AC-01-Item No. 2.0, 2.4, 3.0 & 3.4 dated 29th April 2024

Agnel Charities

Fr. C. Rodrigues Institute of Technology

Sector 9A, Vashi, Navi Mumbai, 400703, Maharashtra, India

www.fcrit.ac.in

An Autonomous Institute Affiliated to the University of Mumbai

Department of Electrical Engineering

Curriculum Structure FY to B.Tech

&

Second Year Syllabus

Prepared by: Board of Studies for Electrical Engineering

Approved by: Academic Council of Fr. C. Rodrigues Institute of Technology

Effective from: 2024-25

Revision: 2024.1

PREAMBLE-DEAN ACADEMICS

Accelerating Towards Excellence: Unveiling a New Era in Education

Dear Students, Faculty, and Stakeholders,

It is with great pleasure and anticipation that we introduce the newly designed curriculum for autonomy at Agnel Charities' Fr. C. Rodrigues Institute of Technology. This pioneering initiative aims to revolutionize engineering education, ensuring our graduates are equipped with not only technical prowess but also the holistic skills necessary for thriving in today's dynamic professional landscape.

1. **Purpose of Autonomy:** Our commitment to autonomy is rooted in the imperative to bridge the gap between academia and industry. We envision education as a catalyst for individual growth, fostering self-sustainability and enhancing employability. Through our curriculum, westrive to nurture engineers who not only excel in their fields but also contribute meaningfullyto society.

2. **Curriculum Design: A Top-to-Down Approach:** Our curriculum is meticulously crafted with a top-to-down approach, encompassing all 12 attributes of Program Outcomes mandated by regulatory bodies. Emphasizing a blend of theoretical knowledge and practical application, it is designed to cultivate well-rounded professionals capable of tackling real-world challenges with confidence and competence.

3. **Alignment with National Education Policy-2020:** In adherence to the guidelines laid out in the National Education Policy-2020, our curriculum embodies a multidisciplinary approach, offering a diverse array of core and elective courses. It integrates hands-on learning experiences such as mini and major projects, skill-based labs, and one-semester internships to nurture innovation and problem-solving skills. Additionally, the inclusion of value-added courses, honours, and minors ensures a comprehensive educational journey tailored toindividual interests and aspirations.

4. **Opportunities for Teachers in Innovation:** We recognize the pivotal role of our faculty in shaping the educational experience. Our curriculum provides ample opportunities for teachers to innovate in teaching-learning methodologies and evaluation techniques. Throughcontinuous professional development programs and collaborative platforms, we empower our educators to experiment with innovative pedagogies, leverage technology for enhanced learning outcomes, and implement novel assessment strategies. By fostering a culture of innovation among our faculty, we aim to enrich the learning experience and inspire a passionfor lifelong learning among our students.

As we embark on this transformative journey, we invite all stakeholders to join us in shaping the futureof engineering education. Together, let us strive towards excellence, innovation, and societal impact.

Sincerely,

Dean of Academics Agnel Charities' Fr. C. Rodrigues Institute of Technology

PREAMBLE- BOS CHAIRPERSON

Established in 1994, the Electrical Engineering department, provides comprehensive programs spanning undergraduate, postgraduate, and Ph. D levels. Comprising a team of highly qualified and experienced faculty, the department distinguishes itself through its cutting-edge facilities such as the Renewable Laboratory, Protection Laboratory, Power Electronics, Drives and Control System Laboratory. Additionally, the program has received accreditation thrice in 2005, 2012, and 2018, maintaining its validity to date. Furthermore, the institute is scheduled to transition to autonomy from the academic year 2024-25.

The scheme and syllabus of the Department of Electrical Engineering under autonomy are centred entirely on fostering the development of learners and cultivating the essential attributes that graduates should possess. When crafting the curriculum, two primary considerations are taken into account: the essential domain knowledge, skill sets, and tools required for the diverse career paths available to contemporary Electrical engineers and the 12 attributes of Program Outcomes mandated by regulatory bodies. The NBA-SAR January 2016 serves as a benchmark for shaping the learning outcomes within each module of the syllabus. Electrical engineering curriculum is structured to cover a range of core areas and specialized topics, ensuring that graduates are well-equipped to tackle the challenges of the modern world.

National Educational Policy-2020 guidelines are considered as reference while designing the curriculum. It incorporates practical learning opportunities like mini projects and major projects, skills-based labs, and internships to foster creativity and problem-solving abilities. Furthermore, offering value-added courses, honours programs, and minors ensures a well-rounded educational experience that caters to students' unique interests and goals.

The curriculum offers abundant chances for educators to pioneer teaching methods and assessment approaches, with the goal of enriching students' learning experiences and cultivating a lifelong passion for learning.

With a strong foundation in electrical engineering principles and specialized knowledge in key areas, graduates of our program are well-prepared to make significant contributions to the field and drive innovation in technology.

As we embark on this transformative journey, we invite all stakeholders to join us in shaping the future of Electrical Engineering education.

BOS Chairperson,
Department of Electrical Engineering.

Contents

A. Abbreviations

AEC	Ability Enhancement Course
AU	Audit Course
BSC	Basic Science Course including Mathematics
BSL	Basic Science Laboratory Course
ELC	Experiential Learning Course
ESC	Engineering Sciences Course
ESL	Engineering Sciences Laboratory Course
HMC	Honours or Minor Core Course
HML	Honours or Minor Laboratory
HMP	Honours or Minor Mini Project
HSS	Humanities Social Sciences and Management Course
IKS	Indian Knowledge System Course
INT	Internship
L	Lecture
LBC	Laboratory Course
LLC	Liberal Learning Course
MDM	Multidisciplinary Minor Course
MDL	Multidisciplinary Laboratory Course
MJP	Major Project
MNP	Mini Project
OEC	Open Elective Course
P	Practical
PCC	Program Core Course
PEC	Program Elective Course
RPC	Research Project Coursework
RPR	Research Project
SBL	Skill Based Laboratory
SEC	Skill Enhancement Course
T	Tutorial
VEC	Value Education Course

B. Credit Structure

1. B. Tech in Electrical Engineering											
Type of Course	**Semester-wise Credit Distribution**									**FCRIT Credit Distribution**	**DTE Credit Distribution**
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**Total**		
Basic Science Course (BSC)	08	08	--	--	--	--	--	--	**16**	**18**	**14-18**
Basic Science Laboratory Course (BSL)	01	01	--	--	--	--	--	--	**02**		
Engineering Science Course (ESC)	05	02	--	--	--	--	--	--	**07**	**16**	**12-16**
Engineering Science Laboratory Course (ESL)	04	05	--	--	--	--	--	--	**09**		
Program Core Course (PCC)	--	--	14	13	06	03	03	--	**39**	**50**	**44-56**
Laboratory Course (LBC)	--	--	02	03	02	02	02	--	**11**		
Program Elective (PEC)	--	--	--	--	03	03	06	03	**15**	**15**	**20**
Multidisciplinary Minor (MDM)	--	--	03	03	03	04	—	--	**13**	**13**	**14**
Multidisciplinary Laboratory Course (MDL)†	--	--	--	--	01	--	--	--	**01**	**01**	
Open Elective (OEC)	--	--	--	--	--	--	03	03	**06**	**06**	**08**
Skill Enhancement Course (SEC)	01	01	--	--	--	--	--	--	**02**	**08**	**08**
Skill Based Laboratory (SBL)	--	--	02	02	--	02	--	--	**06**		
Ability Enhancement Course (AEC)	--	03	--	--	02	--	--	--	**05**	**05**	**04**
Humanities Social Sciences and Management (HSS)	--	--	02	--	02	--	02	--	**06**	**06**	**04**
Indian Knowledge System (IKS)	--	02	--	--	--	--	--	--	**02**	**02**	**02**
Value Education Course (VEC)	02	--	--	02	--	--	--	--	**04**	**04**	**04**
Experiential Learning Course (ELC)	--	--	--	--	--	02	--	--	**02**	**02**	**04**
Mini Project (MNP)	--	--	01	01	01	01	--	--	**04**	**10**	**04**
Major Project (MJP)	--	--	--	--	--	--	02	04	**06**		
Internship (INT)	--	--	--	--	--	--	--	08	**08**	**08**	**12**
Liberal Learning Course (LLC)	--	--	--	--	--	02	--	---	**02**	**02**	**04**
Total Credits	**21**	**22**	**24**	**24**	**20**	**19**	**18**	**18**	**166**	**166**	**160-176**

† NOTE: The Multidisciplinary Laboratory Course can be moved to the sixth semester if the department prefers

C Curriculum Structure and Examination Scheme for B. Tech in Electrical Engineering

(FY and SY with Effect from AY 2024-2025)
Curriculum Structure – FY Semester-I

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
BSC101	Engineering Mathematics I	3	--	1	3	--	1	4
BSC102	Engineering Physics-I	2	--	--	2	--	--	2
BSC103	Engineering Chemistry-I	2	--	--	2	--	--	2
ESC101	Engineering Mechanics	3	--	--	3	--	--	3
ESC102	Basic Electrical Engineering	2	--	--	2	--	--	2
BSL101	Engineering Physics-I Laboratory	--	1	--	--	0.5	--	0.5
BSL102	Engineering Chemistry-I Laboratory	--	1	--	--	0.5	--	0.5
ESL101	Engineering Mechanics Laboratory	--	2	--	--	1	--	1
ESL102	Basic Electrical Engineering Laboratory	--	2	--	--	1	--	1
ESL103	Programming Laboratory-I (C)	--	2*+2	--	--	2	--	2
SEC101	Basic Workshop Practice-I	--	2	--	--	1	--	1
VEC101	Universal Human Values	2	--	--	2	--	--	2
	Total	**14**	**12**	**1**	**14**	**6**	**1**	**21**

*** Instructions should be conducted for the entire class.**

NOTE 1: Compulsory Non-Credit Activities: Participation and/or coordination of co-curricular and extra-curricular events at the Institute or Department level is mandatory for all students from semesters 1 to 8 as part of non-credit liberal education. Please consult the department's Curriculum Book for more information. These activities do not yield credits. Upon successful participation or organization of activities, a certificate will be awarded at the conclusion of semester 8.

NOTE 2: Please note that during semesters 1 to 8 some of the non-technical courses such as Humanities Social Sciences and Management (HSSM), Open Electives (OE), Value Education Course (VEC), and Liberal Learning Course (LLC) may be conducted either online synchronously or asynchronously. For more information, please consult the curriculum book of your respective department.

Examination Scheme – FY Semester-I

Course Code	Course Name	Examination Scheme					Total
		In-Semester Assessment$		End Sem Exam (ESE)	Exam Duration for Theory (in Hrs)		
		Continuous Assessment	Mid-Sem Exam		Mid-Sem	End-Sem	
BSC101	Engineering Mathematics-I	20+25@	30	50	1.5	2	125
BSC102	Engineering Physics-I	15	20	40	1.0	1.5	75
BSC103	Engineering Chemistry-I	15	20	40	1.0	1.5	75
ESC101	Engineering Mechanics	20	30	50	1.5	2	100
ESC102	Basic Electrical Engineering	15	20	40	1.0	1.5	75
BSL101	Engineering Physics-I Laboratory	25	--	--	--	--	25
BSL102	Engineering Chemistry-I Laboratory	25	--	--	--	--	25
ESL101	Engineering Mechanics Laboratory	25	--	--	--	--	25
ESL102	Basic Electrical Engineering Laboratory	25	--	25	--	--	50
ESL103	Programming Laboratory-I (C)	50	--	50	--	--	100
SEC101	Basic Workshop Practice-I	50	--	--	--	--	50
VEC101	Universal Human Values	50	--	--	--	--	50
	Total	**360**	**120**	**295**	--	--	**775**

$Please refer to the Curriculum Book of respective departments for guidelines on in-semester assessments for both theory and laboratory courses.

@For continuous assessment of tutorials.

Curriculum Structure – FY Semester-II

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
BSC204	Engineering Mathematics-II	3	--	1	3	--	1	4
BSC205	Engineering Physics-II	2	--	--	2	--	--	2
BSC206	Engineering Chemistry-II	2	--	--	2	--	--	2
AEC201	Professional Communication and Ethics-I	2	2	--	2	1	--	3
ESC203	Basic Electronics Engineering	2	--	--	2	--	--	2
BSL203	Engineering Physics-II Laboratory	--	1	--	--	0.5	--	0.5
BSL204	Engineering Chemistry-II Laboratory	--	1	--	--	0.5	--	0.5
ESL204	Engineering Graphics Laboratory	--	2*+2	--	--	2	--	2
ESL205	Programming Laboratory-II (Java)	--	2*+2	--	--	2	--	2
ESL206	Basic Electronics Engineering Laboratory	--	2	--	--	1	--	1
SEC202	Basic Workshop Practice-II	--	2	--	--	1	--	1
IKS201	Indian Knowledge System	2	--	--	2	--	--	2
	Total	**13**	**16**	**1**	**13**	**8**	**1**	**22**

*** Instructions should be conducted for the entire class.**

Examination Scheme – FY Semester-II

Course Code	Course Name	Examination Scheme					Total
		In-Semester Assessment$		End Sem Exam (ESE)	Exam Duration for Theory (in Hrs)		
		Continuous Assessment	Mid-Sem Exam		Mid-Sem	End-Sem	
BSC204	Engineering Mathematics-II	20+25@	30	50	1.5	2	125
BSC205	Engineering Physics-II	15	20	40	1.0	1.5	75
BSC206	Engineering Chemistry-II	15	20	40	1.0	1.5	75
AEC201	Professional Communication and Ethics-I	50	--	--	--	--	50
ESC203	Basic Electronics Engineering	15	20	40	1.0	1.5	75
BSL203	Engineering Physics-II Laboratory	25	--	--	--	--	25
BSL204	Engineering Chemistry-II Laboratory	25	--	--	--	--	25
ESL204	Engineering Graphics Laboratory	50	--	50	--	--	100
ESL205	Programming Laboratory-II (Java)	50	--	50	--	--	100
ESL206	Basic Electronics Engineering Laboratory	25	--	25	--	--	50
SEC202	Basic Workshop Practice-II	50	--	--	--	--	50
IKS201	Indian Knowledge System	50	--	--	--	--	50
	Total	**415**	**90**	**295**	--	--	**800**

$Please refer to the Curriculum Book of respective departments for guidelines on in-semester assessments for both theory and laboratory courses.

@For continuous assessment of tutorials.

Curriculum Structure – SY Semester-III

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
EEPCC301	Engineering Mathematics-III	3	--	1	3	--	1	4
EEPCC302	Circuit and Signal Analysis	3	--	1	3	--	1	4
EEPCC303	Elements of Power System	3	--	--	3	--	--	3
EEPCC304	Renewable Sources and Energy Storage	3	--	--	3	--	--	3
XXMDM301Y#	--	3	--	--	3	--	--	3
EELBC301	Electronics Laboratory	--	2	--	--	1	--	1
EELBC302	Electrical System Laboratory	--	2	--	--	1	--	1
EESBL301	Python Laboratory	--	4	--	--	2	--	2
EEMNP301	Mini Project-1A	--	3	--	--	1	--	1
HSS301	Product Design	2	--	--	2	--	--	2
	Total	**17**	**11**	**2**	**17**	**5**	**2**	**24**

#Four theory courses (Three 3-credit courses and one 4-credit course) and one laboratory course (1 credit) offered by other department has to be taken by electrical students, to complete the 14 credit requirements for MDM.

Examination Scheme – SY Semester-III

Course Code	Course Name	Examination Scheme					Total
		In-Semester Assessment$		End Sem Exam (ESE)	Exam Duration for Theory (in Hrs)		
		Continuous Assessment	Mid-Sem Exam		Mid-Sem	End-Sem	
EEPCC301	Engineering Mathematics-III	20+25@	30	50	1.5	2	125
EEPCC302	Circuit and Signal Analysis	20+25@	30	50	1.5	2	125
EEPCC303	Elements of Power System	20	30	50	1.5	2	100
EEPCC304	Renewable Sources and Energy Storage	20	30	50	1.5	2	100
XXMDM301Y	--	20	30	50	1.5	2	100
EELBC301	Electronics Laboratory	25	--	25	--	--	50
EELBC302	Electrical System Laboratory	25	--	25	--	--	50
EESBL301	Python Laboratory	50	--	50	--	--	100
EEMNP301	Mini Project-1A	50	--	--	--	--	50
HSS301	Product Design	50	--	--	--	--	50
	Total	**350**	**150**	**350**	--	--	**850**

$Please refer to the Curriculum Book of respective departments for guidelines on in-semester assessments for both theory and laboratory courses.

@For continuous assessment of tutorials.

Curriculum Structure – SY Semester-IV

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
EEPCC405	Engineering Mathematics-IV	3	--	1	3	--	1	4
EEPCC406	Control System	3		--	3	--	--	3
EEPCC407	Power Electronics	3	--	--	3	--	--	3
EEPCC408	Power System Engineering	3	--	--	3	--	--	3
XXMDM402Y	--	3	--	--	3	--	--	3
EELBC403	Power Electronics Laboratory	--	2	--	--	1	--	1
EELBC404	Control System Laboratory	--	2	--	--	1	--	1
EELBC405	Measurement and Instruments Laboratory	--	2	--	--	1	--	1
EESBL402	PCB Fabrication and Circuit Testing Laboratory	--	4	--	--	2	--	2
EEMNP402	Mini Project – 1B	--	3	--	--	1	--	1
VEC402	Environment and Sustainability	2	--	--	2	--	--	2
	Total	**17**	**13**	**1**	**17**	**6**	**1**	**24**

Examination Scheme – SY Semester-IV

Course Code	Course Name	Examination Scheme					Total
		In-Semester Assessment$		End Sem Exam (ESE)	Exam Duration for Theory (in Hrs)		
		Continuous Assessment	Mid-Sem Exam		Mid-Sem	End-Sem	
EEPCC405	Engineering Mathematics-IV	20+25@	30	50	1.5	2	125
EEPCC406	Control System	20	30	50	1.5	2	100
EEPCC407	Power Electronics	20	30	50	1.5	2	100
EEPCC408	Power System Engineering	20	30	50	1.5	2	100
XXMDM402Y	--	20	30	50	1.5	2	100
EELBC403	Power Electronics Laboratory	25	--	25	--	--	50
EELBC404	Control System Laboratory	25	--	25	--	--	50
EELBC405	Measurement and Instruments Laboratory	25	--	25	--	--	50
EESBL402	PCB Fabrication and Circuit Testing Laboratory	50	--	50	--	--	100
EEMNP402	Mini Project – 1B	50	--	50	--	--	100
VEC402	Environment and Sustainability	50	--	--	--	--	50
	Total	**350**	**150**	**425**	--	--	**925**

$Please refer to the Curriculum Book of respective departments for guidelines on in-semester assessments for both theory and laboratory courses.

@For continuous assessment of tutorials.

