and Hybrid Electric Vehicles

Sr. No.	List of Experiments	CO Mapping
01	Basic vehicle simulations on Matlab or any other vehicle simulation software	CO1, CO2,CO3,CO4
02	Emission test of conventional vehicle, electric vehicle and hybrid electric vehicle	CO1, CO2,CO3,CO4
03	Rechargeable lithium-ion battery SOC test and other performance	CO1, CO2,CO3,CO4
04	Load test of DC Motor/ Induction Motor	CO1, CO2,CO3,CO4
05	Design and testing of controlled rectifier circuit for battery charging	CO1, CO2,CO3,CO4
06	Design and testing of battery connected buck / boost converter	CO1, CO2,CO3,CO4
07	Study of transmission system through simulation/ experiment	CO1, CO2,CO3,CO4
08	study of battery management system through simulation/experiment	CO1, CO2,CO3,CO4
09	Study of regenerative Braking	CO1, CO2,CO3,CO4
10	Visit to EV/Battery/Motor/Capacitor manufacturing Plant	CO1, CO2,CO3,CO4
11	1.Case study of any EV / HEV on road in India 2.Case study of Government policy related to green transportation and EV manufacturing. 3. Case study of Government policy on pollution control 4. Case study on Earth Summit 5. Case study on Environment sustainability and Transportation.	CO1, CO2,CO3,CO4

Any experiment or simulation related to EV and HEV that helps the students understand the course should be included and added other than the suggested list.

Plant Visit:
Visit to existing EV charging station/ battery manufacturing unit/ EV manufacturing unit

5. Special Machine and its Application

Sr. No.	List of Experiments	CO Mapping
01	Study of constructional features and working principle of different special motors (Stepper, SRM, BLDC, PMSM, LIM).	CO1, CO2,CO3,CO4
02	Speed control of a Stepper Motor using Arduino or Microcontroller Interface.	CO1, CO2,CO3,CO4

03	Determination of Step Angle and Resolution of Stepper Motor.	CO1, CO2,CO3,CO4
04	Characteristics of Switched Reluctance Motor (SRM).	CO1, CO2,CO3,CO4
05	Speed control of SRM using a power converter.	CO1, CO2,CO3,CO4
06	Performance characteristics of Permanent Magnet Brushless DC Motor (PMBLDC).	CO1, CO2,CO3,CO4
07	Speed control of PMBLDC motor using microcontroller/DSP.	CO1, CO2,CO3,CO4
08	Study of Permanent Magnet Synchronous Motor (PMSM).	CO1, CO2,CO3,CO4
09	Experimental setup of PMSM drive using inverter and controller.	CO1, CO2,CO3,CO4
10	Study of Linear Induction Motor (LIM) and its characteristics.	CO1, CO2,CO3,CO4
11	Study of Hysteresis Motor and its torque characteristics.	CO1, CO2,CO3,CO4
12	Performance evaluation of Universal Motor under AC and DC supply.	CO1, CO2,CO3,CO4
13	Demonstration of Piezoelectric / Ultrasonic Motor (if available).	CO1, CO2,CO3,CO4
14	Integration of special motor with sensor and control module for application (e.g., robotic arm / conveyor).	CO1, CO2,CO3,CO4

Virtual Lab Website Reference:

1. http://vlab.co.in/broad-area-electrical-engineering

6. Microgrid and SmartGrid

Sr. No.	List of Experiments	CO Mapping
	Simulation Based Practical's. (Use of tools like MATLAB, Scilab, PSIM, LTSPice, python, C, Java platforms etc. for the following experiments). (OR any other simulations based on Microgrid related systems/ subsystems).	CO1, CO2,CO3,CO4
01	Study of Smart Grid components.	CO1, CO2,CO3,CO4
02	Simulation on Modelling of PV system using MATLAB.	CO1, CO2,CO3,CO4
03	Simulation on Modelling of DFIG based wind power system.	CO1, CO2,CO3,CO4
04	Simulation of Grid connected PV MPPT single stage.	CO1, CO2,CO3,CO4
05	To measure and analyze the power quality parameters with and without compensation. (voltage, THD, pf and current)	CO1, CO2,CO3,CO4

06	Simulation/Emulation of DC Microgrid with steady state/transient performance analysis.	CO1, CO2,CO3,CO4
07	Simulation/ Emulation of AC Microgrid with steady state/transient performance analysis.	CO1, CO2,CO3,CO4
08	Microgrid Stability analysis with study of impact of ESS on stability.	CO1, CO2,CO3,CO4
09	Study and testing of Overcurrent relay, Over voltage relay and Under Voltage relay.	CO1, CO2,CO3,CO4
10	Simulation on protection of distributed generation sources (wind and solar power generators).	CO1, CO2,CO3,CO4
11	Relay coordination in smart grid protection scheme for Radial Circuit Topology.	CO1, CO2,CO3,CO4
	Practical's based on Experimental Setups. **(OR any other experiments based on Microgrid related systems/ subsystems).**	
12	Testing of Power Conversion Unit for DC Microgrid.	CO1, CO2,CO3,CO4
13	Testing of Power Conversion Unit for AC Microgrid.	CO1, CO2,CO3,CO4
14	DC Microgrid: Power Sharing between the sources.	CO1, CO2,CO3,CO4
15	AC Microgrid: Power Sharing between the sources.	CO1, CO2,CO3,CO4
16	Islanding detection.	CO1, CO2,CO3,CO4
17	Island mode of operation of DC or AC Microgrid.	CO1, CO2,CO3,CO4
18	Standalone Microgrid operation.	CO1, CO2,CO3,CO4
19	Voltage and current sensing circuits.	CO1, CO2,CO3,CO4

Virtual Lab Website Reference:

1. http://vlab.co.in/broad-area-electrical-engineering
2. https://www.vlab.co.in/broad-area-mechanical-engineering - Energy Storage Labs, Solar Energy lab, Wind Energy Lab

Plant Visit:

Visit an existing Microgrid facility or a Solar PV/ Wind Installation or a power converters manufacturing / research facility.

Any other simulations / algorithms / practical's based on **THEORY syllabus (EEPEC6023)**, which will help students to understand the topic / concept.

Term Work: Lab work should consist of 4 practicals from Program Elective Course 2 and 4 practicals from Program Elective Course 3 opted by the students.