Curriculum Structure – TY Semester-V

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
EEPCC509	Electrical Machines	3	--	--	3	--	--	3
EEPCC510	Protection and Switchgear	3	--	--	3	--	--	3
XXMDM503Y	--	3	--	--	3	--	--	3
EEPEC501Y	Program Elective Course-I	3	--	--	3	--	--	3
EELBC506	Switchgear and Safety Laboratory	--	2	--	--	1	--	1
EELBC507	Electrical Machines Laboratory	--	2	--	--	1	--	1
XXMDL501Y	--	--	2	--	--	1	--	1
AEC502	Professional Communication and Ethics-II	1	2	--	1	1	--	2
EEMNP503	Mini Project-2A	--	3	--	--	1	--	1
HSS502	Entrepreneurship	2	--	--	2	--	--	2
Total		**15**	**11**	**--**	**15**	**5**	**--**	**20**

NOTE: Students who choose not to pursue Honours or Minor are welcome to register for the initial two courses of the fifth and sixth semesters' Honours or Minor track in 'Audit' mode (AU). This allows them to explore the course material without the expectation of earning a letter grade. Upon fulfilling the requirements in 'Audit' mode, their participation will be acknowledged on the grade sheet. Audit courses are excluded from grade point averages and have no impact on SGPI/CGPI calculations. For more information on Honours and Minor track courses, please refer to the Institute Handbook for Honours/Minor/Honours in Research degree programs.

Program Elective Course-I:

Students should take one PE from the following list of Program Elective Course- I.

Course Code	Program Elective Course-I
EEPEC5011	Advanced Power Electronics
EEPEC5012	Engineering Electromagnetics
EEPEC5013	Electric Vehicle Technology

Examination Scheme – TY Semester-V

Course Code	Course Name	Examination Scheme					Total
		In-Semester Assessment$		End Sem Exam (ESE)	Exam Duration for Theory (in Hrs)		
		Continuous Assessment	Mid-Sem Exam		Mid-Sem	End-Sem	
EEPCC509	Electrical Machines	20	30	50	1.5	2	100
EEPCC510	Protection and Switchgear	20	30	50	1.5	2	100
XXMDM503Y	--	20	30	50	1.5	2	100
EEPEC501Y	Program Elective Course-I	20	30	50	1.5	2	100
EELBC506	Switchgear and Safety Laboratory	25	--	25	--	--	50
EELBC507	Electrical Machines Laboratory	25	--	25	--	--	50
XXMDL501Y	--	25	--	25	--	--	50
AEC502	Professional Communication and Ethics-II	50	--	--	--	--	50
EEMNP503	Mini Project-2A	50	--	--	--	--	50
HSS502	Entrepreneurship	50	--	--	--	--	50
	Total	**305**	**120**	**275**	--	--	**700**

$Please refer to the Curriculum Book of respective departments for guidelines on in-semester assessments for both theory and laboratory courses.

Curriculum Structure – TY Semester-VI

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
EEPCC611	Drives and Control	3		--	3	--	--	3
XXMDM604Y	--	4		--	4	--	--	4
EEPEC602Y	Program Elective Course-II	3	--	--	3	--	--	3
EELBC608	Drives and Control Laboratory	--	2	--	--	1	--	1
EELBC609	Electrical Software Laboratory	--	2	--	--	1	--	1
EESBL603	Industrial Automation Laboratory	--	4	--	--	2	--	2
EEMNP604	Mini Project-2B	--	3	--	--	1	--	1
ELC601	Research Methodology	2	--	--	2	--	--	2
LLC601Y*	Liberal Learning Course	2	--	--	2	--	--	2
	Total	**14**	**11**	**--**	**14**	**5**	**--**	**19**

NOTE: Students who choose not to pursue Honours or Minor are welcome to register for the initial two courses of the fifth and sixth semesters' Honours or Minor track in 'Audit' mode (AU). This allows them to explore the course material without the expectation of earning a letter grade. Upon fulfilling the requirements in 'Audit' mode, their participation will be acknowledged on the grade sheet. Audit courses are excluded from grade point averages and have no impact on SGPI/CGPI calculations. For more information on Honours and Minor track courses, please refer to the Institute Handbook for Honours/Minor/Honours in Research degree prorams.

***Liberal Learning Course:**

Every student should take Liberal Learning Course for Semester VI. Students can take this course from the following list of Liberal Learning Courses.

Liberal Learning Courses	
Course Code	**Course Name**
LLC6011	Art of Living
LLC6012	Yoga and Meditation
LLC6013	Health and Wellness
LLC6014	Diet and Nutrition
LLC6015	Personality Development

Program Elective Course-II:

Students should take one PE from the following list of Program Elective Course- II.

Course Code	Program Elective Course-II
EEPEC6021	Lighting System Design
EEPEC6022	High Voltage DC transmission
EEPEC6023	Advanced Control System

Examination Scheme – TY Semester-VI

Course Code	Course Name	Examination Scheme					Total
		In-Semester Assessment$		End Sem. Exam (ESE)	Exam Duration for Theory (in Hrs)		
		Continuous Assessment	Mid-Sem Exam		Mid-Sem	End-Sem	
EEPCC611	Drives and Control	20	30	50	1.5	2	100
XXMDM604Y	--	20	30	50	1.5	2	100
EEPEC602Y	Program Elective Course-II	20	30	50	1.5	2	100
EELBC608	Drives and Control Laboratory	25	--	25	--	--	50
EELBC609	Electrical Software Laboratory	25	--	25	--	--	50
EESBL603	Industrial Automation Laboratory	50	--	50	--	--	100
EEMNP604	Mini Project-2B	50	--	50	--	--	100
ELC601	Research Methodology	50	--	--	--	--	50
LLC601Y*	Liberal Learning Course	50	--	--	--	--	50
	Total	**310**	**90**	**300**	--	--	**700**

$Please refer to the Curriculum Book of respective departments for guidelines on in-semester assessments for both theory and laboratory courses.

Curriculum Structure – B. Tech Semester-VII

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
EEPCC712	Electrical Systems Design and Auditing	3	--	--	3	--	--	3
EEPEC703Y	Program Elective Course-III	3	--	--	3	--	--	3
EEPEC704Y	Program Elective Course-IV	3	--	--	3	--	--	3
OEC701Y	Open elective Course –I	3	--	--	3	--	--	3
EELBC710	Electrical System Design and Audit Laboratory	--	2	--	--	1	--	1
EELBC711	Applied Power Electronics Laboratory	--	2	--	--	1	--	1
EEMJP701	Major Project A	--	6	--	--	2	--	2
HSS703	Financial Planning	2	--	--	2	--	--	2
	Total	**14**	**10**	**--**	**14**	**4**	**--**	**18**

Program Elective Course-III:

Students should take one PE from the following list of Program Elective Course- III.

Course Code	Program Elective Course-III
EEPEC7031	Power System Operation and Control
EEPEC7032	Digital VLSI Design
EEPEC7033	Automation and Control

Program Elective Course-IV:

Students should take one PE from the following list of Program Elective Course- IV.

Course Code	Program Elective Course-III
EEPEC7041	Smart Power System
EEPEC7042	Power Quality and FACTS
EEPEC7043	Artificial Intelligence in Renewable Energy System

Open Elective Course - I

Every student is required to take one Open Elective Course-I for Semester VII. Students can take this course from the following list of Open Elective Course-I.

Course Code	**Open Elective Course-I**
OEC7011	Product Lifecycle Management
OEC7012	Reliability Engineering
OEC7013	Management Information System
OEC7014	Design of Experiments
OEC7015	Operation Research
OEC7016[@@]	Cyber Security and Laws
OEC7017	Disaster Management and Mitigation Measures
OEC7018	Energy Audit and Management
OEC7019	Development Engineering

[@@] Students opting for Honours/Minor degree in Cybersecurity or relevant domain need to select other Open Elective.

Examination Scheme – B. Tech Semester-VII

Course Code	Course Name	Examination Scheme					Total
		In-Semester Assessment$		End Sem Exam (ESE)	Exam Duration for Theory (in Hrs)		
		Continuous Assessment	Mid-Sem Exam		Mid-Sem	End-Sem	
EEPCC712	Electrical Systems Design and Auditing	20	30	50	1.5	2	100
EEPEC703Y	Program Elective Course-III	20	30	50	1.5	2	100
EEPEC704Y	Program Elective Course-IV	20	30	50	1.5	2	100
OEC701Y	Open elective Course –I	20	30	50	1.5	2	100
EELBC710	Electrical System Design and Audit Laboratory	25	--	25	--	--	50
EELBC711	Applied Power Electronics Laboratory	25	--	25	--	--	50
EEMJP701	Major Project A	50	--	--	--	--	50
HSS703	Financial Planning	50	--	--	--	--	50
Total		**230**	**120**	**250**	--	--	**600**

$Please refer to the Curriculum Book of respective departments for guidelines on in-semester assessments for both theory and laboratory courses.

Curriculum Structure – B. Tech Semester-VIII

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
EEPEC805Y		3	--	--	3	--	--	3
OEC802Y		3	--	--	3	--	--	3
EEMJP802	Major Project-B	--	12	--	--	4	--	4
INT801	Internship~	--	--	--	--	8	--	8
	Total	**6**	**12**	**--**	**6**	**12**	**--**	**18**
~ Students have the opportunity to engage in a three-month internship within industry, research organizations, foreign universities, or internal internship for research and product development during the 8th semester, provided they meet the semester requirements and receive approval from the institute.								

Program Elective Course-V:

Students should take one PE from the following list of Program Elective Course- V.

Course Code	Program Elective Course-V
EEPEC8051	Power Electronics and Control
EEPEC8052	Advanced Power System
EEPEC8053	Microgrid and Smart Grid

Open Elective Course -II

Every student is required to take one Open Elective Course-II for Semester VIII. Students can take this course from the following list of Open Elective Course-II.

Course Code	Open Elective Course-II
OEC8021	Project Management
OEC8022	Finance Management
OEC8023	Entrepreneurship Development and Management
OEC8024	Human Resource Management
OEC8025	Professional Ethics and CSR
OEC8026	Circular Economy
OEC8027	IPR and Patenting
OEC8028	Digital Business Management
OEC8029	Environmental Management

Examination Scheme – B. Tech Semester-VIII

Course Code	Course Name	Examination Scheme					Total
		In-Semester Assessment$		End Sem Exam (ESE)	Exam Duration for Theory (in Hrs)		
		Continuous Assessment	Mid-Sem Exam		Mid-Sem	End-Sem	
EEPEC805Y		20	30	50	1.5	2	100
OEC802Y		20	30	50	1.5	2	100
EEMJP802	Major Project-B	50	--	50	--	--	100
INT801	Internship	50	--	50	--	--	100
Total		**140**	**60**	**200**	--	--	**400**

$Please refer to the Curriculum Book of respective departments for guidelines on in-semester assessments for theory, laboratory, and internship courses.

NOTE: Please note that due to the internship requirement in the 8th semester, theory courses during this semester will be conducted either online synchronously or asynchronously. For more information, please consult the curriculum book of your respective department.

D. Multidisciplinary Minor Courses Offered by the Department for the Other Program Students

Curriculum Structure for MDM Courses

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
EEMDM301	Industrial Electronics	3	--	--	3	--	--	3
EEMDM402	Measurements and Control	3	--	--	3	--	--	3
EEMDM503	Electrical Drives and Control	3	--	--	3	--	--	3
EEMDL601	Automation & AI	--	2	--	--	1	--	1
EEMDM604	Automation and Artificial Inteligence	4	--	--	4	--	--	4
	Total	**13**	**2**	**--**	**13**	**1**	**--**	**14**

Examination Scheme for MDM Courses

Course Code	Course Name	Examination Scheme					Total
		In-Semester Assessment$		End Sem Exam (ESE)	Exam Duration for Theory (in Hrs)		
		Continuous Assessment	Mid-Sem Exam		Mid-Sem	End-Sem	
EEMDM301	Industrial Electronics	20	30	50	1.5	2	100
EEMDM402	Measurements and Control	20	30	50	1.5	2	100
EEMDM503	Electrical Drives and Control	20	30	50	1.5	2	100
EEMDL601	Automation & AI	25	--	25	--	--	50
EEMDM604	Automation and Artificial Inteligence	20	30	50	1.5	2	100
	Total	**105**	**120**	**225**	--	--	**450**

$Please refer to the Curriculum Book of respective departments for guidelines on in-semester assessments for theory, laboratory, and internship courses.

E. Honours, Minor, and Honours in Reseach Degree Program

The Honours, Minor, and Honours in Research degree programs aim to empower students by offering specialized courses/research internships or projects in emerging fields of their interest, thus enhancing their proficiency in those areas. Students who achieve a CGPI of 7.5 or higher by the end of the fourth semester are eligible to pursue an additional 18 credits from the fifth to eighth semesters to qualify for a B. Tech degree with Honours, Minor, or Honours in Research designation. Students need to refer to the Institute level Handbook for Honours/Minor/Honours in Research Degree Programs for further details.

F. Syllabi
Second Year

Course Type	Course Code	Course Name	Credits
PCC	EEPCC301	ENGINEERING MATHEMATICS-III	03+01*

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20+25@	30	50	1.5	2	125

Pre-requisite:

1. BSC101- Engineering Mathematics-I
2. BSC204- Engineering Mathematics-II

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis

Course Objectives:

1. To provide the basic knowledge on the concepts of Mathematics in the field of Engineering.
2. To build a foundation to the methodology necessary for solving problems by applying the knowledge of Mathematics to the field of Engineering.

Module	Details	Hrs
	Course Introduction Engineering Mathematics III is often a foundational course designed to provide students with the mathematical tools and concepts essential for various engineering disciplines. Engineering Mathematics III has many applications in Electrical engineering such as • To introduce the study of Harmonic Analysis, Circuit Analysis and Control system using the various Mathematical Transforms, • Application of Fourier series in Spectrum analysis, and Concept of complex numbers and variables provides a knowledge to solve electrical engineering problems.	**01**
01.	**Laplace Transform**	**7-9**
	Learning Objective/s: *To analyze the standard Laplace Transforms using basic definitions and apply it to solve mathematical problems.*	
	Contents: Definition of Laplace Transforms, Condition of existence of Laplace Transform, Laplace Transforms of standard functions: $e^{at}, sinat, cosat, sinhat, coshat, t^n\ n > 0.$	

	Properties of Laplace Transform: Linearity, First Shifting Theorem, Change of scale Property, Multiplication by t, Division by t, Laplace Transform of derivatives and integrals, Heaviside's Unit Step function.	
	Self-Learning Topics: Second Shifting Theorem, Laplace Transform of Periodic functions.	
	Learning Outcomes : *A learner will be able to* *LO 1.1: Interpret standard Laplace transforms and its applicability to a given mathematical problem. (P.I.- 1.1.1)* *LO 1.2: Apply the properties of Laplace Transform and use it for solving advanced mathematical problems. (P.I.- 1.1.2)* *LO 1.3: Identify unit steps functions to solve engineering problems. (P.I-2.1.2)* *LO 1.4: Identify the correct properties of Laplace Transform applicable to a given problem (P.I.-2.1.3)*	
02.	**Inverse Laplace Transform**	**6-8**
	Learning Objective/s: *To analyze and apply the techniques of Laplace and inverse Laplace transform to solve differential equations. .*	
	Contents: Definition of Inverse Laplace Transform, Properties of Inverse Laplace Transform: Linearity, Shifting Theorem, Finding Inverse Laplace Transform using partial fraction, Finding Inverse Laplace Transform using differentiation Property, Solution of Differential equations-initial value problem and Boundary Value Problem.	
	Self-Learning Topics: Convolution Theorem.	
	Learning Outcomes : *A learner will be able to* *LO 2.1: Interpret standard Inverse Laplace transforms and its applicability to a given mathematical problem. (P.I.-1.1.1)* *LO 2.2: To solve initial and boundary value problems of differential equation by applying advanced mathematical techniques. (P.I.-1.1.2)* *LO 2.3: Identify the correct properties of inverse Laplace Transform applicable to a given problem (P.I.-2.1.3)* *LO 2.4: Identify the types of partial fraction method to find the solution of inverse Laplace transform. (P.I.-2.2.3)*	
03.	**Fourier Series**	**7-9**
	Learning Objective/s: *To analyze various wave forms and use the knowledge of periodic wave forms in determining a function in terms of its sine and cosine counterparts.*	

	Contents: Dirichlet's conditions, Definition Periodic function and graphical representation of periodic function: sine wave form, cosine wave form, square wave form, saw tooth wave form, Definition of Fourier series, Fourier series of periodic function with period 2π and Fourier series of periodic function with period 2l, Fourier series of even and odd functions, Half range Sine and Cosine Series.	
	Self-Learning Topics: *Parseval's Identity, Complex form of Fourier Series, Orthogonal and orthonormal set of functions.*	
	Learning Outcomes : *A learner will be able to* *LO 3.1: To apply mathematical techniques of algebra and calculus in determining Fourier coefficients. (P.I.-1.1.1)* *LO 3.2: To apply fundamental concept of mathematics to solve engineering problems. (P.I.-1.3.1)* *LO 3.3: Articulate and interpret the basics of periodic functions and series. (P.I.-2.1.1)* *LO 3.4: Identify the knowledge of periodic functions to solve given engineering problems. (P.I.-2.1.3)* *LO 3.5: To synthesize the information about any given mathematical function and express it in terms of sine and cosine waveforms. (P.I.-2.1.3)*	
04.	**Z-Transform**	**6-8**
	Learning Objective/s: *To identify the properties and theorem of z-transform to apply and solve engineering problems.*	
	Contents: Significance of z-transform, Definition and Region of Convergence, z-Transform of Standard Functions, Properties of z-transform: Linearity, Change of Scale, Shifting Property, Multiplication and Division property, Convolution theorem.	
	Self-Learning Topics: *Initial Value Theorem and Final Value Theorem*	
	Learning Outcomes : *A learner will be able to* *LO 4.1: Interpret standard z-transforms and its applicability to a given mathematical problem. (P.I.-1.1.1)* *LO 4.2: Apply the properties of z-transform and use it for solving advanced mathematical problems. (P.I.- 1.1.2)* *LO 4.3: To apply knowledge of fundamental engineering concepts in finding z-Transforms. (P.I.- 1.3.1)* *LO 4.4: Identify the correct properties of z-Transform applicable to a given problem. (P.I.-2.1.3).* *LO 4.5: Identify the existing solutions to solve given problems.(P.I.-2.2.3)*	
05.	**Inverse z-Transform**	**5-7**

	Learning Objective/s: *To apply the concept of Inverse z-transform and analyze its methods to solve difference equations in discrete time system.*	
	Contents: Definition of Inverse z-transform, Region of Convergence, Finding Inverse z-transform using Partial fraction, Finding Inverse z-transform using Convolution theorem, Solution of Difference Equations.	
	Self-Learning Topics: *Finding Inverse z-transform using Binomial expansion.*	
	Learning Outcomes: *A learner will be able to* *LO 5.1: To apply inverse z-transforms and its applicability to a given mathematical problem. (P.I.-1.1.1)* *LO 5.2: To apply knowledge of fundamental engineering concepts in finding inverse z-transforms. (P.I.-1.3.1)* *LO 5.3: To identify the various methods such as Partial fraction, Convolution theorem to finding solution of inverse z-transform. (PI-2.2.3)* *LO 5.4: To apply the knowledge of Partial fraction, and Convolution theorem to finding solution of given problems. (PI-2.1.3)*	
06.	**Complex Variables-I**	**6-8**
	Learning Objective/s: *To analyses if a given complex function is analytic or not by applying basic definitions and theorems of Complex Variables.*	
	Contents: Statement of D'Moivre's Theorem, Expansion of sinnθ, cosnθ in terms of sines and cosines of multiples of θ ,Expansion of sinnθ, cosnθ in powers of sinθ, cosθ .Complex Variables, Calculus of Complex Variables: Limit, Continuity Differentiability Analytic Functions: Necessary and sufficient conditions for f(z) to be analytic, Cauchy-Riemann equations: Cartesian coordinate and Polar coordinates.	
	Self-Learning Topics: *Roots of a complex number, Conformal mapping*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: To apply mathematical techniques such as calculus and algebra to solve mathematical problems of complex variables and functions. (P.I-1.1.1)* *LO 6.2: To apply the fundamental concept of complex functions to solve engineering problems. (P.I.-1.3.1)* *LO 6.3: To interpret complex functions using the knowledge of complex variables. (P.I-2.1.2)* *LO 6.4: Identify if given complex function is analytic or not using Cauchy Riemann Equations. (P.I-2.1.2)*	

	LO 6.5: To identify the concept of analyticity by using Cauchy-Riemann equations to solve given problem. (P.I-2.1.3) *LO 6.6: To Identify if the derivatives of a given complex function exist or not by applying the theory of complex variables to a given problem. (P.I-2.1.3)*	
	Course Conclusion Engineering Mathematics provides the problem solving skills necessary for electrical engineering to design, analyse and optimize system and device across a wide range of applications.	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.1.1	Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems
1.1.2	Apply advanced mathematical techniques to model and solve engineering problems
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
2.1.1	Articulate problem statements and identify objectives
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.2.3	Identify existing solution/methods to solve the problem, including forming justified approximations and assumptions.