Continuous Internal Evaluation (CIE):

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	02 Hrs
		Internal Assessment		Oral	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					01
EECEP601	Mini Project II	-	25	25	-	-	50	

Prerequisite: Basic Electrical & Electronics Engineering	
Course Objectives: The course aims to	
1	To design and develop a moderately complex electrical/electronic/digital circuit with practical applications.
2	To understand basic concepts of circuit design while developing the project.
3	To enable the students to gain hands-on experience independently proposing and implementing the project
4	To acquire the necessary confidence to deal with complex electrical/electronic/digital systems design and development using various softwares.
Course Outcomes: Learners will be able to	
1	Identify and define a practical problem in the field of electrical/electronic/digital systems and also analyze the functional requirements, constraints of problems using appropriate engineering principles suitable for project implementation.
2	Design an electrical/electronic/digital circuit or system to meet specified performance objectives using suitable hardware and/or software tools.
3	Develop and implement the designed system through simulation and/or hardware realization to validate its functionality through effective team work and project management.
4	Evaluate the performance of the developed system, identify limitations, and propose possible improvements through effective communication

A. Mini Project Topic Selection and Approval

1. The group may be of maximum FOUR (04) students.

2. Students should propose project ideas & finalize the project idea in consultation with the guide/ HOD.

Students should select a problem which addresses some basic home, office or other real life applications.

The mini project must have hardware part. The software part is optional.

3. Students should identify different components/ devices, instruments, simulation/emulations software

tools required for the project.

4. Students should submit implementation plan in the form of Gantt/ PERT/ CPM chart, which will cover

weekly activity of project.

5. A Log Book to be prepared by each group to record the work progress in terms of milestones per week by

students. Weekly comment, remarks to be put by guiding faculty.

B.Mini Project –Execution

i. Design and Fabrication

a. Initial fabrication of the project by students can be done using standard devices/material/software tools to verify the circuit functionalities Initial project fabrication and testing is expected to be done by soldering/assembling on general purpose PCB/ Bakelite boards or suitable platforms required for the electrical/electronic/digital components. Discourage the use of breadboards.

b. If essential, use of a simulation/ emulation software tools to test and verify the performance of the circuit

should be encouraged.

c. Students should prepare the proper drawings (electrical/ mechanical), schematics/ layouts of the project.

d. For final implementation of the circuit, preparation of PCB (if any required) using suitable CAD tools and

fabricating the same in the lab is expected.

ii. Devices/ Components/ Systems to be Used:

Students are encouraged to use passive components like resistors, capacitors, inductors etc. If any specialize

inductor is not readily available, the fabrication of the same in the lab should be encouraged. Other components like: Transistors, diodes, voltage regulators, logic gates, Op-amps, general purpose

microcontroller, DC motors/ AC motors, sensors, actuators, relays etc. (Students may add more components

as per the requirement of project).

iii. Testing and analysis of the Project

Students should test the circuit using suitable laboratory equipments like power supply, multi-meter, CRO,

DSO etc. In case of any debugging requirement, students should record the problems faced during the testing and solutions sought after for the fault in the circuit. All the testing results must be well documented in the final project report verifying the functionalities of the propose project.

iv. Use of Reference Material/Literature :

Students are advised to refer Application Notes, research publications & data sheets of various electrical/electronic/digital devices from Texas Instruments, Microchips, International Rectifiers, ST Microelectronics, Philips, NXP and many other manufacturers.

C. Project Report Format:

Mini Project report should include circuit diagram, operation, application, design details, testing, waveforms

(if applicable) references, simulation results and final prepared PCB image, conclusion, etc. Project report

should include report of all above steps listed in (2) and the conclusion.

Note:-

It is expected that the department should organise some of the guidance expert lectures / video lectures/ courses/webinars/ workshops etc. for the students at the appropriate timing during the Mini Project practical slots on following topics:

1) Understanding passive components viz. resistors, capacitors and inductors from practical point of view:

types/ varieties, device packages, applications and cost.

2) Understanding semiconductor components viz. diodes, BJT and JFET/MOSFETs from practical point of view:types/ varieties, device packages, applications and cost.

3) Design principles of simple electrical / electronic circuits with some examples.

4) Selection of switches and circuit protection components.

5) Selection and sizing of wires and conductors.

6) Soldering Practice.

7) Heat-sinking and Enclosure design concepts

8) Overall workmanship while working on the project fabrication.

9) Use of different software tools for design and development of circuits

10) Use of standard as well as some of the advanced laboratory equipments needed for testing of such projects

Application Domains:

List of key application domains from where students are encouraged to derive Mini Projects topics:

1. Smart Agriculture solutions
2. Power converter applications in various Applications
3. IoT based applications in power systems
4. AI/ML applications in disaster management
5. Renewable Energy
6. Energy Conservation
7. Energy Storage
8. Battery Charging and Protection
9. Fire Safety
10. Electrical System Protection
11. Lighting Control
12. Wireless Power Transfer
13. Electrical Components Testing
14. Electrical Parameters Measurement
15. Non-conventional Electricity Generation
16. Laboratory Equipments
17. E-Mobility / Electric Vehicles
18. Video Surveillance Systems
19. Robotics for Hazardous applications
20. Waste Management System
21. Smart City Solutions
22. Smart Classrooms and learning Solutions
23. Design of Electrical Equipment
24. PLC based automation system
25. Power system Monitoring System (EMS)

It is every much expected that the complexity of the Mini Project II should be increased compared to the selection of projects during Mini Project I. Also based on the subjects learned in lower semesters broader area inclusive of the concepts learned must be selected. Students can identify the mini project topics either from above suggested domains or any other relevant electrical engineering domains. The inter-disciplinary nature of the project is also desirable. Mini Project II may be extension of Mini Project I based on recommendation and scope.

Guidelines for Assessment of Mini Project:

Term Work

The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester. In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.

Continuous Internal Evaluation (25 Marks)

1. Regularity and Attendance : 05 Marks
2. Review of Project : 15 Marks
3. Quality of Project Report : 05 Marks

Prepare detailed rubrics for Review of Project and Quality of Project Report

Sujjested Rubrics for Review of Project

1. Quality of survey/ need identification
2. Clarity of Problem definition based on need.
3. Inattentiveness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness
6. Societal impact
7. Inattentiveness
8. Cost effectiveness and Societal impact
9. Full functioning of working model as per stated requirements
10. Effective use of skill sets
11. Effective use of standard engineering norms
12. Contribution of an individual's as member or leader
13. Clarity in written and oral communication

Guidelines for Assessment of Mini Project Oral Examination:

- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or

research organizations having experience of more than five years approved by head of Institution.

- Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Oral Examination(25 Marks)

Mini Project shall be assessed based on following points:

1. Quality of Problem and Clarity
2. Inattentiveness in solutions
3. Cost effectiveness and Societal impact
4. Working of Project
5. Understanding
6. Full functioning of working model as per stated requirements
7. Effective use of skill sets
8. Effective use of standard engineering norms
9. Contribution of an individual's as member or leader
10. Clarity in written and oral communication

Prepare detailed rubrics for Mini Project Oral Examination

Reference Books:

1. P. Horowitz and W. Hill, "The Art of Electronics", 3 rd Edition, Cambridge University Press, 2015

2. R. S. Khandpur, "Printed Circuit Board", McGraw-Hill Education; 1st edition, 2005.

3. Simon Monk, "Hacking Electronic: Learning Arduino and Raspberry Pi", McGraw-Hill Education TAB; 2 edition (September 28, 2017).