Course Outcomes : A learner will be able to

1. Analyse the techniques of Laplace and inverse Laplace transform and apply it to determine the solutions of differential equations. *(LO1.1, LO1.2, LO1.3, LO1.4, LO2.1, LO2.2, LO2.3, LO2.4)*
2. Analyse the periodic functions and expand it by using Fourier series to solve complex engineering problems.*(LO3.1, LO3.2, LO3.3, LO3.4, LO3.5)*
3. Apply the concept of Z-transform and Inverse Z-Transform to analyse its methods to solve difference equations.*(LO4.1, LO4.2, LO4.3, LO4.4, LO4.5, LO5.1, LO5.2, LO5.3 LO5.4)*
4. Apply the concept of complex variables to analyse the function is holomorphic or not.*(LO6.1, LO6.2, LO6.3, LO6.4, LO6.5, LO6.6)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
EEPCC301.1	3	2									
EEPCC301.2	3	2									
EEPCC301.3	3	2									
EEPCC301.4	3	2									
Average	3	2									

Text Books :

1. Higher Engineering Mathematics, Dr.B.S.Grewal, Khanna Publication
2. Advanced engineering mathematics, H.K. Das, S. Chand, Publications

Reference Books :

1. Advanced Engineering Mathematics, Erwin Kreyszig, Wiley Eastern Limited,
2. Complex Variables and Applications, Brown and Churchill, McGraw-Hill Education.
3. Higher Engineering Mathematics B.V. Ramana, McGraw Hill Education
4. Laplace transforms, Murray R. Spiegel, Schaum's Outline Series

Other Resources :

1	NPTEL Course: Laplace Transform,IMSc By Prof. .Indrava Roy, Web link- https://nptel.ac.in/courses/111/106/111106139/

IN-SEMESTER ASSESSMENT (75 Marks)

1. Continuous Assessment (45 Marks)

Continuous Internal Evaluation of Theory (20 Marks)

Numerical Assignments: 5 Marks

Class test based on above numerical Assignment: 5 Marks

Team-pair- Solo: 5 Marks

Regularity and attentiveness: 5 Marks

Continuous Internal Evaluation of Tutorial (25 Marks)

Minimum six Tutorials: 20 Marks

Regularity and attentiveness: 5 Marks

Students must be encouraged to write at least 6 class tutorials. At least 6 Class tests will be conducted based on class tutorials on entire syllabus. Each class tests carries 20 Marks. Average will be taken of all class tests.

2. Mid Semester Exam (30 Marks)

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

END SEMESTER EXAMINATION (50 Marks)

End semester examination will be based on the syllabus coverage up to Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying70%- 80% weightage.

Course Type	Course Code	Course Name	Credits
PCC	EEPCC302	CIRCUIT AND SIGNAL ANALYSIS	03+01*

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20+25@	30	50	1.5	2	125

Pre-requisite :

1. BSC101- Engineering Mathematics I
2. BSC204 - Engineering Mathematics II
3. ESC102- Basic Electrical Engineering

Program Outcomes addressed :

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO5: Modern tool usage

Course Objectives:

1. To impart the knowledge of various fundamental electrical theorems for analysis of electrical circuits from application point of view.
2. To inculcate the problem solving and analysis skills in students.
3. To impart knowledge on signals and system.

Module	Details	Hrs
	Course Introduction Overview of course, application of course in Industry/real life problem. This is a foundation course which deals with fundamental knowledge of signals and systems, basic elements of electrical network, analysis of electrical network using fundamental laws. The fundamental concepts of this subject are essential for analyzing the electrical power system/machines/electronic system under various conditions.	**01**
01.	**Network Theorems**	**7-9**
	Learning Objective/s: *To* apply the fundamental theorems in electrical engineering to analyze electrical network with dependent voltage/current sources and validate the results of analysis with software tool.	
	Contents: With DC Dependent Sources: Mesh analysis, Nodal analysis, Superposition theorem, Thevenin's theorems and Norton's theorem and Maximum power transfer theorem; With AC Sources: Magnetic coupling, Thevenin's theorem, Superposition theorem, Norton's theorem and Maximum power transfer theorem. Simulation of electrical network with software tools and verification using theorem	

	Learning Outcomes: *A learner will be able to* *LO1.1 Apply fundamental Kirchhoff laws and theorems in electrical engineering to simplify any complex electrical network with DC dependent sources and AC sources (PI-1.4.1)* *LO1.2 Apply advanced mathematical techniques to model and solve the electrical network. (PI-1.1.2)* *LO1.3 Apply network theorems to identify and determine various circuit parameters such as current and voltage. (PI- 2.1.2).* *LO1.4 Apply network theorems to identify and determine power dissipated across circuit elements, optimum load to be connected for maximum power flow and role of source resistance that applies to a given electrical network. (PI- 2.1.3).* *LO1.5 Identify and use software tool to model/build an electrical network. (PI-5.1.1)* *LO1.6 Simulate the electrical circuit in software and validate the results analytically using network theorems. (PI-5.3.1)*	
02.	**Graph Theory and Network Topology**	**5-7**
	Learning Objective/s: *To develop the problem-solving skills to analyze complex electrical network using graph theory techniques*	
	Contents: Introduction, Graph of network, Tree, Co-tree, Loop incidence matrix, Cut set matrix, Tie set matrix and Loop current matrix, Number of possible trees of a graph, Application of graph theory to circuit analysis. Principle of duality.	
	Self-Learning Topics: *KCL and KVL equilibrium equation representation of electrical network.*	
	Learning Outcomes: *A learner will be able to* *LO2.1 Model the graphical structure of an electrical network with the use of graph theory (PI-1.1.2)* *LO2.2 Identify tree, Co-tree, twig, link of graph using electrical engineering concept of nodes and meshes. (PI-1.4.1)* *LO2.3 Derive the loop incidence matrix, tieset matrix and loop current matrix of the graph. (PI-2.3.1)* *LO2.4 Derive the equilibrium equation from the graph of electrical network. (PI-2.3.1)* *LO2.5 Apply engineering mathematics tools to solve the equilibrium equation for voltage/ current. (PI-2.4.1)*	
03.	**Switching Transients Analysis**	**8-10**
	Learning Objective/s: *To analyze the effect of energy storage elements inductor, capacitor and energy dissipating element resistor in the electrical network under transient and steady state conditions and validate the results of analysis with software tool.*	

	Contents: Transient analysis of DC and AC circuit: Solution of first and second order differential equations for series and parallel R-L, R-C, R-L-C circuits, forced and natural response, time constant, steady state and transient state response. Introduction to transient analysis in ac circuits. Laplace Transforms: Application of Laplace transform to solve RL, RC and RLC electrical network. Simulation of RL, RC & RLC electrical network with software tools for switching transient and steady state.	
	Self-Learning Topics: *Application of Fourier transform in electrical network.*	
	Learning Outcomes: *A learner will be able to* *LO3.1 Reframe the switching conditions in electrical network into initial condition, transient and steady state condition. (PI-2.2.1)* *LO3.2 Derive the equivalent circuit of electrical network for different stages of switching condition by fundamental laws. (PI-2.3.1)* *LO3.3 Apply fundamental laws of KVL and KCL to formulate the differential equation and Laplace mathematical model of the equivalent network. (PI-1.4.1)* *LO3.4 Apply advanced mathematical techniques to solve a first order and second order differential equation of voltage/current of electrical network in time domain. (PI-1.1.2)* *LO3.5 Apply engineering mathematics and computations to solve Laplace equation model of the equivalent network. (PI-2.4.1)* *LO3.6 Combine the initial, transient and steady state response to obtain the total response of the network. (PI-2.3.1)* *LO3.7 Analyze the behaviour of the circuit in terms of voltage, current, time constant for different switching conditions. (PI-2.4.4)* *LO3.8 Identify and use software tool to model/build an electrical network. (PI-5.1.1)* *LO3.9 Demonstrate the electrical circuit in discipline specific software and analyse switching transients in network. (PI-5.2.2)*	
04.	**Two port parameters and network functions**	**6-8**
	Learning Objective/s: *Derive circuit parameters and network functions to analyze the two-port representation of an electrical network, which describe the concise representation of the network's behaviour.*	
	Contents: Circuit parameters: Open circuit and short circuit parameters, reciprocity and symmetry conditions. Network Functions: Network functions for one port and two port networks, driving point and transfer functions of ladder network, general network. Poles and zeros of network functions, time domain behaviour from pole - zero plot.	

	Learning Outcomes: *A learner will be able to* *LO4.1 Apply electrical engineering concepts to derive various parameters associated with two-port networks. (PI-1.4.1)* *LO4.2 Apply fundamental engineering concepts to derive the network functions associated with two-port network. (PI-1.3.1)* *LO4.3 Apply engineering mathematics and computations to solve for the poles and zeros associated with the network functions. (PI-2.4.1)* *LO4.4 Identify location of poles and zero, from the network functions to comment on the stability of the system (PI-2.1.3)*	
05.	**Signals and Systems**	**6-8**
	Learning Objective/s: *To acquire information on fundamental classification and operations on signals and systems in the field of electrical engineering.*	
	Contents: Classification of signals: Continuous time (CT) and Discrete Time (DT) signals, periodic & aperiodic signals, even and odd. Classification of systems: Linear/ Non-Linear, time variant/invariant, causal /anti causal. Basic operations on signals: Folding, scaling and time shifting. Introduction to convolution in signals and system.	
	Self-Learning Topics: *Energy and power signals, stable and unstable system, memory and memoryless system*	
	Learning Outcomes: *A learner will be able to* *LO5.1 Apply mathematical techniques to model the mathematical expression of various standard signals in the time domain (PI-1.1.2)* *LO5.2 Apply fundamental engineering concepts to differentiate periodic and aperiodic signals, even and odd signals, energy and power signals (PI-1.3.1)*	
06.	**Discrete Time Signal and z-transform**	**5-7**
	Learning Objective/s: *To apply Z-Transform technique to convert discrete time signal/system from time domain into Z domain and analyze the stability characteristics with pole zero plot.*	
	Contents: Sampling theorem. Representation of discrete time signals. Z-transform of bilateral signal, Inverse Z-Transform. Stability analysis in Z plane with pole zero plot. Minimum phase, Maximum phase and Mixed phase system. Formation of difference equation, solution of difference equation using Z-transform.	
	Self-Learning Topics: *Definition of ROC, Properties of ROC, Properties of Z-transform*	

	Learning Outcomes: *A learner will be able to* *LO6.1 Use sampling theorem to convert continuous signals into discrete signals (PI-2.1.3)* *LO6.2 Apply electrical engineering concepts to formulate the difference equation representation of signals/system. (PI-1.4.1)* *LO6.3 Apply engineering mathematics to solve difference equations under various initial conditions. (PI-2.4.1)* *LO6.4 Apply mathematical techniques such as calculus to convert discrete time domain signal representation of signals into z domain representation. (PI-1.1.1)*	
	Course Conclusion The course will conclude with a mathematical modeling of an electrical system, analyze it with respect to the transient, steady state and stability behaviour emphasizing the fact that it is a foundation course in Electrical Engineering	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.1.2	Apply advanced mathematical techniques to model and solve electrical engineering problems
1.4.1	Apply electrical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.2.1	Reframe complex problems into interconnected sub problems
2.3.1	Combine scientific principles and electrical engineering concepts to formulate model of a system that is appropriate in terms of applicability and required accuracy.
2.4.1	Apply engineering mathematics and computations to solve mathematical models.
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis
5.1.1	Identify modern engineering tools such as computer aided drafting, modelling and analysis; techniques and resources for engineering activities
5.2.2	Demonstrate proficiency in using discipline specific tools
5.3.1	Discuss limitations and validate tools, techniques and resources

Course Outcomes:

1. Apply the knowledge of fundamental network theorems, graph theory, two port network to solve a given electrical circuit. (*LO1.1, LO1.2, LO1.3, LO1.4, LO2.1, LO2.2, LO2.3, LO2.4, LO2.5)*
2. Formulate a mathematical model of an electrical network through differential equations and Laplace transforms to analyse the effect of switching transients.(*LO3.1, LO3.2, LO3.3, LO3.4, LO3.5, LO3.6, LO3.7*)
3. Formulate the transfer function and network parameters to analyse two port model of an electrical network.(*LO4.1, LO4.2, LO4.3, LO4.4*)
4. Differentiate types of signals/systems, apply Z- transform technique to convert discrete time signals to z domain and analyse the stability.(*LO5.1, LO5.2, LO6.1, LO6.2, LO6.3, LO6.4*)
5. Use IT tools to model and simulate electrical network.(*LO1.5, LO1.6, LO3.8, LO3.9, LO1.2, LO1.3)*

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
EEPCC302.1	3	3									
EEPCC302.2	3	3									
EEPCC302.3	3	3									
EEPCC302.4	3	3									
EEPCC302.5	3	3			3						
Average	3	3			3						

Text Books :

1. Engineering Circuit Analysis, W H Hayt, S M Durbin, J E Kemmerly, 2013, Tata McGraw-Hill Education
2. Network Analysis, M. E. Van Valkenburg, 3rd Edition, PHI Learning
3. Digital Signal Processing, Salivahan S, Edition, Year, Publisher
4. Signals & Systems, Authors A. Nagoor Kani, 2010, Publisher McGraw-Hill Education (India) Pvt Limited
5. Networks and System, D. Roy Choudhury, 2nd Edition, New Age International.

Reference Books :

1. Network Analysis and Synthesis, F. F. Kuo, John Wiley and sons
2. Network Analysis and Synthesis, B. Somanathan Nair, Elsevier Publications
3. Digital Signal Processing, 2001, Mitra S.K, TMH Publication
4. Digital Signal Processing, Proakis & Manolakis, 1995, PHI Publication

Other Resources :

1. NPTEL/ Swayam Course: Basic Electric Circuits By Prof. Ankush Sharma, IIT Kanpur :- Web link - https://swayam.gov.in/nd1_noc19_ee36/preview
2. NPTEL Course: Basic Electrical Circuits by Prof. Nagendra Krishnapura, IIT Madras:- Web link - https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ee64/

IN-SEMESTER ASSESSMENT (75 Marks)

1. Continuous Assessment (20+25@ Marks)

Continuous Internal Assessment of Theory (20 marks)

Class test 1: 5 Marks
Class test: 2 :5 Marks
Open notes test: 5 Marks
Regularity and attentiveness: 5 Marks

Continuous Internal Assessment of Tutorial (25 marks)

Minimum ten Tutorials: 20 Marks
Each tutorial consists of 5 questions which will be shared in advance. Doubts will be cleared during the tutorial session. Solution of the selected questions is to be submitted at the end of each session.
Regularity and attentiveness: 5 Marks

2. Mid Semester Exam (30 Marks)

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

END SEMESTER EXAMINATION (50 Marks)

End semester examination 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 Type	Course Code	Course Name	Credits
PCC	EEPCC303	ELEMENTS OF POWER SYSTEM	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. ESC102- Basic Electrical Engineering

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO6: The Engineer and The World
4. PO 8: Individual and team work
5. PO 9: Communication

Course Objectives:

1. To impart the knowledge of electrical system, various energy sources towards its sustainability
2. To familiarize with transmission line parameters and formulate them for different power system configurations
3. To introduce the representation of power system network and model it to analyse its performance.