Suggested Software tools:

1. LTspice:https://www.analog.com/en/design-center/design-tools-and-calculators/ltspice-simulator.html#

2. Eagle : https://www.autodesk.in/products/eagle/overview

3. OrCAD: https://www.orcad.com/

4. Multisim : https://www.multisim.com/

5. Webbench: http://www.ti.com/design-resources/design-tools-simulation/webench-power-designer.html

6. Tinkercad : https://www.tinkercad.com/

7. Raspbian OS: https://www.raspberrypi.org/downloads

8. Arduino IDE: https://www.arduino.cc/en/main/software

Online Repository:

1. https://www.electronicsforu.com

2. https://circuitdigest.com

3. https://www.electronicshub.org

4. Github

Department of Internet of Things Engineering

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
ITMDM601	Microcontrollers and Application	20	20	60	1	2	100	

Prerequisite: Digital Electronics, Number system	
Course Objectives: The course aims to	
1	understand the features and architecture of PIC 18 microcontroller and Ardino UNO
2	Introduce assembly programming knowledge for PIC 18 microcontroller
3	Impart embedded programming knowledge for PIC 18 microcontroller using C
4	Introduce various applications using microcontroller-based system
Course Outcomes: Learners will be able to	
1	Explain difference between microprocessor and microcontroller architecture and memory
2	Understand PIC 18 instruction and assembly level Programing
3	Describe the timer, counter and interrupt module of PIC 18 with assembly program
4	Explain the serial and parallel I/O with simple assembly program
5	Understand the Arduino UNO programming
6	Write a C program for various applications of microcontrollers.

Prerequisite: Knowledge of No. system, digital electronics, programming basics			
Module	**Detailed Contents**	**Hrs.**	**CO Mapping**
01	**Introduction to Microcontroller**		

	Block diagram of generic microcontroller, Microcontroller versus Microprocessor, A brief history of PIC microcontroller, Overview of PIC 18 family and features, Internal Bus structure of PIC microcontroller, Clock frequency, machine cycle and instruction cycle PIC18 microcontroller programming model, Bus architecture, program memory and data memory organization, Special Function Registers (SFRs), General Purpose Registers (GPRs) , program counter. *CPU registers:* Working Register (Wreg), Status Register, Bank Select Register (BSR), Instruction Decoder **Self learning Topic***:*Memory Pointers, Program ROM, Data ROM	6	CO1
02	**PIC18F Instruction Set** Pipelining. (conceptual overview only) *Instructions and Assembly Programs:* Instruction Set, Instruction formats, Addressing modes, Assembler Directives, Assembly programs. (Assembly programs are restricted to basic arithmetic, logical and data transfer operations only)	9	CO2
03	**PIC 18 Timer/counters and interrupt**		
	Timer Module: Basic Concept of Timers and counters, Timer Registers, Control Registers, 8 bit and 16 bit operation (only for Timer 0), CCP module (Capture, Compare and PWM), Watch dog Timer. *Interrupt Module:* Basic concept of Interrupt, PIC 18 Interrupts, Interrupt versus polling, Interrupt sources, Interrupt vector, Interrupt service routine, Interrupt process, RCON, INTCON, IPR1 and PIE1. **Self Learning Topic:** Watch dog Timer, other SFRs of interrupt module.	6	CO3
04	**Parallel Ports and Serial Communication** IO PORT Module: Basic concept of I/O interfacing, PORT Registers, TRIS Registers, LAT Registers, Simple input /output peripheral interfacing (switches & LEDs). Serial communication: Basics of serial communication, Data framing, USART module, SPBRG, TXREG, RCREG, TXSTA, RCSTA, PIR1.	9	CO4
05	**Introduction to Arduino** Introduction to Arduino -UNO board, Analog and digital Pins, Programming structure of Arduino, basics of C programming, programming Arduino with sensor interfacing, LED blinking, LCD interfacing.	6	CO5
06	**Application of Microcontroller** Interfacing matrix keyboard and Seven segments LED display, LCD Interfacing, ADC Interfacing, Traffic signal controller, DC motor interfacing, Stepper motor interfacing, PWM signal generation. **Self learning topics:** LCD Interfacing, ADC Interfacing.	6	CO6

Text Books:-

1. Ramesh Gaonkar, “Fundamentals of Microcontrollers and Applications in Embedded Systems (with the PIC 18 Microcontroller Family)”, Penram International publications (Ind) Pvt. Ltd.

2. Ali Mazidi, Rolind D Mckinlay and Danny Causey , “PIC Microcontroller and Embedded Systems”, Pearson Education ltd., 2015
3. Robert B. Reese, “Microcontroller from Assembly Language to C using PIC18FXX2”, Davinici Engineering press.
4.Simon Monk, “Programming Arduino: Getting started from Sketches, second Edition,

Reference Books:-

1. Han Way Huang, “PIC Microcontroller: An Introduction to Software and Hardware Interfacing”, Cengage Learning, 2005.
2. NPTEL Course: **Microprocessors And Microcontrollers** By Prof. Santanu Chattopadhyay, Dept. of Electrical Engineering, IIT Kharagpur:- Web link- https://nptel.ac.in/courses/108/105/108105102/
3. https://www.arduino.cc/education/certification/

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Internet of Things Engineering

Second Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hours
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
ITMDML601	Microcontrollers and Application	-	25	-	-	-	25	

Course Objectives: The course aims to	
1	Impart assembly programming of PIC microcontroller
2	Impart assembly programming for I/O interface and timer, counter
3	Impart knowledge of Arduino programming
4	Impart skill of application based microcontroller programming.
Course Outcomes: Learners will be able to	
1	Write and debug simple assembly programs on data transfer
2	Write and debug simple assembly programs on arithmetic and logical instructions
3	Write and debug simple assembly programs on Timers and counters, USART
4	Write and debug Arduino programs
5	Write and debug I/O programming of Arduino and PIC
6	Make application based system using microcontroller

Suggested List of Experiments

Minimum three experiments must be done from each group

Sr. No.	List of Experiments	CO Mapping
Group A	Use at least 3 programs 1. Group of data transfer 2. Addition, Subtraction, Multiplication 3. Time delay using GPRs 4. Time delay using timers 5. Program on USART 6. Conditional and unconditional tasks	CO1 CO2
Group B	1. Square wave generation 2. LED inter facing 3. Blinking LED 4. Serial port programming	CO3

	5. Counter programming	
Group C	1. Simple arduino programming for addition subtraction	CO4
Group D	2. Arduino programming for LED blinking 3. PIC 18 programming for LCD interface 4. PIC 18/Arduino programming for DC motor interface 5. Any other application of Microcontroller	CO5 CO6