Module	Details	Hrs.
	Course Introduction Power System is the backbone of modern infrastructure. It is responsible for generation, transmission and distribution of electrical energy to residence, commercial and industrial establishments and even to agriculture. Studying this subject will give better insights how this critical infrastructure operates. As the demand for electricity continues to rise globally, ensuring energy security becomes increasingly important. The knowledge of power systems allows students to understand the challenges associated with meeting this demand and the strategies for ensuring a sustainability.	**01**
01.	**Introduction:**	**6-8**
	Learning Objective/s: *To gain the knowledge of both conventional and alternative energy sources utilized in power production, and to compare conventional methods with renewable ones in pursuit of sustainability, as well as to familiarize oneself with the economic terms associated with power system operations.*	

	Contents: Single line diagram of typical AC supply system, Conventional energy sources; Thermal power plant (block diagram, Rankine cycle), Hydro power plant (Schematic and types of HPP, Pumped storage power plant, Gas Turbine power plant (basic principle, types of GTP), Nuclear (Nuclear reactor, function of each component), Oil (Block diagram). Review of Non-Conventional Energy Sources: Solar PV, Wind, Fuel Cell, and Geothermal energy. Co-relation of CO_2 emission with reference to conventional power plant Economics of Power Generation: Connected load, maximum demand, demand factor, Average load, load factor, diversity factor, Load Curves and Selection of Generating Units	
	Self-Learning Topics: *Societal impact of renewable energy sources.*	
	Learning Outcomes: *A learner will be able to* *LO1.1 To apply the knowledge of fundamental engineering to understand basic operation of various power plants. (P.I.-1.3.1)* *LO1.2 To apply the electrical engineering concepts to understand general structure of power system network and economics of power generation. (P.I.-1.4.1)* *LO1.3 To understand the relationship between fossil fuel consumption by conventional power plants and CO2 emissions. (P.I.-6.3.2)* *LO1.4 Demonstrate the societal impact of renewable energy sources towards energy sustainability by presenting it as a group work. (P.I.- 8.3.1, 9.2.2)*	
02.	**Single Phase Transformer and Polyphase Circuits**	**8-10**
	Learning Objective/s: *To gain the knowledge of single-phase transformers and evaluate their performance through equivalent circuit parameters, and to grasp the concepts of three-phase networks and compute the three-phase power across various network configurations.*	
	Contents: Working principle of single-phase transformer, EMF equation of a transformer, Transformer losses, Actual (practical) and ideal transformer, Phasor diagram (considering winding resistance and magnetic leakage), Equivalent circuit, Open-circuit test (no-load test), short circuit (SC) test, efficiency. Generation of Three-Phase Voltages, voltage & current relationships in Star and Delta Connections, three phase power measurement.	
	Self-Learning Topics: *Condition for maximum efficiency and All day efficiency*	
	Learning Outcomes: *A learner will be able to* *LO2.1 To apply fundamental engineering concepts to understand the working principle of single phase transformer and transformer losses. (P.I.-1.3.1)* *LO2.2 To apply the electrical engineering concepts to derive the EMF equation of transformer.(P.I.-1.4.1)* *LO2.3 To identify the test to derive the equivalent circuit parameters of the transformer, and develop the equivalent circuit of the transformer.(P.I.-2.1.2)*	

	LO2.4 To identify phasor relationship for star and delta connected three phase network and calculate the power in three phase circuits.(P.I.-2.1.3)	
03.	**Three Phase Transmission/Distribution Line and Its Components**	**6-8**
	Learning Objective/s: *To acquire the knowledge of different types transmission system and different types of overhead line insulator and apply non-uniform voltage distribution concept to analyze performance of insulator string*	
	Contents: Three Phase transmission line (Symmetrical and Unsymmetrical spacing), Single Circuit and Double Circuit transmission line, Representation of three phase distribution line. Concept of Composite conductor, bundle conductor and their application. Types of overhead line insulator, potential distribution across insulator string, string efficiency, methods for improving string efficiency.	
	Learning Outcomes: *A learner will be able to* *LO3.1 To apply fundamental engineering concepts to identify different types of conductor and system and specify their role in transmission and distribution network. (P.I.-1.3.1)* *LO 3.2 To apply electrical engineering concepts to identify different types of overhead line insulators and their applications in power system network. (P.I.-1.4.1)* *LO3.3 To identify the knowledge of potential distribution across the insulator string to derive the expression for string efficiency. (P.I.-2.1.3)* *LO3.4 To identify among the different methods to apply for the string efficiency improvement. (P.I.-2.2.3)*	
04.	**Transmission / Distribution Line Parameters**	**8-10**
	Learning Objective/s: *To acquire the skill, to identify the line parameters and derive expressions for transmission line parameters for different configurations of power system network*	
	Contents: Definition of inductance, internal and external flux linkage of single conductor, 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 bundle conductor lines, Capacitance of transmission line, capacitance of single phase line, capacitance of three phase line with symmetrical and unsymmetrical spacing.	

	Self-Learning Topics: *Resistance of transmission line, skin effect, proximity effect* ***Learning Outcomes:*** *A learner will be able to* *LO4.1 To apply the fundamental engineering concepts to derive magnetic flux linkage with the conductor and electrostatic potential on the charged conductor. (P.I.-1.3.1)* *LO4.2 To apply the knowledge electrical engineering to derive the expression of inductance and capacitance for different system configurations. (P.I.-1.4.1)* *LO4.3 To identify the knowledge of transposition of conductors in three phase unsymmetrical spacing transmission line network to derive inductance and capacitance. (P.I.-2.1.3)* *LO4.4 To identify and apply the system of GMR and GMD, to find the inductance of multi-conductor configurations of a transmission line. (P.I.-2.1.2)*	
05.	**Representation of Power System Components**	**3-5**
	Learning Objective/s: *To gain the knowledge to calculate the PU values of each power system components and apply it to get the simplified per unit impedance diagram of complex three phase network*	
	Contents: Single phase solution of balanced three phase networks, one-line diagram and impedance or reactance diagram, Per Unit (PU) system, advantage of PU system, PU impedance diagram	
	Learning Outcomes: *A learner will be able to* *LO5.1 To apply the concept of fundamental engineering to convert complex three phase network into simple single line diagram. (P.I.-1.3.1)* *LO 5.2To apply the concept of electrical engineering to derive the per unit equivalent circuit of a transformer. (P.I.-1.4.1)* *LO5.3 To identify the parameters of complex three phase network to calculate its equivalent per unit value on the base values. (P.I.-2.1.2)* *LO5.4 To reframe complex three phase network into its equivalent per unit impedance diagram. (P.I.-2.2.1)*	
06.	**Performance of Transmission Line**	**6-8**
	Learning Objective/s: *To acquire the knowledge of modelling of transmission line concept to determine performance parameters of transmission line*	
	Contents: Classification and modelling of short, medium and long lines, regulation and efficiency of short and medium transmission lines, evaluation and estimation of generalized circuit constant (ABCD) for short and medium lines.	
	Self-Learning Topics: *Ferranti effect*	

	Learning Outcomes: *A learner will be able to* *LO6.1 To apply the concept of electromagnetic wave propagation over a transmission line to model it into as short, medium and long transmission line. (P.I.-2.3.1)* *LO6.2 To apply the knowledge of electrical engineering to solve short, medium and long transmission line models. (P.I.-2.4.1)* *LO6.3 To identify the phasor relationship between the equivalent electrical parameters of short, medium transmission line to develop its phasor diagram. (P.I.-2.1.3)*	
	Course Conclusion The conclusion of an Elements of Power System course would typically emphasize the foundational understanding gained in various aspects of power systems, including generation, transmission, and distribution. Additionally, it could stress the importance of sustainable and efficient energy generation to meet growing demands while minimizing environmental impact. It also could stress the significance of applying this knowledge to solve practical problems and design efficient and reliable power systems. Ultimately, the conclusion might encourage students to continue exploring advanced topics in power engineering and to contribute to the development of sustainable and resilient energy infrastructure.	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply Electrical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.1.3	Identify the mathematical, electrical engineering and other relevant knowledge that applies to a given problem
2.2.1	Reframe complex problems into interconnected sub problems
2.2.3	Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions
2.3.1	Combine scientific principles and engineering concepts to formulate model/s (Mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.
2.4.1	Apply engineering mathematics and computations to solve mathematical models.
6.3.2	Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability.
8.3.1	Present results as a team, with smooth integration of contributions from all individual efforts.
9.2.2	Deliver effective oral presentations to technical and non-technical audiences.

Course Outcomes :

1. To apply knowledge of electrical engineering to summarize the general structure of power system network and to calculate different terms related to economics of power system. *(LO1.1, LO1.2, LO3.1, LO3.2)*
2. To compare the societal impact of renewable sources with conventional energy sources towards sustainability and present it as group work. *(LO 1.3, LO 1.4)*
3. To analyze the performance of transformer and calculate the three phase power measurement. *(LO2.1, LO2.2, LO2.3, LO2.4)*

4. To analyze string efficiency of insulator string, identify different transmission line parameter and derive the expression for those parameters *(LO3.3, LO3.4, LO4.1, LO4.2, LO4.3, LO4.4)*
5. To apply per unit system representation of complex three phase network and model it as equivalent per unit impedance diagram. *(LO5.1, LO5.2, LO5.3, LO5.4)*
6. To determine the performance parameters of transmission line using modelling techniques. *(LO6.1, LO6.2, LO6.3)*

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
EEPCC303.1	3										
EEPCC303.2						3		2	2		
EEPCC303.3	3	3									
EEPCC303.4	3	3									
EEPCC303.5	3	3									
EEPCC303.6		3									
Average	**3**	**3**				**3**		**2**	**2**		

Text Books :

1. "Power System Analysis", Grainger, J. J., Stevenson, W. D. (2016), McGraw-Hill.
2. "Modern Power System Analysis", J. Nagrath, D. P. Kothari, 3rd Edition, 2003, Tata McGraw Hill Publishing Co. Ltd.
3. "Power System Analysis", Saadat Hadi, 2010, TMH Publication.
4. "Electric Machinery", Bimbhra P. S., 2003, Khanna Publisher
5. "Power Plant Engineering", Fredrick T Morse, East-West Press Pvt Ltd

Reference Books:

1. "Elements of Power System Analysis", W. D. Stevenson, 4 Edition, TMH Publication
2. "Electrical Power Systems", Wadhwa C. L., Sixth Edition, New Age International
3. "Electrical Machines", Nagrath and Kothari, Fifth Edition, TMH Publication

Other Resources:

1. NPTEL Course: Power System Engineering By Prof. Debapriya Das, Department of Electrical Engineering, IIT Kharagpur :-Web link- https://nptel.ac.in/courses/108105104/
2. NPTEL Course: Power System Analysis, By Prof. A.K. Sinha, Department of Electrical Engineering, IIT Kharagpur :-Web link- https://nptel.ac.in/courses/108105067/

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

Suggested breakup of distribution

Numerical Assignment/s (min. 20 problems) covering the entire syllabus: 05 Marks
Class test based on above numerical assignment: 05 Marks
Seminar on societal impact of renewable sources: 05 Marks
Regularity and active participation in class: 05 Marks

2. Mid Semester Exam (30 Marks)

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

END SEMESTER EXAMINATION (50 MARKS)

End semester examination will be based on 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 Type	Course Code	Course Name	Credits
PCC	EEPCC304	RENEWABLE SOURCES AND ENERGY STORAGE	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. EEPCC- Basic Electrical Engineering

Program Outcomes addressed:

1. PO 1: Engineering Knowledge:
2. PO 2: Problem analysis
3. PO 3: Design/Development of Solutions
4. PO 6: The Engineer and The World
5. PO 11: Life-Long Learning

Course Objectives:

1. To review Conventional and Non-conventional energy sources.
2. To give the students basic knowledge of solar and wind energy system
3. To give the students basic knowledge about other renewable energy sources.
4. To explore the various energy storage technologies and their major applications
5. To increase awareness of ES suitability and capacity calculation for given application

Module	Details	Hrs
	Course Introduction In our rapidly evolving world, the quest for sustainable energy solutions has become more critical. Renewable energy sources are available in abundance to fuel our planet's future. However, unlocking the full potential of renewable energy requires overcoming challenges such as intermittency and variability. This is where energy storage technologies step in, providing the means to capture and store renewable energy. Together, renewable energy and energy storage is a path towards a greener, more resilient energy future.	**01**
01.	**Global & Indian Energy Sources: Production, Reserves, & Alternatives**	**2-4**
	Learning Objective/s: *To compare India's energy production and reserves with global trends, highlighting regional variations, energy security concerns, and implications for national energy policies and strategies.*	

	Contents: Worlds and India's production and reserves of commercial energy sources, energy alternatives, review of conventional and non-conventional energy sources. Statistic of net potential and current generation status of different energy alternatives	
	Self-Learning Topics: *Overview of Global and Indian Energy Landscape: Understand the current energy consumption patterns, sources, and trends both globally and within India.* *Commercial Energy Sources: Study conventional energy sources such as coal, oil, natural gas, and nuclear energy,* ***Learning Outcomes:*** *A learner will be able to* *LO1.1 State the statistical potential and current generation status of different energy alternatives concerning sustainability goals. (PI 1.1.1, PI 11.2.1)* *LO1.2 Identify various conventional and non-conventional energy sources used for power generation. (PI 1.2.1)* *LO1.3 Compare and contrast the availability and utilization of commercial and non-commercial energy sources in India and the world. (PI 2.2.4)* *LO1.4 Identify the role of energy alternatives in addressing energy security and sustainability. (PI 2.4.4, PI 6.3.2)*	
02.	**Solar & Wind Energy Technology**	**7-9**
	Learning Objective/s: *To identify the process of power generation through solar thermal, solar photovoltaic (PV), and wind energy system.*	
	Contents: Solar Thermal applications -Review of solar thermal applications, solar thermal conversion devices and storage applications. Solar Photovoltaic- Solar cell, Solar PV modules, MPPT algorithms, types of PV systems: standalone, grid connected systems; BOS of PV system, Battery charge controllers, Power Conditioning Unit, Solar PV Micro-inverters & Solar Plant design Wind Energy Technology: Review of wind energy system and its components, types of wind turbines, characteristics, Power generation and control in wind energy systems, MPPT algorithm, performance calculations of wind energy systems.	
	Learning Outcomes: *A learner will be able to* *LO2.1 Identify the fundamental principles, technologies and processes of power generation through solar and wind energy systems. (PI 1.2.1)* *LO2.2 Apply concept of energy conversion in solar and wind energy technology to develop efficient renewable energy systems. (PI 1.4.1)* *LO2.3 Investigate Maximum Power Point Tracking (MPPT) algorithms employed in solar photovoltaic and wind turbines to maximize power output under varying wind speeds and directions. (PI 2.2.3, PI 11.2.1)* *LO2.4 Design methodology of standalone/ grid connected PV systems adhering to standards and regulations for public safety. (PI 3.1.6, PI 6.2.1)*	
03.	**Other Non-Conventional Energy Sources: Features and Applications**	**5-7**
	Learning Objective/s: *To identify the process of power generation of other non-conventional resources along with its features and application.*	

	Contents: Review of other nonconventional sources, their features and applications; Biomass, Tidal, Ocean Thermal Electric Conversion, geothermal, and Micro-hydro.	
	Learning Outcomes: *A learner will be able to* *LO3.1 Identify the process of power generation through biomass, tidal, ocean thermal electric conversion, geothermal, and micro-hydro system. (PI 1.3.1)* *LO3.2 Identify emerging technologies and innovations in energy generation biomass, tidal, ocean thermal electric conversion, geothermal, and micro-hydro system (PI 1.4.1, PI 11.1.1)*	
04.	**Energy Storage Systems**	**6-8**
	Learning Objective/s: *To identify the significance of energy storage for future sustainability and investigate its potential to alter the energy sector.*	
	Contents: Storage Needs, Variations in Energy Demand, Interruptions in Energy Supply, Demand for Portable Energy, Environmental and sustainability issues, Necessity of energy storage, different types of energy storage.	
	Self-Learning Topics: *Working principle of different energy storage systems* ***Learning Outcomes:*** *A learner will be able to* *LO4.1 Identify the processes, principles, technologies, and applications of energy storage systems. (PI 1.3.1, PI 11.2.1)* *LO4.2 Apply energy conversion and storage concepts to evaluate the effectiveness and reliability of energy storage system. (PI 1.4.1)* *LO4.3 Compare different types of energy storage devices and identify the factors influencing fluctuations in energy demand to mitigate environmental impacts and promote sustainable energy practices. (PI 2.2.4, PI 6.3.2)*	
05.	**Design, Sizing and Applications of Energy Storage**	**7-9**
	Learning Objective/s: *To analyze design considerations for sizing energy storage systems across diverse applications*	
	Contents: Design considerations for sizing of different types of energy storage systems for various applications, case studies, Battery sizing for stand-alone applications, small scale application- Portable storage systems. E-mobility storage applications- Electric vehicle: V2X, G2V and V2G modes of operation. Hybrid Energy storage systems: configurations and applications, Charging methodologies.	
	Self-Learning Topics: *State of the art technology in energy storage*	

	Learning Outcomes: *A learner will be able to* *LO5.1 Identify storage applications in e-mobility, including electric vehicles (EVs), and Vehicle-to-Everything (V2X) paradigm along with their implications for energy management and grid integration. (PI 2.3.2, PI 11.2.1)* *LO5.2 Determine specific requirements and constraints for sizing energy storage systems across diverse applications, integrating considerations such as power demand, energy usage patterns, and environmental conditions. (PI 3.1.6, PI 6.3.1)*	
06.	**Economic and Policy Considerations**	**10-12**
	Learning Objective/s: *To identify energy conversion calculations, energy auditing principles, and methods to improve energy efficiency.*	
	Contents: Calculations related to energy conversion and energy auditing, and outline their underlying principles, outline the economic and environmental benefits of energy efficiency, current methods employed to improve energy efficiency in all areas of the energy supply sector, principles of distributed generation systems in relationship efficiency and renewable energy systems.	
	Self-Learning Topics: *Standards related to energy audit ISO 50002:2014* ***Learning Outcomes:*** *A learner will be able to* *LO6.1 Identify the key concepts of energy conversion and energy auditing, including their fundamental principles and significance. (PI 1.3.1)* *LO6.2 Identify the economic and environmental benefits of energy efficiency measures. (PI 6.3.2)* *LO6.3 Identify methods employed to improve energy efficiency across all areas of the energy supply sectors. (PI 1.4.1, PI 11.2.1)*	
	Course Conclusion In conclusion, renewable energy and energy storage stand at the forefront of the sustainable energy revolution. By harnessing the power of renewable resources and leveraging innovative energy storage technologies, we have the potential to transition towards a cleaner, more resilient energy future. However, realizing this vision requires collaborative efforts from policymakers, industry stakeholders, and the broader community to invest in research, development, and widespread adoption of renewable energy and energy storage solutions.	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.1.1	Apply statistical analysis to assess renewable energy systems.
1.2.1	Apply advanced mathematical techniques to model and solve problems in renewable energy systems.
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply Electrical engineering concepts to solve engineering problems.

2.2.3 Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions

2.2.4 Compare and contrast alternative solution processes to select the best process.

2.3.1 Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.

2.3.2 Identify assumptions (mathematical and physical) necessary to allow modelling of a system at the level of accuracy required.

3.1.6 Determine design objectives, functional requirements and arrive at specifications.

6.2.1 Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public

6.3.1 Identify risks/impacts in the life cycle of an engineering product or activity

6.3.2 Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability

11.2.1 Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current.

Course Outcomes:

1. Identify the net potential and current status of various energy sources to understand their role in meeting future sustainable energy needs. *(LO1.1, LO1.2, LO1.3, LO1.4)*
2. Identify the fundamental principles, technologies and processes of collection, storage and utilization of solar thermal, solar PV and wind energy power systems. *(LO2.1, LO2.2, LO2.3)*
3. Illustrate different features, types and current state-of-the-art for biomass, tidal, ocean thermal electric conversion, geothermal, and micro-hydro in India. *(LO3.1, LO3.2)*
4. Classify different energy storage systems and its role in mitigating the intermittency of renewable energy sources for grid stability and standalone applications. *(LO4.1, LO4.2, LO4.3)*
5. Design a standalone/ grid-connected renewable energy system with/ without energy storage solution. *(LO2.4, LO5.1, LO5.2)*
6. Differentiate between efficient and inefficient energy usage patterns and recommend specific conservation actions. *(LO6.1, LO6.2, LO6.3)*

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	PO11
EEPCC304.1	3	3				3					3
EEPCC304.2	3	2	2			3					3
EEPCC304.3	3										3
EEPCC304.4	3	2				3					3
EEPCC304.5	3	2	3			3					3
EEPCC304.6	3					3					3
Average	**3**	**2.3**	**2.5**			**3**					**3**

Textbooks:

1. Weber, Edward P. (Summer 2008). "Review of Alternative Energy: Political, Economic, and Social Feasibility". Washington State Magazine. Retrieved 2008-11-11.
2. Robert Huggins, Fundamentals, Materials and Applications Second Edition, Springer, 2016.
3. Dincer I., and Rosen M. A. (2011); Thermal Energy Storage: Systems and Applications, Wiley.
4. Ahmed Faheem Zobaa, Energy storage – Technologies and Applications, InTech Publication 2013.
5. K.T. Chau, Energy Systems for Electric and Hybrid Vehicles, IET, UK, 2016.

Reference Books:

1. Green M.A "Solar Cells": Operating Principles, technology and System Applications, Prentice Hall Inc, Englewood Cliffs N.J, U.S.A, 1982.
2. Chetan Singh Solanki, Solar Photo Voltaics , PHI Learning Pvt Ltd., New Delhi,2009 Hashem Nehrir and Caisheng Wang, Modeling and control of fuel cells: Distributed Generation Applications, IEEE Press, 2009.
3. S. Chakraborty, M. G. Simões and W. E. Kramer, Power Electronics for Renewable and Distributed Energy System, Springer 2013.
4. N. Femia, G. Petrone, G. Spagnuolo and M. Vitelli, Power Electronics and Control Techniques for Maximum Energy Harvesting in Photovoltaic Systems, CRC Press, 2013.
5. J.F. Manwell and J.G. McGowan, Wind Energy Explained, theory design and applications, Wiley publication
6. Leo J.M.J. Blomen and Michael N. Mugerwa, "Fuel Cell System", New York, Plenum Press, 1993.
7. Felix A. Farret and M. Godoy Simoes, Integration of Alternative Sources of Energy, 2006, John Wiley and Sons
8. M. Ehsani, Y. Gao, and Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, Second Edition, CRC Press.

Other Resources:

1. NPTEL Course: Renewable Energy Engineering by Prof. Vaibhav Vasant Goud, Prof. R. Anandalakshmi, IIT Guwahati: -Web link- https://nptel.ac.in/courses/103103206
2. NPTEL Course: Non-Conventional Energy Systems by Prof. L. Umanand, IISc-Bangalore: -Web link- https://nptel.ac.in/courses/108108078

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)
   Suggested breakup of distribution
   Numerical Assignment/s (min 20 problems): 05 Marks
   Class test based on above numerical assignment: 05 Marks
   Think-pair-share worksheets: 05 marks
   Regularity & Active Participation: 5 marks

2. Mid Semester Exam (30 Marks)
   Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on 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.

Course Type	Course Code	Course Name	Credits
LBC	EELBC301	ELECTRONICS LABORATORY	01

Examination Scheme		
Continuous Assessment	**Practical /Oral**	**Total**
25	25	50

Pre-requisite :

1. ESL206- Basic Electronics Engineering Laboratory
2. ECMDM3013 – Electronic Components and Circuits

Program Outcomes addressed :

1. PO2: Problem analysis
2. PO3: Design/Development of Solutions
3. PO4: Conduct investigations of complex problems
4. PO8: Individual and team work

Course Objectives :

1. To develop skill to select appropriate engineering tools to design and implement electronic circuits.
2. To develop skill to use/represent the collected data to analyse the performance of electronic circuits.
3. To demonstrate effective individual and team based performance in implementing electronic circuits.

Module	Details	Hrs
01.	***Learning Objective/s:*** *Use various hardware tools to implement the BJT/MOSFET amplifier and analyze its performance as a team.*	**08**
	Theme for designing multiple experiments: 1. To conduct experiments on BJT/MOSFET amplifier to find gain and bandwidth by plotting the frequency response.	
	Self-Learning Topics: *Watch videos on the applications of BJT/MOSFET amplifiers.*	
	Learning Outcomes: *A learner will be able to* *LO1.1 Identify various parameters required for analyzing the performance of voltage amplifiers(P.I.-2.1.2)* *LO1.2 Use systematic techniques to implement the system and evaluate its operation as a team. (P.I.- 2.2.2, 8.2.1,.8.3.1)* *LO1.3 Use a systematic approach to gather data using the hardware tools to analyze the system's performance across various parametric variations. (P.I.- 4.3.1)* *LO1.4 Compare practical results with the theoretical one (P.I.-4.1.4)*	

02.	***Learning Objective/s:*** *To investigate the functioning of voltage regulator and 555 timer ICs and analyze its performance as a team.* **Theme for designing multiple experiments:** 2. Implement a fixed/adjustable voltage regulator circuit to get a fixed/adjustable DC with suitable AC-DC conversion stage. 3. Implement Astable /Monostable multivibrator circuits using 555 timer IC.	**08**
	Self-Learning Topics: *Watch videos on the applications of voltage regulator and 555 timer ICs.*	
	Learning Outcomes: *A learner will be able to* *LO2.1 Implement the circuit as a team and use systematic procedures to gather the data using hardware tools for analyzing the performance of voltage regulator and timer ICs. (P.I.- 4.3.1, 8.2.1,.8.3.1)* *LO2.2 Identify various parameters required for analyzing the performance of regulator and timer ICs. (P.I.-2.1.2)* *LO2.3 Use the collected data to produce valid results. (P.I.- 2.2.2)* *LO2.4 Compare practical results with the theoretical one (P.I.-4.1.4)*	
03.	***Learning Objective/s:*** *To investigate the functioning of op-amp 741IC and analyze its performance for linear and non-linear applications as a team.*	**08**
	Theme for designing multiple experiments: 4. Implement inverting/non-inverting amplifier, adder/ Subtractor, and Schmitt trigger/comparator circuits using op-amp.	
	Self-Learning Topics: *Watch videos on the applications of op-amp circuits.*	
	Learning Outcomes: *A learner will be able to* *LO3.1 Implement the circuit as a team and use systematic procedures to gather the data using hardware tools for analyzing the applications of operational amplifiers. (P.I.- 4.3.1, 8.2.1,.8.3.1)* *LO3.2 Identify various parameters required for analyzing the performance of op-amps (P.I.- 2.1.2)* *LO3.3 Use the collected data to evaluate its performance. (P.I.- 2.2.2)* *LO3.4 Compare the practical results with the theoretical results ((P.I.- 4.1.4)*	
04.	***Learning Objective/s:*** *Use appropriate hardware tools to design and investigate the performance of combinational and sequential digital circuits as a team.*	**06**
	Theme for designing multiple experiments: 5. Design and implement Adder/ Subtractor /decoder/ demultiplexer /mod N counters using gates and flip-flops.	
	Self-Learning Topics: *Watch videos on the applications of combinational circuits and sequential digital circuits.* ***Learning Outcomes:*** *A learner will be able to* *LO4.1 Implement the digital circuit as a team and use systematic procedures to gather the data using hardware tools for analyzing the performance. (P.I.-4.3.1, 8.2.1,.8.3.1)* *LO4.2 Identify various parameters required for analyzing the performance of op-amps. (P.I.- 2.1.2)* *LO4.3 Use the collected data to evaluate its performance. (P.I.- 2.2.2)*	

	LO4.4 Apply the K-map tool to simplify to design combinational and sequential circuit for various applications. (P.I.-3.2.1) *LO4.5 Develop the combinational circuit using the simplified result (P.I.-3.2.2)* *LO4.6 Compare the practical results with the theoretical results ((P.I.- 4.1.4)*	
	Minimum 02 experiments from each module, and total at least 10 experiments	**30**

Performance Indicators:

P.I. No.	P.I. Statement
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.2.2	Identify, assemble and evaluate information and resources.
4.1.4	Establish a relationship between measured data and underlying physical principles.
4.3.1	Use appropriate procedures, tools and techniques to conduct experiments and collect data.
3.2.1	Apply formal idea generation tools to develop multiple engineering design solutions.
3.2.2	Build models/prototypes to develop a diverse set of design solutions.
8.2.1	Demonstrate effective communication, problem solving, conflict resolution and leadership skills
8.3.1	Present results as a team, with smooth integration of contributions from all individual efforts

Course Outcomes :

1. Use appropriate hardware tools and techniques to conduct experiments and collect data to analyse the performance of analog and digital circuits. *(LO1.1, LO1.3, LO1.4, LO2.1, LO2.2, LO2.3, LO2.4, LO3.1,LO3.2, LO3.3, LO3.4,LO4.1,LO4.2,LO4.3,LO4.6)*
2. Apply the knowledge of logic gates and flip-flops to design and develop combinational and sequential logic circuits.*(LO4.4, LO4.5)*
3. To gain skill in demonstrating the performance as a team with individual contribution from all team members. *(LO1.2, LO2.1, LO3.1, LO4.1)*

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
EELBC301.1		3		3				3			
EELBC301.2		3	3	3				3			
EELBC301.3		3		3				3			
Average		3	3	3				3			

Text Books :

1. Electronic Devices and Circuit Theory, Robert Boylestad and Louis Nashelsky, 10th Edition, 2013, Pearson India Ltd.
2. Op-Amps and Linear Integrated Circuits, Ramakant A. Gayakwad, 4th Edition, 2015, Pearson India Ltd.
3. Integrated Electronics, Millman and Halkias, 2nd Edition, 2007, McGraw Hill
4. Modern Digital Electronics, R.P.Jain, 4th Edition, 2009, McGraw Hill
5. Digital principal and Applications, Malvino & Leach, 8th Edition, 2014, McGraw Hill Education.

Reference Books :

1. Electronic Devices and Circuits, David A Bell, 5th Edition, 2017, Oxford University Press
2. Electronic Devices, Thomas L.Floyd, 10th Edition, 2021, Pearson Education

3. Electronic Devices and Circuits, S. Salivahanan and N. Suresh Kumar, 4th Edition, 2017, McGraw Hill Education.
4. Introduction to Logic Design, Alan b. Marcovitz, 3rd Edition, 2009, McGraw Hill Education.

Other Resources :

1. NPTEL Course: Analog Electronic Circuits By Prof. Shanti Pavan , Department of Electrical Engineering, IIT Madras :-Web link- https://archive.nptel.ac.in/courses/108/106/108106188/

2. NPTEL Course: Digital Electronic Circuits By Prof. Goutam Saha, Department of Electrical Engineering, IIT Kharagpur. Web link- https://archive.nptel.ac.in/courses/108/105/108105132/

CONTINUOUS ASSESSMENT (25 Marks)

Suggested breakup of distribution

- Lab Experiments: 10 Marks
- Internal Assessment (10 marks)
  Evaluating proficiency in the field by assessing the candidate's capability to execute connections or circuits, conduct experiments, accurately record test data, and derive meaningful conclusions through data analysis during regular laboratory session.
- Observation & Active Participation: 5 marks

END SEMESTER EXAMINATION (Practical/Oral Exam) (25 Marks)

Practical and Oral Examination:

Two examiners, one Internal and one External will do the evaluation.

- Students will be randomly allocated an experiment from the list of laboratory exercises and will be asked to draw circuit diagram, observation table with relevant formula. It will be checked by the examiners and evaluated out of 05 Marks.
- Then the student will be allowed to start with the performance of the experiment.
- Students will be given 1 hour to complete the circuit connections and take readings. The connections and output are verified by the examiners. The weightage is 05 Marks
- Students will do sample calculations, draw relevant graphs and write conclusion of the experiment. It will be checked by the examiners and evaluated out of 05 Marks.
- Students will then be appearing for Oral in front of both Internal and External examiners. The weightage of Oral will be of 10 Marks.

Course Type	Course Code	Course Name	Credits
LBC	EELBC302	ELECTRICAL SYSTEM LABORATORY	01

Examination Scheme		
Continuous Assessment	**Practical /Oral**	**Total**
25	25	50

Pre-requisite:

1. ESC102-Basic Electrical Engineering

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO4: Conduct investigations of complex problems
4. PO5: Modern tool usage
5. PO8: Individual and team work

Course Objectives: To impart knowledge on

1. The choice of suitable tests to obtain performance curves of transformers, DC machines, and transmission lines.
2. Conduction of experiments on transformers, DC machines, and transmission lines to draw valid conclusions about the performance curves.
3. Derivation of steady state mathematical models of transformers and transmission lines based on the test data, and forecasting the performance curves.
4. Selection and usage of relevant hardware and software tools to analyse simple power system networks effectively.

Module	Details	Hrs.
	Course Introduction This is a laboratory course covering the fundamentals of single phase transformers, DC motors, and transmission lines which will play a vital role in the education of electrical engineering students by providing hands-on experience, reinforcing theoretical concepts, developing practical skills, and fostering teamwork with an introduction to safety awareness when working with high voltage equipment.	
01.	**Single Phase Transformer**	**10**
	Learning Objective: *To develop skill in obtaining and analyzing the performance curves of a given single-phase transformer by conducting suitable tests.*	
	Content: Construction and operational principle of single-phase transformer, open-circuit (OC) and short-circuit (SC) tests, Sumpner's (back to back) test, equivalent circuit, parallel operation, and performance analysis of transformers	

	Theme for designing multiple experiments: 1. Analyze various parts of transformers and comprehend the operational principle. 2. Derive the steady-state equivalent circuit and predict the performance curves of single-phase transformers through relevant tests. 3. Assess performance curves through direct load test on both isolated and parallel-connected single-phase transformers.	
	Self-Learning Topics: *Watch videos on constructional details and operational principle of single /three phase transformers to get valuable insight into their design and functionality.*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: As a team, analyze the importance of the different elements in the magnetic, electric, and thermal circuits of a transformer, by applying the fundamental principles of energy transfer (1.3.1, 8.2.2).* *LO 1.2: Select suitable meters and perform open circuit (OC) and short circuit (SC) tests on single phase transformer (4.1.3).* *LO 1.3: Develop the steady-state mathematical model of single phase transformers, outlining the underlying assumptions (2.3.1).* *LO 1.4: Predetermine, plot and analyze the performance curves obtained from the OC & SC test data of transformer (4.3.3).* *LO 1.5: Perform Sumpner's test on single-phase transformers taking care of safety aspects, then compare it with OC and SC tests to assess their applicability in various situations. (2.2.4, 6.1.1).* *LO 1.6: Conduct load test on single phase transformer, analyze and interpret the results obtained and correlate them with theoretical principles) (4.1.4).* *LO 1.7: Conduct polarity test to ensure safe connection when paralleling two transformers, highlighting its necessity for the proper functioning (1.4.1, 6.1.1).* *LO 1.8: As a team, establish parallel connection between two single-phase transformers, ensuring all necessary conditions are met, and then individually analyze the power distribution between them (2.4.4, 8.2.1).*	
02.	**DC Motors**	**10**
	Learning Objective: *To develop skill in analyzing the performance and speed control methods of a given DC motor by conducting suitable tests.*	
	Content: Electromechanical Energy Conversion, Principle, Energy stored in magnetic field, Field and co energy, Force and torque equations, Torque in singly and doubly excited systems. Construction of DC machine, Commutator and brushes, Back EMF, Torque equations, Types of DC machines, Armature reaction, Characteristics (Speed-Torque & Performance) of DC motors. Necessity of starter/soft starting, Speed control and braking methods, Swinburne's test.	
	Theme for designing multiple experiments: 1. Analyze various parts of DC motors and comprehend the operational principle. 2. Analyze the performance characteristics of DC motor by conducting direct and indirect tests. 3. Conduct various speed control methods and electrical braking methods of DC motors.	

	Self-Learning Topics: *Watch videos on constructional details and operational principle of DC motors to get valuable insight into their functionality.*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: As a team, identify the key components of DC machines and clarify the roles of each part. (1.3.1, 8.2.2).* *LO 2.2: Ensure safety precautions, then demonstrate the conversion of electrical energy into linear mechanical motion using a basic electromechanical system (1.4.1, 6.1.1).* *LO 2.3: Predetermine and plot the efficiency curve of a DC shunt/compound motor by conducting suitable test and compare the results with that of direct load test (2.2.3, 4.3.3).* *LO 2.4: As a team, conduct load tests on different types of DC motors to gather their performance data and assess their suitability for diverse applications (2.2.3, 8.2.1).* *LO 2.5: Use armature and field control to adjust the speed of a DC motor, analyze their speed ranges, and ensure safety precautions are followed. (2.4.4, 6.1.1).* *LO 2.6: Test different electrical braking methods on a DC motor, assess the stopping time for each approach, and document safety precautions implemented throughout the testing process. (2.4.4, 6.1.1).*	
03.	**Transmission Lines**	**10**
	Learning Objectives: *To analyze simple power system networks using hardware/software tools.*	
	Content: Classification and modelling of short, medium and long lines, regulation and efficiency of short and medium lines, Ferranti effect, estimation of generalized circuit constant (ABCD) for short and medium line, VAR compensation (only basics), Introduction to Power System Analyzer software (like ETAP, PSS Sincal).	
	Theme for designing multiple experiments: 1. Conduct suitable tests on the given transmission line model and obtain the ABCD parameters. 2. Predetermine the voltage regulation of transmission line for various power factor loads using the test data *3.* Analyze the effect of basic VAR compensation on receiving end voltage profile. *4.* Use power system analyzer software for simple basic power system analysis	
	Self-Learning Topics: *Watch videos on different software available for power system analysis to get valuable insight into their functionality.*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Conduct tests on the given transmission line model to obtain the A, B, C, D parameters stating the assumptions made (2.3.1).* *LO 3.2: Predetermine, plot and analyze the voltage regulation of transmission line for various power factor loads using the test data (4.3.3).* *LO 3.3: Observe and analyze Ferranti effect in transmission line (2.2.2).* *LO 3.4: Analyze the effect of basic VAR compensation on receiving end voltage profile of distribution line (2.2.3).* *LO 3.5: Use power system analyzer software for simple basic power system analysis (5.1.1).*	
	Minimum 03 experiments from each module, and total at least 10 experiments	**30**

Performance Indicators:

P.I. No.	P.I. Statement
1.3.1	Apply fundamental engineering concepts to solve engineering problems
1.4.1	Apply electrical engineering concepts to solve engineering problems.
2.2.2	Identify, assemble and evaluate information and resources.
2.2.3	Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions
2.2.4	Compare and contrast alternative solution processes to select the best process.
2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis
4.1.3	Apply appropriate instrumentation and/or software tools to make measurements of physical quantities
4.1.4	Establish a relationship between measured data and underlying physical principles.
4.3.3	Represent data (in tabular and/or graphical forms) so as to facilitate analysis and explanation of the data, and drawing of conclusions.
5.1.1	Identify modern engineering tools such as computer aided drafting, modeling and analysis; techniques and resources for engineering activities.
6.1.1	Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at global, regional and local level
8.2.1	Demonstrate effective communication, problem-solving, conflict resolution and leadership skills.
8.2.2	Treat other team members respectfully

Course Outcomes: Learner will be able to

1. Choose suitable tests, conduct experiments on transformers and DC machines as a team, while prioritizing safety measures, and collect the necessary data to derive the performance curves. *(LO 1.1, LO 1.2, LO 1.7, LO 2.1, LO 2.2, LO 2.4)*
2. Develop mathematical models for transformers and transmission lines in steady state to derive the performance curves.*(LO 1.3, LO 1.4, LO 3.1)*
3. Apply fundamental concepts of transformers, DC machines, and transmission lines to analyse the performance curves and draw valid conclusions.*(LO 1.5, LO 1.6, LO 1.8, LO 2.3, LO 2.5, LO 2.6, LO 3.2, LO 3.3)*
4. Utilize appropriate hardware and software tools to analyse fundamental power system networks effectively. *(LO 3.4, LO 3.5)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
EELBC302.1	3	2		2		3		3			
EELBC302.2		3		2							
EELBC302.3		3		3		3		2			
EELBC302.4		2			2						
Average	**3**	**2.5**		**2.3**	**2**	**3**		**2.5**			

Text Books :

1. Electric Machinery, Bimbhra P.S., Seventh Edition, 1990, Reprint: 2018, Khanna Publisher

2. Power System Engineering, D. P. Kothari, I. J. Nagrath, Third Edition, 2019, Mc Graw Hill

Reference Books :

1. Performance and Design of Alternating Current Machines, M.G. Say, First Edition, 2002, CBS.
2. Electric Machines, Ashfaq Husain, Haroon Ashfaq, Third Edition, 2016, Dhanpat Rai and Co.
3. Electric Machinery, A.E. Fitzgerald, Kingsly, Stephen, Sixth Edition, 2002, McGraw-Hill Education
4. Elements of Power System, W. D. Stevenson, Fourth Edition, 1982, McGraw-Hill

Other Resources :

1. NPTEL Course: Electrical Machines by Prof. G. Bhuvaneshwari, Dept. of Electrical Engineering, IIT-Delhi. Weblink:- https://nptel.ac.in/courses/108/102/108102146/
2. Course: Power System Analysis by Prof. Debapriya Das, Dept. of Electrical Engineering, IIT, Kharagpur. Weblink: - https://swayam.gov.in/nd1_noc19_ee62/preview

CONTINUOUS ASSESSMENT (25 Marks)

Suggested breakup of distribution

- Practical Exercises - 10 Marks (Readiness to perform experiment (2 Marks), Performance (2 Marks), Report writing (2 Marks), Interpretation of result (2 Marks), Regularity in Submission (2 Marks))
- Internal Assessment - 10 Marks

  Evaluating proficiency in the field by assessing the candidate's capability to execute connections or circuits, conduct experiments, accurately record test data, and derive meaningful conclusions through data analysis during regular laboratory session.
- Regularity and active participation – 5 Marks

END SEMESTER EXAMINATION (25 Marks)

Two examiners, one Internal and one External will do the evaluation.