Continuous Internal Evaluation (25 Marks):

1. **Minimum 9 experiments and case study hardware project and one assignment are compulsory for the term work.**

2. **Lab Performance: 10 Marks**
3. **Mid Semester Oral & Practical Exam during lab session: 10 Marks**
4. **Regularity and Attendance: 5 Marks**

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
ARMDM601	**Robotics**	20	20	60	1	2	100	

Prerequisite: Engineering mechanics, Electrical engineering	
Course Objectives: The course aims to	
1	To acquaint with significance of robotic system in agile and automated manufacturing processes.
2	To make conversant with robotic elements/ peripherals, their selection and interface with manufacturing equipment's
3	To study the basics of robot kinematics
Course Outcomes: Learners will be able to	
1	Understand the basic components and types of robots.
2	Analyze and model robotic arms, manipulators, and end-effectors.
3	Acquire skills in image processing and object recognition for robotic applications.
4	Apply kinematic and dynamic analysis to robotic systems
5	Acquire skills of robot intelligence and its role in autonomous decision-making.
6	Understand social, ethical, and economic impacts of robotics on labour, productivity, and society.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Introduction:** Automation & its Overview, Introduction to robotics: Robotic system & Anatomy, Classification of robots and Robot degrees of freedom (DoF) and joint & join types.	**04**	**CO1**
02	**Drives & Peripherals End Effecters:** **Drives** Control Loops, Basic Control System Concepts & Models, Control System Analysis, Robot Activation & Feedback Components, Position & Velocity Sensors, Actuators and Power Transmission system. **Robot & its Peripherals End Effecters**: Type mechanical and other grippers, Tool as end effecter. Sensors: Sensors in Robotics,	**08**	**CO2**

	Tactile Sensors, Proximity & Range Sensors, Sensor Based Systems, Vision systems and Equipment		
03	**Machine vision & Programming for Robots:** **Machine vision** Introduction, Low level & High level Vision, Sensing & Digitizing, Image Processing & analysis, Segmentation, Edge detection, Object Description & recognition, interpretation and Applications. **Programming for Robots** Method, motion & task level Languages, Robot languages, Programming in suitable languages and characteristics of robot.	**09**	**CO3**
04	**Robot Kinematics & Robot Dynamics:** Robot Kinematics Forward, reverse & Homogeneous Transformations, Manipulator Path control and Robot Dynamics. Introduction to wheeled and legged robots including humanoids.	**08**	**CO4**
05	**Robot Intelligence & Task Planning:** Robot Intelligence & Task Planning Introduction, State space search, Problem reduction, use of predictive logic, Means Ends Analysis, Problem solving, Robot learning and Robot task planning.	**07**	**CO5**
06	**Robot application:** Robot application in manufacturing Material transfer, machine loading & un loading, processing operation, Assembly & inspectors, robotic Cell design & control, social issues & Economics of Robotics. Introduction to AI in Robotics industrial safty standards in robotics, Recent trends in robotics like service,Medical,humanoid robot,Softrobotics.	**06**	**CO6**

Text Books:

1. Fundamentals of Robotics, Larry Health
2. Robotics for Engineers, Yoram Koren , Mc Graw hill.
3. Industrial Robotics, Technology, Programming & Applications, Grover, Weiss, Nagel, Ordey,Mc Graw Hill.
4. Robotic technology & Flexible Automation, S R Deb. TMH.
5. Robot Analysis & Control, H Asada, JJE Slotine.
6. Robot Technology, Ed. A Pugh, Peter Peregrinus Ltd. IEE, UK.
7. Handbook of IndustrialRobotics, Ed. Shimon. John Wiley
8. Roland Siegwart, Illah Reza Nourbakhsh, and Davide Scaramuzza, "Introduction to AutonomousMobile Robots", Bradford Company Scituate, USA

References:

1. https://onlinecourses.nptel.ac.in/noc23_me07/preview
2. https://onlinecourses.nptel.ac.in/noc25_me166/preview
3. https://online**courses**.nptel.ac.in/noc19_cs47/preview

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
ARMDML601	ROBOTICS Lab	-	25	-	-	-	25	

Prerequisite: Mechatronics, Theory of Machines, Dynamics of Machinery	
Course Objectives: The course aims to	
1	To acquaint with programming of robots.
2	To learn the implementation of image processing algorithms.
3	To demonstrate the working of machine learning algorithms for data prediction
Course Outcomes: Learners will be able to	
1	Identify and describe the main components and Apply principles of sensors, actuators, and embedded systems to enable real-time decision-making in robots.
2	Obtain the tool to base transformations using software simulations.
3	Program a robotic arm to perform pick-and-place tasks
4	Apply image processing techniques to perform edge detection
5	Implement image segmentation algorithms to isolate and recognize objects
6	Develop and simulate trajectory generation and path planning algorithms for robotic manipulators
7	Formulate and program forward (direct) and inverse kinematics solutions for different robot configurations.

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
01	Robot Components and Configuration: Understanding robot types, configurations, and components. using an educational robotic arm, open Ware robotic simulator. Procedure: Identify the components of a robot. Classify robots based on their configuration. Observe actuators, sensors, and controllers. Results: Document robot types and components.	CO1
02	Study different coordinate frames and transformations. Using Open Ware simulation software. Steps: Define the base and tool coordinate frames. Perform homogeneous transformations. Visualize transformed points in Open Ware. Results: Record transformed coordinates.	CO2

03	Program a robotic arm to perform pick-and-place tasks. Apparatus: Educational robotic arm with Open Ware interface. Procedure: Identify pick and place coordinates. Write program using Open Ware commands. Execute and observe operation. Results: Successful pick-and-place operation	CO3
03	Edge detection using image processing (simulation/hardware)Result: Edges in the image successfully detected using gradient-based algorithms.	CO4
04	Segmentation using image processing (simulation/hardware)	CO5
05	Trajectory Generation and Path Planning(simulation/hardware)	CO6
06	Programming the robots to solve direct and inverse kinematics problems	CO7
06	Acquisition of sensor data over cloud using microcontroller (simulation/hardware)	CO5
07	Implementation of Clustering algorithm (K-means / K-medoids)	CO6
08	A Lab course project such as Mobile Robot Line Following, Obstacle Avoidance for Mobile Robot, surveillance robots etc to be developed in a batch of 4 students.	CO1,CO4

Note: Students should do at least 06 experiments from the suggested list.

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Oral & Practical Exam (25 Marks)

An Oral & Practical exam will be held based on entire syllabus.