- Students will be randomly allocated an experiment from the list of laboratory exercises and will be asked to draw circuit diagram, observation table with relevant formulae. It will be checked by the examiners and evaluated out of 05 Marks.
- Then the student will be allowed to start with the performance of the experiment.
- Students will be given 1 hour to complete the circuit connections and take readings. The connections and output are verified by the examiners. The weightage is 05 Marks
- Students will do sample calculations, draw relevant graphs and write conclusion of the experiment. It will be checked by the examiners and evaluated out of 05 Marks.
- Students will then be appearing for Oral test in front of both Internal and External examiners. The weightage of Oral test will be of 10 Marks.

Course Type	Course Code	Course Name	Credits
SBL	EESBL301	PYTHON LABORATORY	02

Examination Scheme		
Continuous Assessment	End Semester Examination (ESE)	Total
50	50	100

Pre-requisite :

1. BSC101- Engineering Mathematics-I
2. ESL103- Programming Laboratory-I (C)
3. ESL205- Programming Laboratory-II (Java)
4. BSC204- Engineering Mathematics - II

Program Outcomes addressed :

1. PO1: Engineering Knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of solutions
4. PO4: Conduct investigations of complex problems
5. PO5: Modern tool usage
6. PO8: Individual and team work

Course Objectives :

1. Tools used for Python programming and error debugging.
2. Fundamentals concepts of python operators, math functions, flow control instructions, libraries, GUI toolkits, database operations in different types of applications.
3. Fundamental concepts and applications of object oriented programming concepts using Python.
4. Representation, visualization and analysis of data using arrays and advanced Python libraries.
5. Development of GUI using Tkinter and database operations.

Module	Details	Hrs.
	Course Introduction This is a foundation course on Python. Python is widely used across various industries and domains due to its versatility, simplicity, and the vast ecosystem of libraries and frameworks available. Here are some real-world applications of Python: Web Development, Data Science and Machine Learning, Artificial Intelligence, Scientific Computing, Automation and Scripting, Finance and Trading, Game Development, Education, Healthcare, Internet of Things (IoT) and many more. **Python's versatility allows it to be applied in almost any domain where programming is involved. Its rich ecosystem and active**	**01**

	community ensure that it remains a top choice for developers across various industries.	
01.	**Introduction to Python** ***Learning Objective:*** *To acquire knowledge and skill on adaption of suitable tool, fundamental concepts of variables and identifiers, and error debugging to develop a Python program.* **Contents:** History, features and applications in electrical engineering, how to run Python programs. Identifiers, reserved keywords, variables, comments in Python. Indentation, multiline statements, quotes. Input, output, and import functions, Operators in Python. **Theme for designing multiple experiments:** 1. Download and install software tools required for writing and executing Python programs. 2. Write and execute simple Python programs to understand different operators, variables, quotes, comments, indentation, input, and output functions in Python. ***Self-Learning Topics: History of Python, Applications in Electrical Engineering Field*** ***Learning Outcomes:*** *A learner will be able to* *LO 1.1: Apply knowledge of mathematics and write Python programs to solve simple problems. (1.1.1, 8.2.1, 8.3.1)* *LO 1.2: Apply fundamental concepts of Python programming to solve engineering problems. (1.3.1, 8.2.1, 8.3.1)* *LO 1.3:Identify keywords, operators, and software libraries to write/ execute Python programs to solve problems. (2.1.2, 8.2.1, 8.3.1)* *LO 1.4: Identify the mathematical and other relevant knowledge to write/execute Python programs and apply to a given problem. (2.1.3, 8.2.1, 8.3.1)* *LO 1.5: Identify tools/techniques to build a Python code for solving engineering problem. (5.1.1, 8.2.1, 8.3.1)* *LO 1.6: Adapt suitable programming techniques to build a Python code for engineering problem. (5.1.2, 8.2.1, 8.3.1)*	**04**
02.	**Data Types, Operators, Flow Control Instructions** ***Learning Objective:*** *To acquire knowledge and skill on fundamentals concepts of data types, operators, math functions, flow control instructions, and representation/analysis of data to build a Python program.* **Contents:** Data types, number formats, basic math operations, built in math functions. Data Structures: Lists, Tuples, Sets, and Dictionaries. String operations: If-else, if-elif-else, for loop, while loop, Exception handling, try-except, break-continue, functions. **Theme for designing multiple experiments:** 3. Perform math operations using built in functions.	**12**

	4. Apply flow control instructions to write/execute Python programs for a specific application. 5. Write and execute Python programs to understand operational functionalities of Lists, Tuples, Sets, and Dictionaries.	
	Self-Learning Topics: Complete exercies from w3schools.com based on above topics.	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply fundamentals concepts of math, cmath libraries, and flow control instructions to solve engineering problems and also execute error debugging. (1.3.1, 8.2.1, 8.3.1)* *LO 2.2: Apply mathematical techniques using Python to solve engineering problems. (1.1.1,8.2.1, 8.3.1)* *LO 2.3: Identify suitable function, parameters, and flow control instructions to write/execute and debug Python programs. (2.1.2, 8.2.1, 8.3.1)* *LO 2.4: Identity relevant knowledge of flow control instructions, exception handling, and data structures applicable to a given problem. (2.1.3, 8.2.1, 8.3.1)* *LO 2.5: Represent, analyze data using formats/tools such as lists, tuples, sets, and dictionaries. (4.3.3, 8.2.1, 8.3.1)* *LO 2.6: Synthesize information from raw data using data structures such as lists, tuples, dictionaries. (4.3.4, 8.2.1, 8.3.1)* *LO 2.7: Identify different libraries and resources for building a Python code to perform mathematical computations and data analysis. (5.1.1, 8.2.1, 8.3.1)* *LO 2.8: Create/adapt mathematical tools to solve engineering problems. (5.1.2, 8.2.1, 8.3.1)*	
03.	**Object Oriented Programming using Python:**	**12**
	Learning Objective: *To acquire knowledge and skill on fundamental OOP concepts and exception handling to create engineering application using Python programming.*	
	Contents: Creating class and objects, self-variables, constructors, methods. Inheritance and polymorphism, encapsulation. Assertion, types of exception and exception handling in Python. **Theme for designing multiple experiments:** 6. Develop a Python code to create an application using object oriented programming concepts.	
	Self-Learning Topics: Identify and analyze case studies on OOP aaplications in real world.	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply knowledge of mathematics with object oriented programming to solve problems. (1.1.1, 8.2.1, 8.3.1)* *LO 3.2: Apply fundamental object oriented programming concepts and develop software tools to solve engineering problems. (1.3.1, 8.2.1, 8.3.1)* *LO 3.3: Identify variables, parameters, and adapt suitable software tools/techniques in OOP to solve engineering problem demonstrating effective communication, conflict resolution and leadership skills. (2.1.2, 8.2.1, 8.3.1)* *LO 3.4: Identify the mathematical, engineering knowledge to develop application using OOP. (2.1.3, 8.2.1, 8.3.1)* *LO 3.5: Build a software model using OOP Python with alternate design solutions. (3.2.2, 8.2.1, 8.3.1)*	

	LO 3.6: Identify suitable criteria to build a software model using Python. (3.2.3, 8.2.1, 8.3.1) *LO 3.7: Use appropriate procedures, tools and techniques to build an application using OOP Python to conduct experiments and collect data. (4.3.1, 8.2.1, 8.3.1)* *LO 3.8: Represent and analyze data to create mathematical or engineering tools to solve engineering problems in a team. (4.3.2, 8.2.1, 8.3.1)*	
04.	**Data Visualization, and Analysis using Advanced Python Libraries**	**20**
	Learning Objectives: *To acquire knowledge and skill on advanced mathematical computation, representation, visualization, and analysis of data using Matplotlib and Pandas, Numpy, and SciPy libraries of Python to develop applications for solving engineering problem.*	
	Contents: Visualization using Matplotlib: working with plots (line plot, bar graph, histogram, scatter plot, area plot, pie chart etc.), working with multiple figures. Data manipulation and analysis using Pandas: Introduction to Pandas, importing data into Python, series, data frames, indexing data frames, basic operations with data frame, filtering, combining and merging data frames, Removing Duplicates. Introduction to Objects and Functions of Numpy - core library for scientific computing SciPy - ecosystem of open-source software for mathematics, science, and engineering **Theme for designing multiple experiments:** 7. Perform computations and analyze statistical data by using functionalities of advanced Python libraries such as Matplotlib, Pandas, Numpy, and SciPy.	
	Self-Learning Topics: Identify online data resources for performing intended actions and apply the same base on syllabus.	
	Learning Outcomes:	
	A learner will be able to *LO 4.1: Apply fundamental knowledge of mathematical techniques along with advanced Python libraries to develop data analysis tools. (1.1.1, 8.2.1, 8.3.1)* *LO 4.2: Apply fundamental concepts of advanced Python libraries to solve engineering problems. (1.3.1, 8.2.1, 8.3.1)* *LO 4.3: Identify/adapt suitable tool/library to build programs to develop diverse design solution. (2.1.2, 8.2.1, 8.3.1)* *LO 4.4: Identify relevant knowledge of advanced Python libraries applicable to a given problem. (2.1.3, 8.2.1, 8.3.1)* *LO 4.5: Build data models using advanced Python libraries satisfying suitable criteria. (3.2.2, 8.2.1, 8.3.1)* *LO 4.6: Identify suitable criteria for visualization and analysis of data for evaluation of alternate design solutions. (3.2.3, 8.2.1, 8.3.1)* *LO 4.7: Use appropriate library tools to collect and analyze data for a specific engineering application. (4.3.1, 8.2.1, 8.3.1)* *LO 4.8:Represent, visualize, and analyze data using Matplotlib and Pandas, Numpy, and SciPy libraries. (4.3.3, 8.2.1, 8.3.1)* *LO 4.9: Identify different libraries and resources for building a Python code to perform mathematical computations and data analysis. (5.1.1, 8.2.1, 8.3.1)*	

	LO 4.10: Create applications using Python libraries to solve Engineering problem. (5.1.2, 8.2.1, 8.3.1)	
05.	**GUI Programming and Database Operations.**	**10**
	Learning Objective/s: *To acquire knowledge and skill on creating an application/simulator using GUI programming to solve engineering problem and applying database operations to modify data in a particular application.*	
	Contents: **Content:** GUI Programming - Writing a GUI with Python: GUI Programming Toolkits, Creating GUI Widgets with Tkinter, Creating Layouts, Radio Buttons and Checkboxes, Dialog Boxes. Creating a simulator for small electrical or electronic system. Database Access - Python's Database Connectivity, Types of Databases Used with Python, MySQL database Connectivity with Python, Performing Insert, Deleting & Update operations on database **Theme for designing multiple experiments:** 8. Write and execute simple Python programs to develop GUI and perform different database operations.	
	Self-Learning Topics: Study applications of Tkinter GUI in Electrical Engineering Field using case studies or research papers.	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Apply knowledge of mathematical techniques to build a Python GUI to solve mathematical problems. (1.1.1, 8.2.1, 8.3.1)* *LO 5.2: Apply fundamentals of GUI programming and database operations to solve engineering problems. (1.3.1, 8.2.1, 8.3.1)* *LO 5.3: Build a Tkinter GUI program to develop diverse design solutions. (3.2.2, 8.2.1, 8.3.1)* *LO 5.4: Identify criteria and develop alternate design solutions for GUI development. (3.2.3, 8.2.1, 8.3.1)* *LO 5.5: Identify GUI library and its resources for engineering activities. (5.1.1, 8.2.1, 8.3.1)* *LO 5.6: Create an application using Tkinter for particular application. (5.1.2, 8.2.1, 8.3.1)*	
	Course Conclusion The course emphasizes the development of problem-solving capabilities through structured modules that align with both individual and team-based work. This structure ensures that students are not only familiar with Python's technical aspects but also gain experience in applying Python to solve engineering and mathematical problems effectively. With a strong foundation in Python programming and its libraries, students will be equipped with the knowledge and skills to contribute to a wide range of industries, including electrical engineering, data science, automation, and more.	**01**
	Total	**60**

Performance Indicators:

P.I. No.	P.I. Statement
1.1.1	Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems.
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem.
3.2.2	Build models/prototypes to develop a diverse set of design solutions.
3.2.3	Identify suitable criteria for the evaluation of alternate design solutions.
4.3.1	Use appropriate procedures, tools and techniques to conduct experiments and collect data.
4.3.2	Analyze data for trends and correlations, stating possible errors and limitations
4.3.3	Represent data (in tabular and/or graphical forms) so as to facilitate analysis and explanation of the data, and drawing of conclusions.
4.3.4	Synthesize information and knowledge about the problem from the raw data to reach appropriate conclusions.
5.1.1	Identify modern engineering tools such as computer aided drafting, modelling and analysis; techniques and resources for engineering activities.
5.1.2	Adapt the tools and techniques to solve engineering problems.
8.2.1	Demonstrate effective communication, problem solving, conflict resolution and leadership skills.
8.3.1	Present results as a team, with smooth integration of contributions from all individual efforts.

Course Outcomes: A learner will be able to -

1. Identify tools and techniques to write/execute and debug Python programs. *(LO 1.3, LO 1.4, LO 1.5, LO 1.6, LO 2.3, LO 2.4, LO 2.7, LO 3.3, LO 3.4, LO 3.6, LO 3.7, LO 4.3, LO 4.4, LO 4.6, LO 4.7, LO 4.9, LO 5.4, LO 5.5)*
2. Apply fundamental concepts of python operators, math functions, flow control instructions, libraries, GUI toolkits, database operations in specific application. *(LO 1.1, LO 1.2, LO 2.1, LO 2.2, LO 3.1, LO 3.1, LO 4.1, LO 4.2, LO 5.1, LO 5.2)*
3. Create an application using concepts of Object Oriented Programming and database operations in Python. *(LO 2.8, LO 3.5, LO 4.5, LO4.10, LO 5.3, LO 5.6)*
4. Represent, visualize and analyze data using arrays and advanced Python libraries such as Matplotlib, Pandas, Numpy, and SciPy. *(LO 2.5, LO 3.8, LO 4.8)*
5. Develop a GUI using Tkinter and database operations in Python for a specific application. *(LO 5.3, LO 5.6)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
EESBL301.1	3	3			3			3			
EESBL301.2	3	3			3			3			
EESBL301.3	3	3	3		3			3			
EESBL301.4	3	3	3	3	3			3			
EESBL301.5	3	3	3		3			3			
Average											

Text Books :

1. "Core Python Programming", Dr. R. Nageswara Rao, Dreamtech Press.
2. "Beginning Python: Using Python 2.6 and Python 3.1", James Payne, Wrox Publication.
3. "Python Programming", Anurag Gupta, G. P. Biswas, McGraw-Hill.
4. "Introduction to computing and problem-solving using python", E Balagurusamy, McGraw Hill Education.

Reference Books :

1. "Learning Python", Mark Lutz, O Reily, 4thEdition, 2009.
2. "Programming Python", Mark Lutz, O Reily, 4thEdition, 2010.
3. "Python 3 for Absolute Beginners", Tim Hall and J-P Stacey, 2009.
4. "Beginning Python: From Novice to Professional", Magnus Lie Hetland, , 2nd Edition, 2009.
5. "Core Python Programming", Wesley J. Chun, Second Edition, Pearson.
6. "Taming Python by Programming", Jeeva Jose, Khanna Publishing House.
7. Introduction to Computing and Problem Solving with Python, J. Jose, Khanna Publications.
8. "Python Programming", Seema Thareja, Pearson.

Other Resources :

1. Python 3.4.3, By Prof Kannan Moudgalya, Indian Institute of Technology Bombay, Python 3.4.3 - Course (swayam2.ac.in)
2. Python Tutorial, Website link: https://www.w3schools.com/python/default.asp

CONTINUOUS ASSESSMENT (50 Marks)
Suggested breakup of distribution

- **Laboratory Exercises: 15 Marks**
- **Internal Assessment: 10 Marks**
  As a part of Internal Assessment, students will do course mini project as a team to inculcate teamwork. Students will be tasked with developing a small-scale system using Python. This project-based assessment will require students to apply their knowledge and skills gained throughout the course to design and implement a functional system using Python programming language.
  Course Project Rules in Python:
  1. Group Size: Groups of 2 to 4 members allowed.
  2. Project Proposal: Detailed proposal with scope, objectives.
  3. Project Requirements:
     Develop using Python.
     Encouraged to use relevant libraries and show core concepts understanding.
  4. Presentation:
     Present project features, challenges faced, and solutions.
     Q&A session for evaluation.
  5. Evaluation Criteria:
     Adherence to requirements and objectives.

  Code quality, readability, and organization.
  Functionality, UI/UX (if applicable), and error handling.
  Effective presentation and Q&A skills.