Department of Electronics and Telecommunication Engineering

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
CEMDM601	**Big Data Computing**	20	20	60	1	2	100	

Prerequisite: Data base management system	
Course Objectives: The course aims to	
1	Describe an Overview of an exciting growing field of Big Data Analytics.
2	Discuss the tools required to manage and analyze big data like Hadoop, NoSQL, Map Reduce.
3	Apply the fundamental techniques in achieving big data analytics with scalability and streaming capability
4	Discuss the several types of big data like social media, web graphs and data streams.
Course Outcomes: Learners will be able to	
1	Describe the key issues in big data management and its associated applications in intelligent business and scientific computing
2	Outline fundamental enabling techniques and scalable algorithms like Hadoop, MapReduce and NoSQL in big data analytics.
3	Predict the business models and scientific computing paradigms, and apply software tools for big data analytics
4	Describe adequate perspectives of big data analytics in various applications like recommender systems, social media applications etc
5	Develop applications for Big Data analysis using Hadoop and NoSQL etc.
6	Design and implement successful Recommendation engines for enterprises.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Introduction to Big data Analytics** Introduction to Big Data, Big Data characteristics, Types of Big Data, Traditional vs. Big Data a business approach, Traditional vs. Big Data business approach, Big Data Challenges, Examples of Big Data in Real Life, Big Data Applications	**2**	**CO1**
02	**Hadoop** Introduction to Hadoop. Core Hadoop Components, Hadoop Ecosystem-Apache HBase, Hive, HCatalog, Pig, Mahout, Oozie, Zookeeper, Sqoop, Physical Architecture, Hadoop limitations.	**6**	**CO2**

03	**NoSQL**	**7**	**CO3**
	Introduction to NoSQL, NoSQL business drivers, NoSQL database case studies. NoSQL data architecture patterns: Key-value stores, Graph stores, Column family (Bigtable) stores, Document stores, Variations of NoSQL architectural patterns Using NoSQL to manage big data: What is a big data NoSQL solution? Understanding the types of big data problems; Analysing big data with a shared-nothing architecture; Choosing distribution models: master-slave versus peer-to-peer; Four ways that NoSQL systems handle big data problems, Managing MongoDB database with CRUD operations		
04	**Map Reduce**	**6**	**CO4**
	MapReduce and The New Software Stack: Distributed File Systems, Physical Organization of Compute Nodes, Large Scale File-System Organization. MapReduce: The Map Tasks, Grouping by Key, The Reduce Tasks, Combiners, Details of MapReduce Execution, Coping with Node Failures Algorithms Using MapReduce: MapReduce Wordcount Program, Matrix-Vector Multiplication by MapReduce, Relational-Algebra Operations by MapReduce, Matrix Operations, Matrix Multiplication by MapReduce .		
05	**Techniques in Big Data Analytics**	**14**	**CO5**
	Finding Similar Item: Nearest Neighbour Search, Similarity of Documents, Distance Measures: Euclidean, Jaccard, Cosine , Edit and Hamming Distance with its Examples Mining Data Streams: Data Stream Management Systems, Data Stream Model, Examples of Data Stream Applications: Sensor Networks, Network Traffic Analysis Filtering streams: The Blooms filter. Link Analysis: PageRank Definition, Structure of the web, dead ends, Using Page rank in a search engine, Efficient computation of Page Rank: Page Rank Implementation Using MapReduce Frequent Itemset Mining: Market-Basket Model, Apriori Algorithm, Algorithm of Park-Chen-Yu		
06	**Big Data Analytics Applications**	**7**	**CO6**
	Recommendation Systems: Introduction, A Model for Recommendation Systems: Collaborative-Filtering System, Content based system and its Examples Mining Social-Network Graphs: Social Networks as Graphs, Types of Social-Networks. Clustering of Social Graphs: Applying Standard Clustering Techniques, counting triangles using Mapreduce.		
	Total	**42**	

Text Books:

1. Radha Shankarmani and M Vijayalakshmi ―Big Data Analytics, Wiley
2. Alex Holmes ―Hadoop in Practice‖, Manning Press, Dreamtech Press.
3. Dan McCreary and Ann Kelly ―Making Sense of NoSQL – A guide for managers and the rest of us, Manning Press.

References:

1. Bill Franks, ―Taming The Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics‖, Wiley
2. Chuck Lam, ―Hadoop in Action‖, Dreamtech Press
3. Analytics in a Big Data World: The Essential Guide to Data Science and its Applications, Bart Baesens , WILEY Big Data Series
4. https://onlinecourses.nptel.ac.in/noc25_cs131/preview

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Electronics and Telecommunication Engineering

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
CEMDML601	Big Data Computing Lab	-	25	-	-	-	25	

Prerequisite: DBMS	
Course Objectives: The course aims to	
1	Describe an overview of an exciting growing field of Big Data analytics.
2	Discuss the challenges traditional data mining algorithms face when analyzing Big Data.
3	Explain the tools required to manage and analyze big data like Hadoop, NoSql MapReduce.
4	Tell the tools that will help them to solve complex real-world problems in decision support.
Course Outcomes: Learners will be able to	
1	Explain the motivation for big data systems and identify the main sources of Big Data in the real world.
2	Demonstrate an ability to use frameworks like Hadoop, NOSQL to efficiently store, retrieve and process Big Data for Analytics.
3	Build several Data Intensive tasks using the Map Reduce Paradigm
4	Apply several newer algorithms for Clustering Classifying and finding associations in Big Data
5	Design algorithms to analyze Big data like streams, Web Graphs and Social Media data.
6	Design and implement successful Recommendation engines for enterprises.

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
01	Case Study: on Study of Hadoop ecosystem	CO1
02	Programming exercises on Hadoop Using Hive, Pig, Hbase,Sqoop NOSQL, MongoDB	CO2
03	Implementing simple algorithms in MapReduce Matrix,multiplication, Aggregates, joins, sorting, searching etc.	CO3

04	Implementing Algorithms using MapReduce (Any 2)	CO3
05	Implementing Frequent Item set Mining	CO4
06	Implementing Clustering algorithms Implementing Classification Algorithms	CO5
07	Big Data Applications (Any 2) ● Implementing Analytics on data streams ● Implementing Social Network Analysis Algorithms	CO6
08	Implementing Web Graph Algorithms Implementing recommendation Engines	CO6
09	Mini Project: One real life large data application to be implemented (Use standard Datasets available on the web) a) Twitter data analysis b) Fraud Detection c) Text Mining d) Recommendation Engines (list of datasets also given in the text book)	CO5,CO6

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Useful Links:

1 https://www.coursera.org/learn/hadoop#syllabus

2 https://www.coursera.org/learn/introduction-mongodb#syllabus

3 https://www.coursera.org/learn/data-visualization-tableau?specialization=data-visualization#syllabus

4 https://www.coursera.org/learn/introduction-to-big-data-with-spark-hadoop#syllabus