- **Regularity and active participation: 05 Marks**
- **Practical Test: (20 Marks)**

The practical test will be conducted after completion of 50% of laboratory exercises.

- The allocation of laboratory exercises for testing programming and problem-solving skills will be randomized, with each student receiving two or more programs from the exercise list.
- Students will have a designated 2-hour timeframe for code development. After the first hour, an internal examiner will review the progress, offering suggestions for program enhancement to evaluate programming skill. Additionally, problem-solving skill will be assessed.
- During the practical assessment or at its conclusion, students will be queried to evaluate their conceptual understanding, ensuring comprehension.

END SEMESTER ASSESSMENT (Practical/Oral Exam) (50 Marks)

For the End semester exams, practical examination will be conducted. The detail of the end-sem evaluation is as follows. It will consist of three sections.

Practical Examination (20 Marks)

The section one will have practical exam based on the laboratory exercises conducted during the term. The assessment criteria will be similar to Internal Practical Test.

Debugging and Output Prediction Exercise (20 Marks)

The second section involves questions problems such as providing partial code segments with bugs and asking students to identify and correct the errors, predict the output of the corrected code, complete the code, identify the appropriate library etc. This option is designed to prepare students for placements or industry roles by testing their ability to debug and understand code in real-world scenarios.

Oral (10 Marks)

Two examiners, one Internal and one External will do the evaluation.

Course Type	Course Code	Course Name	Credits
MNP	EEMNP301	Mini Project- 1A	02 each

Program Outcomes addressed:

1. PO1 : Engineering knowledge
2. PO2 : Problem Analysis
3. PO3 : Design/Development of Solutions
4. PO4 : Conduct investigations of complex problems
5. PO5 : Modern Tool Usage
6. PO6 : The Engineer the world
7. PO7 : Ethics
8. PO8 : Individual & team work
9. PO9: Communication
10. PO10: Project Management & Finance
11. PO11: Life-long learning

Course Objectives

1. To familiarize students about available infrastructure at Department/Institute level, online resources, plagiarism, expectations from MP 1A and 1B, etc.
2. To guide students in identifying societal or research needs and formulating them into problem statements.
3. To facilitate problem-solving in group settings.
4. To apply basic engineering principles to address identified problems.
5. To foster self-learning and research skills.

Course Outcomes

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

1. Identify problems based on societal or research needs and methodology for solving them.
2. Apply knowledge and skills to solve societal problems collaboratively.
3. Develop interpersonal skills necessary for teamwork.
4. Analyze, verify, and validate results effectively through various methodologies, including, test cases/benchmark data/theoretical/inferences/experiments/simulations, etc.
5. Evaluate the societal and environmental impacts of proposed solutions.
6. Adhere to standard engineering practices.
7. Excel in written and oral communication by technical report writing, oral presentation, and publishing results in
   - Research/white paper/article/blog writing/publication, etc.
   - Business plan for entrepreneurship product creation
   - Patent filing/copyright.
8. Gain technical competencies by participating in competitions, hackathons, etc.
9. Demonstrate lifelong learning capabilities through self-directed group projects.
10. Apply project management principles effectively.

Guidelines for the Mini Project

- At the beginning of semester-III, project guides are required to conduct around 4 hours' orientation sessions including following topics:
    - Familiarizing students about infrastructure available at Department/Institute level and how to use it.
    - How to identify societal problems and formulate project problem statement.
    - How to carry out literature survey.
    - What is plagiarism and what care needs to be taken while writing a report.
    - What is project report template and how it should be used.
    - What are expectations from mini-projects 1A and 1B.
- Mini project may be carried out in one or more form of following:
  Product preparations, prototype development model, fabrication of set-ups, laboratory experiment development, process modification/development, simulation, software development, integration of software (frontend-backend) and hardware, statistical data analysis, creating awareness in society/environment etc.
- Students must form groups of 3 to 4 members either from the same or from different departments.
- Groups should conduct surveys to identify needs and develop problem statements in consultation with faculty.
- An implementation plan in Gantt/PERT/CPM chart format covering weekly activities must be submitted.
- Each group must maintain a logbook to record weekly progress, to be verified by the faculty supervisor.
- Faculty input should emphasize guiding by faculty and self-learning by group members.
- Groups should propose multiple solutions, select the best one in consultation with the supervisor, and develop a working model.
- The solution to be validated with proper justification and report to be compiled in standard format of the Institute. Research papers, competition certificates may be submitted as part of annexure to the report.
- With the focus on self-learning, innovation, addressing societal/research/innovation problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality be carried out in two semesters by all the groups of the students.
- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above, gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on a case by case basis.

In-Semester Continuous Assessment and End-Semester Examination Guidelines

- The Head of the Departments will assign a guide to each of the mini-projects and shall form a progress monitoring committee. The guide will carry out weekly monitoring of the project's progress. The committee shall carry out in-semester project evaluation based on presentations with a minimum of two evaluations per semester.
- Assessment will be based on individual contributions, understanding, and responses to questions asked.
- Continuous Assessment marks distribution in semester III (50 marks):

    - 10 marks for the Topic Approval Presentation in front of the progress monitoring committee
    - 15 marks for the Mid-Semester Progress Presentation in front of the progress monitoring committee
    - 25 marks for the Final Report & Presentation
- Continuous Assessment marks distribution in semester IV (50 marks):
    - 15 marks for the In-Semester Two Presentations
    - 10 marks for the Participation in Project Competitions, TPP, etc.
    - 25 marks for the Final Report & Presentation

The review/progress monitoring committee will assess projects based on the following criteria.

Semester III:

- Theoretical solution completion, including component/system selection/design of software solution and cost analysis.
- Two reviews will occur:
    - The first review will focus on finalizing the problem statement (topic approval).
    - The second review will focus on finalizing the proposed solution.

Semester IV:

- Expected tasks include procuring components/systems, constructing a working prototype, and validating results based on prior semester work.
- Reviews will be conducted as follows:
    - The first review will assess the readiness to build a working prototype.
    - The second review will involve a poster presentation and demonstration of the working model in the last month of the semester.

In addition to the above-mentioned points, the following performance criteria shall be included during the in-semester continuous assessment:

1. Quality of survey and need identification.
2. Clarity and innovativeness in problem definition and solutions.
3. Requirement gathering feasibility study, cost-effectiveness, and societal impact of proposed solutions.
4. Completeness and full functioning of the working model.
5. Effective use of skill sets and engineering norms.
6. Verification & validation of the solutions/test cases.
7. Individual contributions to the group.
8. Clarity in written and oral communication.
9. Participation in technical paper presentations/project competitions/hackathon competitions, etc.

End-Semester Examination in Semester IV (50 marks):

1. Presentation and demonstration to internal and external examiners: 20 marks.
2. Emphasis on problem clarity, innovativeness, societal impact, functioning of the model, skill utilization, and communication clarity: 30 marks**.**

Course Type	Course Code	Course Name	Credits
HSSM	HSSM301	PRODUCT DESIGN	02

Program Outcomes addressed:

1. PO2 Problem analysis
2. PO3 Design/Development of solutions
3. PO5 Engineering tool usage
4. PO6 The engineer and the world
5. PO7 Ethics
6. PO8 Individual and collaborative team work
7. PO10 Project management & finance
8. PO11 Life-long learning

Course Objectives:

1. Understand the product design process and its user-centered principles.
2. Apply fundamental design principles to create innovative product designs.
3. Demonstrate proficiency in generating and evaluating design concepts through ideation techniques.
4. Evaluate and synthesize sustainable and user-centric design practices in product development.

Module	Details	Hrs.
	Course Introduction – The course Product Design provides a thorough understanding of the principles, methods, and methodologies used in developing unique and functional products. Whether you want to be an industrial designer, a UX/UI specialist, or a creative problem solver, this course will provide you the necessary knowledge and abilities to envision, develop, and revise products that fulfill user needs and market demands. Students will investigate many areas of product design, such as aesthetics, usability, and sustainability, using both theory and hands-on practice. Design thinking, prototyping, and research will demonstrate to students how to turn ideas into concrete things that improve user experience and address real-world challenges.	**01**
01.	**Introduction to Product Design** ***Learning Objective:*** *Understand the fundamental principles and key elements that contribute to effective product design.* **Contents:** Overview of product design process, Importance of user-centered design, Design thinking methodologies, Case studies of successful product designs, Introduction to design tools and software (e.g., Sketch, Adobe XD)	**04**

	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply design thinking methodologies to develop user-centered solutions.* (*P.I.- 2.1.1, 2.3.1, 3.2.1, 3.3.1*) *LO 1.2: Gain introductory experience with digital design tools.* (*P.I. – 5.1.1, 5.2.1*)	
02.	**Design Principles and Fundamentals** ***Learning Objective:*** *Understand and apply core design principles to create functional and aesthetically pleasing products.*	**06**
	Contents: Understanding design principles (e.g., balance, hierarchy, contrast), Human factors in design (ergonomics, anthropometrics), Material selection and properties, Basics of aesthetics and styling, Hands-on exercises in sketching and prototyping	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply fundamental design principles such as balance, contrast, proportion, and harmony to create aesthetically and functionally effective designs.* (*P.I. – 3.1.5, 3.2.3, 6.1.1*) *LO 2.2: Analyze and evaluate design elements to develop user-centered solutions that enhance usability, accessibility, and overall user experience.* (*P.I. – 3.1.1, 6.2.1*)	
03.	**Concept Generation and Ideation** ***Learning Objective:*** *Develop creative ideas and transform them into viable product concepts through structured ideation techniques.*	**06**
	Contents: Techniques for brainstorming and idea generation, Sketching and visualization techniques, Developing design briefs and specifications, Evaluating and selecting design concepts, Design for X, Rapid prototyping methods (e.g., 3D printing, CNC machining)	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply various ideation techniques such as brainstorming, mind mapping, and SCAMPER to generate innovative and creative product concepts.* (*P.I. – 2.4.4, 3.1.6, 3.2.1*) *LO 3.2: Develop and evaluate multiple design concepts based on user needs, feasibility, and functionality to refine ideas into viable solutions.* (*P.I. – 2.2.4, 3.1.1, 3.1.6*)	
04.	**Product Lifecycle** ***Learning Objectives:*** *Understand the stages of a product's lifecycle and how they influence design, development, and sustainability.*	**04**
	Contents: Detailed overview of the product development lifecycle, Cost estimation and budgeting, Marketing and Market research, Regulatory and compliance requirements (e.g., safety standards)	

	Learning Outcomes: *A learner will be able to* *LO 4.1: Understand and analyze the stages of the product lifecycle and their impact on design, marketing, and sustainability decisions.* (*P.I. – 3.1.1, 3.1.6, 6.3.2, 11.3.2*) *LO 4.2: Analyze the influence of lifecycle considerations such as material selection, manufacturing processes, and end-of-life disposal to develop sustainable and cost-effective product solutions.* (*P.I. – 3.1.5, 6.3.1, 6.4.1, 6.4.2, 11.1.1, 11.2.2*)	
05.	**User Experience (UX) Design** ***Learning Objective:*** *Design intuitive and user-friendly products by applying UX principles and usability testing.*	**04**
	Contents: Understanding user needs and behaviour, Usability testing and feedback gathering, Wire-framing and prototyping for digital products, Iterative design process, Accessibility and inclusive design principles	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Apply UX design principles such as usability, accessibility, and interaction design to create intuitive and user-friendly products.* (*P.I. – 3.1.6, 3.3.1, 5.2.2*) *LO 5.2: Conduct user research and usability testing to analyze user needs, gather feedback, and refine designs for an enhanced user experience.* (*P.I. – 3.1.1, 3.1.6, 5.1.2, 5.2.1, 10.3.1, 10.3.2*)	
06.	**Sustainability in Product Design** ***Learning Objective:*** *Incorporate sustainable practices and materials to create environmentally responsible product designs.*	**04**
	Contents: Environmental impact assessment in product design, Sustainable materials and manufacturing processes, Design for disassembly and recycling, Circular economy principles Case studies of eco-friendly product designs.	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Apply sustainable design principles by selecting eco-friendly materials, optimizing manufacturing processes, and minimizing environmental impact throughout the product lifecycle.* (*P.I. – 3.1.5, 6.3.2, 7.1.1, 11.3.1*) *LO 6.2: Assess the lifecycle impact of products in terms of resource consumption, carbon footprint, and end-of-life disposal to develop eco-friendly and socially responsible design solutions.* (*P.I. – 3.4.1, 6.4.1, 7.2.2, 11.3.2*) *LO 6.3: Demonstrate good communication and collaboration with interdisciplinary teams by incorporating sustainable design concepts, explaining environmental and social implications, and enabling cross-disciplinary discussions to create new, eco-friendly product solutions.* (*P.I. – 8.2.1, 8.3.1*)	
	Course Conclusion	**01**
	Total	**30**

Performance Indicators:

P.I. No.	P.I. Statement
2.1.1	Articulate problem statements and identify objectives.
2.2.4	Compare and contrast alternative solution processes to select the best process.
2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis.
3.1.1	Recognize that need analysis is key to good problem definition.
3.1.5	Explore and synthesize engineering requirements considering health, safety risks, environmental, cultural and societal issues.
3.1.6	Determine design objectives, functional requirements and arrive at specifications.
3.2.1	Apply formal idea generation tools to develop multiple engineering design solutions.
3.3.1	Apply formal decision-making tools to select optimal engineering design solutions for further development.
3.2.3	Identify suitable criteria for the evaluation of alternate design solutions.
3.4.1	Refine a conceptual design into a detailed design within the existing constraints (of the resources)
5.1.1	Identify modern engineering tools such as computer-aided drafting, 4 odelling and analysis; techniques and resources for engineering activities.
5.1.2	Create/adapt/modify/extend tools and techniques to solve engineering problems.
5.2.1	Identify the strengths and limitations of tools for (i) acquiring information, (ii) 4odelling and simulating, (iii) monitoring system performance, and (iv) creating engineering designs.
5.2.2	Demonstrate proficiency in using discipline-specific tools.
6.1.1	Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at the global, regional and local level.
6.2.1	Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public.
6.3.1	Identify risks/impacts in the life-cycle of an engineering product or activity.
6.3.2	Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability.
6.4.1	Describe management techniques for sustainable development.
6.4.2	Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline.
7.1.1	Identify situations of unethical professional conduct and propose ethical alternatives.
7.2.2	Examine and apply moral & ethical principles to known case studies.
8.2.1	Demonstrate effective communication, problem-solving, conflict resolution and leadership skills.
8.3.1	Present results as a team, with smooth integration of contributions from all individual efforts.
10.3.1	Identify the tasks required to complete an engineering activity, and the resources required to complete the tasks.
10.3.2	Use project management tools to schedule an engineering project, so it is completed on time and on budget.
11.1.1	Describe the rationale for the requirement for continuing professional development.
11.2.2	Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field.
11.3.1	Source and comprehend technical literature and other credible sources of information.
11.3.2	Analyze sourced technical and popular information for feasibility, viability, sustainability, etc.

Course Outcomes: A learner will be able to –

1. Apply design thinking methodologies effectively to solve design problems. (*LO 1.1, LO 2.1, LO 2.2, LO 3.1, LO 3.2*)
2. Demonstrate proficiency in utilizing design tools and techniques for product development. (*LO 1.2, LO 5.1*)
3. Communicate and collaborate effectively for interdisciplinary teamwork. (*LO 6.3*)
4. Create functional and aesthetically pleasing product designs. (*LO 5.2*)
5. Integrate sustainable and user-centric design principles into product development processes. (*LO 4.1, LO 4.2, LO 6.1, LO 6.2*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
HSSM301.1		3	3			3					
HSSM301.2			3		3						
HSSM301.3								3			
HSSM301.4			3		3					3	
HSSM301.5			3			3	3				3
Average		3	3		3	3	3	3		3	3

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. "Product Design and Development" by Karl T. Ulrich and Steven D. Eppinger, published by McGraw-Hill Education; 7th edition (January 25, 2021).
2. "Engineering Design: A Project-Based Introduction" by Clive L. Dym and Patrick Little, published by Wiley; 4th edition (August 26, 2015).
3. "Universal Principles of Design" by William Lidwell, Kritina Holden, and Jill Butler, published by Rockport Publishers; Revised and updated edition (January 1, 2010).

Reference Books :

1. "Sketching: Drawing Techniques for Product Designers" by Koos Eissen and Roselien Steur, published by BIS Publishers; 2nd edition (March 1, 2011).
2. "Materials and Design: The Art and Science of Material Selection in Product Design" by Mike Ashby and Kara Johnson, published by Butterworth-Heinemann; 3rd edition (October 10, 2014).
3. "The Design of Everyday Things" by Don Norman, published by Basic Books; Revisedand expanded edition (November 5, 2013).

Other Resources :

1. NPTEL Course: Product Design and Development, Prof. Inderdeep Singh, IITRoorkee Weblink: https://onlinecourses.nptel.ac.in/noc21_me83/preview
2. NPTEL Course: Product Design and Innovation, By Prof. Supradip Das, Prof. Swati Pal, Prof. Debayan Dhar, IIT Guwahati, IIT Guwahati, Web link: https://onlinecourses.nptel.ac.in/noc21 de01/preview

Continuous Assessment – Theory - (50 Marks)

Suggested breakup of distribution

Multiple Choice Questions	10 marks
Case Study	20 marks
Group Project	15 marks
Regularity and Active participation	5 marks

Course Type	Course Code	Course Name	Credits
PCC	EEPCC405	ENGINEERING MATHEMATICS-IV	03+01*

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20+25@	30	50	1.5	2	125

Pre-requisite :

1. BSC101- Engineering Mathematics-I
2. BSC204- Engineering Mathematics-II
3. EEPCC301-Engineering Mathematics-III

Program Outcomes addressed :

1. PO1: Engineering knowledge
2. PO2: Problem analysis

Course Objectives:

1. To provide the basic knowledge on the concepts of Mathematics in the field of Engineering.
2. To build a foundation to the methodology necessary for solving problems by applying the knowledge of Mathematics to the field of Engineering.

Module	Details	Hrs
	Course Introduction Engineering Mathematics IV is often a foundational course designed to provide students with the mathematical tools and concepts essential for various engineering disciplines. Engineering Mathematics IV has many applications in Electrical engineering such as • Application of in Probability in control systems, communication system and power system. • Application of in Correlation and Regression in Deep learning. • Application of numerical methods used in optimization, simulation and modeling. • Concept of complex numbers and variables provides a knowledge to solve electrical engineering problems.	**01**
01.	**Probability Theory and Random Variable**	**6-8**
	Learning Objective/s: *To analyze random variables using the basic theory of probability and will be able to apply various mathematical techniques in determining probability functions.*	
	Contents: Conditional Probability, Bayes Theorem, Total Probability Theorem, Definition of Random Variable. Types of Random Variable: Discrete and Continuous, Probability Mass and Density Function.	