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
EEMDM601	Electric Vehicle Technology	20	20	60	1	2	100	

Prerequisite: Sustainability and environment, Electrical Machine.	
Course Objectives: The course aims to	
1	Describe the history and evolution of electric & hybrid electric vehicles to emphasize on the need and importance of EV/HEV for a sustainable future.
2	Identify and describe the principles of various EV/HEVs drive train topologies.
3	Develop an understanding of EV/HEV Electric Machines drives for Propulsion Applications and Energy Sources.
4	Model, analyze and design electric and hybrid electric vehicles drive train and to understand energy management strategies.
Course Outcomes: Learners will be able to	
1	Identify and describe the history and evolvement of electric & hybrid electric vehicles.
2	Identify and describe the principles of various EV/HEVs drive train topologies.
3	Select electric propulsion system components for EV/HEV drives for the desirable performance and control.
4	Compare and evaluate various energy sources and energy storage components for EV/HEV
5	Model, analyze and design EV/HEV drive train with energy management
6	Recognize the need to adapt and engage in operations EV/HEV with the absolute technological change in the transportation system for a sustainable future.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Introduction** 1. Basics of vehicle mechanisms, history of Electric vehicles (EV) and hybrid electric vehicles (HEV), importance of EV and HEV. 2. Power/Energy supplies requirements for EV/HEV applications, transmission characteristics. 3. State of the art and Indian and global scenario in EV/HEV.	07	CO1

	Self Learning Topic: Basics of vehicle parts, Bharat standard for vehicle emission.		
02	**Drive train Topologies** 2.1 Common parts in ICE drive train and EV/ HEV electric drive train topologies, Classification of HEV (Micro, Mild and Full hybrid) 2.2 basics of hybrid traction system, various hybrid drive-train topologies 2.3 fuel efficiency analysis for series and hybrid drive train, comparison. **Self Learning Topic: Electric motor, single and multi drive system,**	**07**	**CO2**
03	**DC and AC machines and Drives for propulsion application** 3.1 DC and AC machines used in EV/HEV, Electrical system components. 3.2 Features of DC and AC Motors for EV/HEV propulsion. 3.3 Permanent magnet(BLDC) and switch reluctance machines, configuration and control of drives. **Self Learning Topic: comparison of DC and AC machines, induction motor drive characteristics.**	**07**	**CO3**
04	**Energy sources for EV and HEV** 4.1 Requirements of energy storage in EV/HEV: batteries, fuel cells, flywheels and ultra-capacitors as energy sources for EV/HEV 4.2 characteristics and comparison of energy sources for EV/HEV 4.3 hybridization of different energy sources. **Self Learning Topic: Basics of cell, overview of battery.**	**07**	**CO4**
05	**Drive train modeling in EV/HEV** 5.1 Modeling and analysis of EV/HEV drive train: Total tractive force calculation, sizing Of motor 5.2 Power electronics drive used in EV/HEV **Self Learning Topic: Basic electronic components guidelines.**	**07**	**CO5**
06	**Energy management strategies in EV/HEV** 6.1 EV/HEV energy management strategies, classification of various energy management strategies. Rule based EMS, optimization methods of EMS. 6.5 Standards for EV and HEV. Case studies. **Self Learning Topic: 2w and 3w EV/HEV vehicles.**	**07**	**CO6**

Text Books:

1. I. Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2003.
2. M. Ehsani, Y. Gao, S.E. Gay and Ali Emadi, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, CRC Press. 2005
3. Sheldon Williamsom, *Energy Management Strategies for Electric and Plug-in Hybrid Vehicles*, Springer 2013
4. J. Larminie and J. Lowry, *Electric Vehicle Technology Explained*, Wiley, 2003
5. C. MI, M. Abul and D. W. Gao, *Hybrid Electrical Vehicle Principles and Application with Practical Perspectives,* Wiley 2011

Reference Books:

1. N.Mohan, T.M.Undeland, and W.P Robbins, *Power Electronics, Converters, Applications & Design,* Wiley India Pvt. Ltd., 2003
2. B. K Bose*, Modern Power Electronics and AC Drives*, Pearson Education
2002 3. Robert A. Huggins, *Energy Storage*, Springer 2010

NPTEL/ Swayam Course:

1. Course: Intro. to Hybrid and Electric Vehicles - Prof. Praveen Kumar & Prof. S. Majhi (IIT Guwahati): https://nptel.ac.in/courses/108/103/108103009/

2. Course: Electric Vehicles - Part 1 By Prof. Amit Kumar Jain (IIT Delhi) https://nptel.ac.in/courses/108/102/108102121/

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Electrical Engineering

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Practical	
		Marks Distribution					Exam Duration (Hrs)		2 Hrs
		Internal Assessment		Oral	MSE	ESE	Total Marks		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)						
EEMDM601	Electric Vehicle Technology Lab	-	25	-	-	-	25		01

Prerequisite: Renewable Energy System and Energy Storage System, Electrical Machines, Power Electronics	
Course Objectives: The course aims to	
1	Study the fundamental concepts and principles of electric and hybrid electric vehicles Drive train topologies
2	Develop a thorough understanding of the key elements of EV/HEV: Electric Machines For Propulsion Applications and Energy Sources
3	Model, analyze and design electric and hybrid electric vehicles drive train and to Understand energy management strategies
Course Outcomes: Learners will be able to	
1	Explore EV and HEV and convention vehicle performance
2	Interpret the salient features and components of Electric and Hybrid electric vehicles
3	Test and analyze various propulsion motor loading under variable speed and torque conditions.
4	Observe and analyze the charging and discharging characteristics of electric vehicle batteries.
5	Describe about the applications of power electronics in electrical vehicles
6	Explore the transportation sustainability

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
01	Basic vehicle simulations on Matlab or any other vehicle simulation software	CO1
02	Study of transmission system through simulation/ experiment	CO1
03	Emission test of conventional vehicle, electric vehicle and hybrid electric vehicle	CO2

04	Develop schematic diagram of hybrid electric vehicle and identify its parts in matlab simulation	CO2
05	Load test of DC series Motor	CO3
06	Testing and analysis of induction motor loading at different speed and torque conditions.	CO3
07	Connect and run the three phase squirrel cage induction motors (in both directions) using the DOL starter/ autotransformer starter.	CO3
08	Rechargeable lithium-ion battery SOC test and other performance	CO4
09	Design and testing of controlled rectifier circuit for battery charging	CO4
10	Prepare a report on batteries used from market survey	CO4
11	study of battery management system through simulation/experiment	CO5
12	Design and testing of battery connected buck / boost converter	CO5
13	List safety procedures and schedule for handling HEVs and EVs	CO6
14	Case study- Compare minimum four vehicles for economic and environmental analysis	CO6
15	Visit to EV/Battery/Motor/Capacitor manufacturing Plant	All COs

Any experiment or simulation related to EV and HEV that helps the students understand the course should be included and added other than the suggested list.

Plant Visit:
Visit to existing EV charging station/ battery manufacturing unit/ EV manufacturing unit.

Term Work: Minimum 8 experiment/simulation must be done for satisfactory completion of the term.

Continuous Internal Evaluation (25 Marks)
1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Department of Mechanical Engineering

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
MEMDM601	**Automobile Systems**	20	20	60	1	2	100	

Prerequisite: Engineering Mechanics	
Course Objectives: The course aims to	
1	Understand the major systems and subsystems in modern automobiles.
2	Analyse the working principles of vehicle drivetrain, chassis, braking, steering and suspension systems.
3	Apply mechanical engineering fundamentals (mechanics, strength of materials, kinematics) to vehicle systems.
4	Understand the fundamentals of electric/hybrid vehicle (EV) systems and how they differ from conventional vehicles.
5	Select appropriate components/materials for automotive applications and appreciate trends in automotive technology (EV, ADAS).
Course Outcomes: Learners will be able to	
1	Identify and classify automotive clutches and transmission systems.
2	Explain the working of Driveline, Final Drive & Differential.
3	Explain Steering mechanisms, Wheels, Tyres & Suspension.
4	Identify and classify Braking Systems & Chassis Layout in Automobile.
5	Identify and classify Vehicle Body, Aerodynamics, Materials for Automobile.
6	Relate emerging technologies (electric/hybrid vehicles, regenerative braking, ADAS) to conventional systems.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Clutch and Transmission Systems** Purpose of clutch & transmission in a vehicle, Single-plate, multi-plate clutches, centrifugal clutches, Manual transmissions: sliding mesh, constant mesh, synchromesh Automatic transmissions: torque converter, fluid coupling Continuously Variable Transmission (CVT), Introduction to EV / hybrid transmission layouts.	07	**CO1**
02	**Driveline, Final Drive & Differential** Driveline components: propeller shaft, universal joints, driveshafts Final drive gears & bearings Differential: open, limited slip, locking types Rear axle construction for different vehicles (2WD, 4WD) Introduction to EV/Hybrid drivetrain configurations (e.g., single motor, dual motor, hub motors)	08	**CO2**
03	**Steering, Wheels, Tyres & Suspension** Steering geometry, types of steering mechanisms (rack & pinion, recirculating ball) Power steering systems, steer-by-wire Tyre construction, types, loads; wheel & hub assembly Suspension systems: leaf, coil, air, independent suspension Vehicle dynamics basics: camber, toe, roll, pitch EV/HV implications: regenerative braking effect on suspension, weight distribution, hub motors	08	**CO3**
04	**Braking Systems & Chassis Layout** Braking fundamentals: friction brakes, drum vs disc Hydraulic and pneumatic braking systems ABS, EBD, regenerative braking (in EV/HV) Chassis types: ladder, monocoque, space-frame Vehicle layouts: FR, FF, MR, RR, 4WD, AWD Impact of EV architecture on chassis-body design (battery placement, low centre of gravity)	07	**CO4**
05	**Vehicle Body, Aerodynamics, Materials** Vehicle body structures, loads, crashworthiness Aerodynamics basics: drag, lift, side-wind, airflow Materials in automotive industry: steels, aluminium, composites	05	**CO5**

	Integration of thermal management systems for EV		
06	**Electric & Hybrid Vehicle Systems**	07	**CO6**
	Overview of electric vehicle (EV) and hybrid architectures, Batteries: types, performance metrics Electric motors / motor drives: types (DC, AC, PMSM, etc.) Power electronics: inverters, converters, charger systems, Charging infrastructure, vehicle-to-grid (V2G) & future trends. Comparison of conventional vs EV systems: lifecycle, maintenance, Sustainability.		

Text Books:

1. A Textbook of Automobile Engineering by S. K. Gupta.
2. A Textbook of Automobile Engineering by R. K. Rajput.
3. Automobile Engineering by G. B. S. Narang
4. Automobile Engineering Vol I and II by Kirpal Singh.

References:

1. Heitner, J. J., *Fundamentals of Vehicle Dynamics and Driveline Systems*.
2. Heldt, P. M., *Automotive Chassis & Body*.
3. Crouse, W. H. & Anglin, D. L., *Automotive Mechanics*.
4. Ganesan, V., *Electric Vehicles and Hybrid Vehicles*.
5. Husain, I., *Electric and Hybrid Vehicles: Design Fundamentals*.

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Visit/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Mechanical Engineering

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
MEMDML601	Automobile Systems	-	25	-	-	-	25	

Prerequisite:	
Course Objectives: The course aims to	
1	To study construction, working and performance of key automobile subsystems.
2	To gain hands-on experience with vehicle transmission, steering, suspension, braking, and driveline systems.
3	To introduce modern EV and hybrid powertrain components through simulation and hardware demonstrations.
4	To correlate theoretical concepts with practical automotive systems and diagnostics.
Course Outcomes: Learners will be able to	
1	Identify and explain the construction and working principle of single-plate and multi-plate clutch mechanisms used in vehicles.
2	Compare the working and torque transmission characteristics of manual (synchromesh) and automatic (torque converter/CVT) transmissions.
3	Demonstrate the function and interaction of propeller shaft, universal joint, and differential gear in the driveline system using models.
4	Examine different suspension systems (leaf, coil, air, independent) and analyze their impact on vehicle ride comfort.
5	Distinguish between chassis frame constructions (ladder, monocoque, space-frame) and identify vehicle layouts (FR, FF, 4WD, etc.).
6	Illustrate the architecture and components of Electric Vehicles, including battery, motor, inverter, and charging system.

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
01	Study and demonstration of single-plate and multi-plate clutch mechanisms.	CO1
02	Comparative study of manual (synchromesh) and automatic transmission (torque converter / CVT).	CO1
03	Study and demonstration of propeller shaft, universal joint, and differential gear using cut section models.	CO2
04	Demonstration of suspension systems.	CO3
05	Analysis of chassis frames (ladder, monocoque, space-frame) and vehicle layout identification.	CO4
06	Study of EV architecture – components like battery, motor, inverter, and charging systems.	CO6

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks

Oral & Practical Exam (25 Marks)

An Oral/ Practical exam will be held based on the entire syllabus.

Department of Computer Engineering / CSE(DS) / CSE(AIML) / CSE(IoT & CSBT)

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Lecture
		Marks Distribution			Exam Duration (Hrs)		Total Marks	3 Hrs
		Internal Assessment		End Semester Exam (ESE)	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					3
ETMDM601	Digital Image Processing	20	20	60	1	2	100	

Prerequisite: Basic concepts of Mathematics and Digital Communication	
Course Objectives: The course aims to	
1	Familiarize fundamental concepts of Digital Image Processing
2	Learn Spatial and Frequency domain Image enhancement techniques
3	Gain knowledge of Image Segmentation and Image Compression
4	Understand Image Morphology, Restoration, Descriptors and Object recognition applications
Course Outcomes: Learners will be able to	
1	Understand the fundamentals of Digital Image Processing and perform basic operations on image.
2	Analyze and apply Spatial and Frequency domain Image enhancement techniques.
3	Illustrate image segmentation techniques based on principle of discontinuity and similarity using various algorithms.
4	Describe and analyze various digital image compression techniques.
5	Demonstrate morphological operations, image restoration model and various shape descriptors
6	Apply image processing algorithms for object recognition applications.

Module	Detailed Contents	Hrs.	CO Mapping
01	**Introduction** Fundamental steps in Digital Image Processing, Representation of a Digital Image, Tonal and Spatial Resolutions, Pixel relationships - neighbors, adjacency, connectivity, distance measures, Basic image operations - arithmetic, logical, geometric transformations, Image File Formats: BMP, TIFF and JPEG, RGB Color model.	06	CO1

	Self Learning Topic: Sampling and Quantization		
02	**Image Enhancement** Spatial domain enhancement techniques – Image Negative, Contrast Stretching, Thresholding, Gray level transformation, Histogram Equalization, Histogram Specification. Spatial filtering – Smoothing, Sharpening, Highboost and Median Filters. Frequency domain enhancement techniques - Introduction to 2-D DFT and IDFT, Frequency domain filtering - Low pass, High pass and Homomorphic filtering.	09	**CO2**
03	**Image Segmentation** Fundamentals of segmentation and edge detection, Thresholding techniques - global, local, and adaptive thresholding, Edge based segmentation- Robert, Sobel, Prewitt, Laplacian, and Canny operators, Region-based segmentation - region growing, splitting, and merging.	08	**CO3**
04	**Image Compression** Fundamentals of image compression, Types of redundancy, Fidelity criteria, Lossless compression techniques: Runlength coding, Huffman coding, Bitplane coding, Arithmetic coding, Introduction to DCT, Wavelet transform, Lossy compression techniques: Transform coding, Image and Video Compression Standards – JPEG, MPEG.	08	**CO4**
05	**Morphological Operations, Image Restoration and Description** Introduction to mathematical morphology, Erosion and Dilation, Opening and Closing operations, Hit-or-Miss transform, Boundary Extraction and Region Filling, Thinning and Thickening, Image Restoration Models, Boundary and Region Descriptors, Shape descriptors, Fourier descriptors, Moments, Skeletons.	07	**CO5**
06	**Object Recognition and Applications** Feature extraction, Patterns and Pattern Classes, Representation of Pattern classes, Types of classification algorithms. Applications- Biometric Authentication, Character Recognition, Content based Image Retrieval, Remote Sensing. **Self Learning Topic:** Medical application of Image processing	04	**CO6**

Text Books:

1. Gonzales and Woods, “Digital Image Processing”, Pearson Education, India, Fourth Edition 2018
2. Anil K.Jain, “Fundamentals of Image Processing”, Prentice Hall of India, Second Edition 2004
3. Pratt W.K, “Digital Image Processing”, Third Edition, John Wiley, New York, 2002

References:

1. Kenneth R. Castleman, Digital Image Processing, Pearson, 1996.
2. B. Chanda and D. Dutta Majumder, Digital Image Processing and Analysis, PHI, 2011.
3. S. Jayaraman, E. Esakkirajan and T. Veerkumar, “Digital Image Processing”, Third Edition, Tata McGraw Hill Education Private Ltd, 2009
4. Digital Image Processing, IIT Kharagpur, Prof. P.K. Biswas Link: https://nptel.ac.in/courses/117105079

Internal Assessment (40 Marks)

A. Mid Semester Exam (20 Marks)

Mid semester examination will be based on 40 % to 50% of the syllabus.

B. Continuous Internal Evaluation (20 Marks)

1. Assignment: 5 Marks
2. Quiz/Open book test/Presentation: 10 Marks
3. Regularity and attendance: 5 Marks

End Semester Examination (60 Marks)

End semester will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20% to 30% weightage and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Department of Computer Engineering / CSE(DS) / CSE(AIML) / CSE(IoT & CSBT)

Third Year Engineering Curriculum: Semester VI

Course Code	Course Name	Examination Scheme						Practical
		Marks Distribution			Exam Duration (Hrs)		Total Marks	2 Hrs
		Internal Assessment		Oral & Practical	MSE	ESE		Total Credits
		Mid Sem Exam (MSE)	Continuous Internal Evaluation (CIE)					1
ETMDML601	Digital Image Processing Lab	-	25	-	-	-	25	

Prerequisite: Python Programming Skill Lab	
Course Objectives: The course aims to	
1	Gain practical experience with various operations on digital image.
2	Apply Image enhancement, Image Segmentation, and Image Compression techniques on digital image.
3	Perform morphological operations and compute region and shape descriptors.
4	Strengthen the ability to apply image processing techniques for the given real-world problem.
Course Outcomes: Learners will be able to	
1	Demonstrate basic operations on Image.
2	Implement Spatial and Frequency domain Image enhancement techniques.
3	Perform various image segmentation techniques.
4	Implement and analyze various digital image compression techniques.
5	Demonstrate morphological operations, region and shape descriptors.
6	Apply image processing algorithms for object recognition and applications.

Suggested List of Experiments

Implementation can be carried out in MATLAB / Scilab /c / Python (OpenCV)

Sr. No.	List of Experiments	CO Mapping
01	Perform Image reading, displaying, and writing	CO1
02	Perform Image transformations like rotation, scaling, and translation	CO1

03	Implement Histogram equalization	CO2
04	Implement Spatial Domain Filtering: Smoothing and Sharpening Filters	CO2
05	Implement Frequency domain filtering: Low-pass and High-pass Filters	CO2
06	Implement Edge based segmentation- Sobel, Prewitt, Laplacian, and Canny operators	CO3
07	Implement region growing and watershed segmentation	CO3
08	Image segmentation using global Thresholding Algorithm	CO3
09	Implement RLE and Huffman coding for images	CO4
10	Implement Discrete Cosine Transform	CO4
11	Implement Wavelet transform	CO4
12	Implement Morphological operation – Erosion and Dilation, Opening and Closing operations, Hit-or-Miss transform, Boundary Extraction and Region Filling, Thinning and Thickening	CO5
13	Compute region and shape descriptors for given images	CO5
14	Perform object detection	CO6
15	Case Study on applications of Image Processing	CO6

Continuous Internal Evaluation (25 Marks)

1. Lab Performance: 10 Marks
2. In-Semester Practical Exam during lab session: 10 Marks
3. Regularity and Attendance: 5 Marks