	Self-Learning Topics: *Cumulative Distribution and Density Function.*	
	Learning Outcomes: *A learner will be able to* *LO1.1: Apply mathematical techniques of union, intersection and addition of sets, numbers for finding probabilities of events using Bayes' Theorem and Total Probability Theorem. (P.I.-1.1.1)* *LO1.2: Apply mathematical techniques of integration and summation for finding Expectation, Variance, Probability density function and Probability distribution function. (P.I.-1.1.2)* *LO1.3: Identify if a given Random variable is Discrete or continuous in nature using existing definitions and formulas from Probability. (P.I.-2.1.2)* *LO1.4: Identify independents sets and disjoint sets and use its knowledge in the context of conditional probability. (P.I.-2.1.3)*	
02.	**Probability Distribution**	**6-8**
	Learning Objective/s: *To analyze and identify standard probability distribution functions and apply the knowledge of distribution for finding probabilities of various events.*	
	Contents: Measures of Central Tendency and Dispersion, Binomial distribution, Poisson Distribution ,Fitting of a Poisson Curve, Gaussian Distribution, Normal Distribution (Standard Normal distribution, Reverse problem of Normal distribution)	
	Self-Learning Topics: *Joint Probability Distribution.*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply mathematical techniques of exponents, algebra and basic probability for finding the probabilities of various events using Binomial, Poisson and Normal Distribution. (P.I.-1.1.1)* *LO 2.2: Apply the advance mathematical techniques of statistics to find the probabilities the random variable (P.I. -1.1.2)* *LO 2.3: Identify the area under a Standard Normal Curve (bounded or unbounded) and use its knowledge in the context of Normal Distribution. (P.I.-2.1.3)* *LO 2.4: Identify whether Poisson distribution or Normal Distribution is applicable to a given problem using basic definitions of distribution and the data inferred from the problem. (P.I.-2.1.1)*	
03.	**Numerical Methods-I**	**7-9**
	Learning Objective/s: *To analyze and apply the appropriate numerical method to solve Numerical differentiation and integration problems.*	
	Contents: Introduction to Difference Formula, Newton Backward Difference Formula and Newton Forward Difference Formula, Newton Cote Formula, Stirling's Formula, Trapezoidal Rule , Simpson's 1/3rd and Simpson's 3/8th rule	
	Self-Learning Topics: *Analysis of numerical errors in differentiation and integration.*	

	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply the Numerical techniques to solve definite integral problems. (P.I.-1.1.1)* *LO 3.2: Apply analytical methods to solve the numerical problems. (P.I.-1.1.3)* *LO 3.3: Identify Analytical method to determine value of definite integral and determine error. (P.I.-2.2.4)* *LO 3.4: Identify the appropriate methods of difference formula to solve interpolation. (P.I.-2.1.3)* *LO 3.5: Identify the numerical differentiation and integration methods to solve various functions and data set in engineering field. (2.2.3)*	
04.	**Numerical Methods -II**	**7-9**
	Learning Objective/s: *To analyze and apply the appropriate numerical method to solve transcendental equation and system of simultaneous equations.*	
	Contents: Solution of Transcendental Equations: Newton Raphson method, Regula – Falsi Method, Solution of system of linear algebraic equations, Gauss Jacobi Iteration Method, Gauss Seidel Iteration Method.	
	Self-Learning Topics: *Bisection Method, Gauss Elimination Method.*	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Apply Newton Raphson method and Regula Falsi method to solve the transcendental equation. (P.I.-1.1.1)* *LO 4.2: Apply Gauss Jordan or Gauss Siedel Iterative method to solve the system of equations. (P.I.-1.1.2)* *LO 4.3: Identify the appropriate numerical method to solve the system of equation. (P.I.-2.1.3)* *LO 4.4: Examine the limitation for the convergent solution of system of equation using iterative method.(P.I.-2.4.3)*	
05.	**Correlation and Regression**	**5-7**
	Learning Objective/s: *To analyze the mathematical dataset given and apply techniques of correlation and regression to identify the relationships between variables from the dataset.*	
	Contents: Correlation, Karl Pearson's coefficients of correlation(r), Spearman's Rank correlation coefficient (R): Repeated Rank, Non-repeated rank, Regression, Line of regression, Curve fitting: Linear and Second-Degree Curves.	
	Self-Learning Topics: Fitting of an exponential Curve	
	Learning Outcomes: *A learner will be able to* *LO 5.1: Apply basic mathematical techniques from algebra in finding the lines of regression and regression coefficients. (P.I.-1.1.1)* *LO 5.2: Apply Least Square Method to fit a particular to the given data (P.I.-1.1.2)* *LO 5.3: Identify whether a linear degree curve or a quadratic degree curve is to be fit for the given data set based on the knowledge of Curve Fitting (P.I.-2.2.2)*	

	LO 5.4: Identify whether Karl Pearson's or Spearman's coefficient of correlation is to be used in establishing relationship between two variables depending on the dataset given. (P.I.- 2.1.3)	
06.	**Complex Variables-II**	**6-8**
	Learning Objective/s: *To analyze if a given function has its harmonic conjugate and apply it for finding the Orthogonal Trajectories of a given mathematical function using the concept of Complex Variables.*	
	Contents: Milne-Thomson method: Determine analytic function f(z) when real part (u) is given, Determine analytic function f(z) when imaginary part (v) is given, Determine the analytic function when the combination of Real and Imaginary part is given, Harmonic function , and Harmonic conjugate, Orthogonal trajectories.	
	Self-Learning Topics: *Linear mapping, bilinear mapping, cross ratio, fixed points.*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: To apply the mathematical techniques of calculus and algebra for determining the analytic function using Milne Thomson Formula. (P.I.-1.1.1)* *LO 6.2: To apply the fundamental concept of complex Variables to solve engineering problems. (P.I.-1.3.1)* *LO 6.3: Identify the harmonic function and determine its harmonic conjugate. (P.I.-2.1.2)* *LO 6.4: Identify the analytic functions to solve orthogonal trajectory.(P.I.-2.1.3)*	
	Course Conclusion Engineering Mathematics provides the problem solving skills necessary for electrical engineering to design, analyze and optimize system and device across a wide range of applications.	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.1.1	Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems
1.1.2	Apply advanced mathematical techniques to model and solve engineering problems
1.1.3	Apply advanced mathematical techniques such as integral and differential equations to describe/solve/construct a mathematical model.
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
2.1.1	Articulate problem statements and identify objectives
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.2.3	Identify existing solution/methods to solve the problem, including forming justified approximations and assumptions.
2.2.4	Compare and contrast alternative solutions to select the best methodology
2.4.3	Identify sources of error in the solution process, and limitations of the solution.

Course Outcomes: A learner will be able to

1. Analyse random variables and apply the concepts of probability for getting the spread of data.*(LO 1.1, LO 1.2, LO 1.3, LO 1.4)*
2. Analyse the mathematical problem given and apply the concepts of distribution in finding probabilities.*(LO 2.1, LO 2.2, LO 2.3, LO 2.4)*
3. Identify and apply appropriate numerical methods to solve numerical differentiation, integration and System of equations.*(LO 3.1, LO3.2, LO 3.3, LO 3.4, L 3.5, LO 4.1, LO 4.2, LO 4.3, LO 4.4)*
4. Analyse and interpret the data using Correlation and Regression.*(LO5.1, LO5.2, LO5.3, LO5.4)*
5. Apply the concept of complex variables to analyze the function is Harmonic or not, and also determine orthogonal trajectory. *(LO 6.1, LO 6.2, LO6.3, LO 6.4)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
EEPCC405.1	3	2									
EEPCC405.2	3	2									
EEPCC405.3	3	2									
EEPCC405.4	3	2									
EEPCC405.5	3	2									
Average	3	2									

Text Books :

1. Higher Engineering Mathematics, Dr.B.S.Grewal, Khanna Publication
2. Advanced engineering mathematics, H.K. Das, S. Chand, Publications

Reference Books :

1. Advanced Engineering Mathematics, Erwin Kreyszig, Wiley Eastern Limited,
2. Complex Variables and Applications, Brown and Churchill, McGraw-Hill Education.
3. Higher Engineering Mathematics B.V. Ramana, McGraw Hill Education
4. Laplace transforms, Murray R. Spiegel, Schaum's Outline Series

Other Resources :

1. NPTEL Course: Probability and Statistics By Dr. Somesh Kumar, Department of Mathematics, IIT Kharagpur :-Web link- https://youtu.be/VVYLpmKRfQ8?si=Gh3EtQrLSrEFZMNo
2. NPTEL Course: Complex Analysis by Prof. P. A. S. Sree Krishna, Department of Mathematics, IIT Guwahati :-Web link https://youtu.be/Mwpz1zjPlzI?si=JU090YU2-MxJOXJD

IN-SEMESTER ASSESSMENT (75 Marks)

1. **Continuous Assessment (45 Marks)**

Continuous Internal Evaluation of Theory (20 Marks)
Numerical Assignments: 5 Marks
Class test based on above numerical Assignment: 5 Marks
Team-pair- Solo: 5 Marks
Regularity and attentiveness: 5 Marks
Continuous Internal Evaluation of Tutorial (25 Marks)
Minimum six Tutorials: 20 Marks
Regularity and attentiveness: 5 Marks
Students must be encouraged to write at least 6 class tutorials. At least 6 Class tests will be conducted based on class tutorials on entire syllabus. Each class tests carries 20 Marks. Average will be taken of all class tests.

2. **Mid Semester Exam (30 Marks)**
   Mid semester examination will be based on 40% to 50% of the syllabus

END SEMESTER EXAMINATION (50 Marks)

End semester examination 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 Type	Course Code	Course Name	Credits
PCC	EEPCC406	CONTROL SYSTEM	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. EEPCC301- Engineering Mathematics-III
2. EEPCC302-Circuit and Signal Analysis

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis

Course Objectives:

1. To impart the knowledge to differentiate real-life applications as open loop or closed loop systems and to obtain mathematical models of the systems.
2. To impart the knowledge to perform time response analysis of the model to predict the system's behaviour.
3. To introduce root locus technique and use this tool to analyse systems for transient and stability.
4. To introduce various frequency-domain techniques to analyse the systems for stability.

Module	Details	Hrs
	Course Introduction History, importance of control system, analysis and design objectives, control system design process.	**01**
01.	**Fundamentals of Control System**	**02-04**
	Learning Objective: *To apply the fundamentals of control system to identify suitable open loop or closed loop systems for real life applications.*	
	Contents: Concept of transient, steady state and stability, classifications of control system, concept of feedback, open loop and closed loop system properties. open loop and closed loop example with electrical systems.	
	Learning Outcomes: *A learner will be able to* *LO1.1: Apply electrical engineering concepts to identify different components of control system with its significance. (P.I.-1.3.1)* *LO1.2: Use core principles of engineering to understand the importance of Feedback in control system. (P.I.-1.4.1)* *LO1.3: Differentiate open loop and closed loop systems, use this knowledge to identify a suitable system for real life applications. (P.I.-2.1.2)* *LO1.4: Identify major performance criteria for the design of control system. (P.I.-2.1.3)*	

02.	**Mathematical Modelling**	**07-09**
	Learning Objective: *To formulate transfer function models for complex electrical systems by breaking them down into smaller components or constructing signal flow graphs using electrical and mechanical engineering concepts.*	
	Contents: Mathematical modelling of electro-mechanical systems, transfer functions, block diagrams, block diagram reductions, signal flow graph, signal flow graphs of electrical circuits, conversion of block diagram to signal flow graph, Mason's gain formula.	
	Self-Learning Topics: *Mathematical modelling of mechanical system with and without gears and its Electric Circuit Analog.*	
	Learning Outcomes: *A learner will be able to* *LO2.1: Formulate the transfer function model for electromechanical system by applying basic concepts in mechanical/electrical engineering. (P.I.-1.3.1)* *LO2.2: Reframe the complex systems into interconnected subsystems, construct transfer function for each subsystem, then reduce to a single transfer function model for the entire system. (P.I.-1.4.1)* *LO2.3: Use electrical engineering concepts to construct signal flow graphs for electrical systems and then to formulate the transfer function model using Mason's rule. (P.I.-2.3.1)* *LO2.4: Apply fundamental engineering concepts to convert transfer function to SFG.(P.I.-2.2.1)*	
03.	**Time Response Analysis**	**10-12**
	Learning Objective: *To analyze the transient, steady state and stability behavior of the system using the time domain specifications.*	
	Contents: Poles and zeros of the transfer function and their effects on response, step response of standard first order and second order systems, time-domain specifications, effect of addition of poles and zeros, static error coefficients, concept of stability, Bounded Input Bounded Output stability, Routh stability criterion.	
	Self-Learning Topics: *Derivation of closed loop transient parameter formula for the second order under damped system with ramp input.*	
	Learning Outcomes: ***A learner will be able to*** *LO3.1: Identify poles and zeros of a system from its transfer function and then analyze it to determine the time response. (P.I.-2.1.2)* *LO3.2: Solve the given transfer function to determine the damping ratio, natural frequency and static error coefficients of a system and use this information to analyze the transient and steady state behavior of the system. (P.I.-2.4.1)*	

	LO3.3: Construct and interpret a basic Routh array to analyze the system for its stability. (P.I.-2.4.2)	
04.	**Root Locus Technique**	**06-08**
	Learning Objective: *Use the root locus tool to analyze the transient response and stability of the given systems.*	
	Contents: Definition and properties of root locus, rules for plotting root locus, impact of gain on root locus, stability analysis using root locus. active and passive compensators in control system. impact of different compensators through root-locus.	
	Self-Learning Topics: *Realization of active and passive compensators*	
	Learning Outcomes: *A learner will be able to* *LO4.1: Use engineering mathematics and computations to sketch the root locus from the given transfer function model. (P.I.-2.1.2)* *LO4.2: Identify the coordinates of points on the root locus alongside their corresponding gains to analyze the transient behavior and stability of the system. (P.I.-2.4.1)* *LO4.3: Analyze the effect of adding active and passive compensators in control system using root locus. (P.I.-2.4.2)*	
05.	**Frequency Response Analysis**	**07-09**
	Learning Objective: *To analyze the given system for its stability using various techniques in frequency domain such as Bode and Nyquist plots.*	
	Contents: Bode plot, asymptotic Bode plot, determination of steady state error coefficients, stability analysis using Bode plot, mapping theorem, Nyquist plot, stability analysis using Nyquist plot.	
	Self-Learning Topics: *Relation Between Closed-Loop Transient and Closed-Loop Frequency Responses, Relation Between Closed-Loop Transient and Open-Loop Frequency Responses*	
	Learning Outcomes: *A learner will be able to* *LO5.1: Use engineering mathematics to sketch the Bode and Nyquist plot, from the given transfer function model. (P.I.-2.1.2)* *LO5.2: Identify the gain, phase margins and cross over frequencies from the Bode and Nyquist plot to analyze the system stability. (P.I.-2.4.1)* *LO5.3: Determine the steady-state error coefficients by sketching Bode plot to analyze the system's steady-state error characteristics. (P.I.-2.4.2)*	
06.	**State Variable Analysis**	**05-07**
	Learning Objective:	

	To formulate the state variable models, identify the eigen values and use it to analyze the system behaviour	
	Contents: State variable representation of electrical systems, different state space realizations. conversion of state variable models to transfer functions, conversion of transfer functions to state variable models, significance of eigen values, stability analysis.	
	Self-Learning Topics: *Solution of state equation using Laplace transform*	
	Learning Outcomes: *A learner will be able to* *LO6.1: Formulate the state space model for electrical system by applying linear algebra and the basic concepts in electrical engineering. (P.I.-1.1.1)* *LO6.2: Use engineering mathematics to determine various state space representations for the given system from its transfer function model. (P.I.-1.4.1)* *LO6.3: Identify the Eigen values from the state space model to analyze the system for its stability. (P.I.-2.1.2)*	
	Course Conclusion The course will conclude with the importance of circuit and signal analysis, for understanding electric power systems, design of electrical system, their behavior, and optimization in various applications, emphasizing the fact that it is a foundation course in Electrical Engineering.	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.1.1	Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply electrical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.2.1	Reframe complex problems into interconnected sub problems
2.3.1	Combine scientific principles and electrical engineering concepts to formulate model of a system that is appropriate in terms of applicability and required accuracy.
2.4.1	Apply engineering mathematics and computations to solve mathematical models.
2.4.2	Produce and validate results through skilful use of contemporary engineering tools and models

Course Outcomes:

1. Apply the fundamentals of engineering to identify a suitable control system for the given application. *(LO1.1, LO1.2, LO1.3, LO1.4)*
2. Formulate mathematical models for control system using transfer function and state space techniques. *(LO2.1, LO2.2, LO2.3, LO2.4, LO6.1, LO6.2)*

3. Apply engineering mathematics to identify the time domain specifications of the given control system, facilitating the analysis of its stability, transient and steady-state behaviour. *(LO3.1, LO3.2, LO3.3, LO6.3)*
4. Analyse the transient behaviour and stability of the system for change in parameters using root locus. *(LO4.1, LO4.2, LO4.3)*
5. Identify the steady state error and stability parameters from the Bode plot to analyse the system behaviour. *(LO5.1, LO5.2, LO5.3)*

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
EEPCC406.1	3	3									
EEPCC406.2	3	3									
EEPCC406.3	3	3									
EEPCC406.4		3									
EEPCC406.5		3									
Average	3	3									

Text Books:

1. Control Systems Engineering, Norman S. Nise, Seventh Edition, 2015, John Wiley & Sons
2. Control Systems Engineering, I. J. Nagrath. M. Gopal, Seventh Edition, 2021, New Age International Publisher
3. Modern Control System Engineering, K. Ogata, Fifth Edition, 2010, Prentice Hall.
4. Modern Control Systems, Richard C Dorf, Robert H Bishop, Twelfth edition, 2021, Pearson.
5. Feedback control of Dynamic System, G.F. Franklin, Eighth Edition, 2021, Pearson higher education

Reference Books:

1. Control System Engineering, Shivanagraju S. Devi L., 2010, New Age International
2. Control Systems Technology, Curtis Johnson, Heidar Malki, 2002, Pearson
3. Control Systems Engineering, S. K. Bhattacharya,Second Edition, 2015, Pearson.
4. Control Systems, Theory and applications, Smarajit Ghosh, 2013, Pearson

Other Resources:

1. 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/
2. NPTEL Course: Control Engineering By Prof. Ramkrishna Pasumarthy, Department of Electrical Engineering, IIT Madras :-Web link- https://nptel.ac.in/courses/108/106/108106098/
3. 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/

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

Suggested breakup of distribution

01 MCQ test strictly as per GATE exam pattern / level: 05 Marks
01 Class test: 05 Marks
Open book test/ Open notes test: 05 Marks
Regularity and active participation: 05 Marks

Mid Semester Exam (30 Marks)

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

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on 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

Course Type	Course Code	Course Name	Credits
PCC	EEPCC407	POWER ELECTRONICS	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. EEPCC302- Circuit and Signal Analysis

Program Outcomes addressed :

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/development of solutions
4. PO4: Conduct investigations of complex problems
5. PO9: Communication

Course Objectives :

1. To learn the operation of various power electronic devices and auxiliary circuits needed for power conversion and select them for suitable application.
2. To analyse various power electronic converters and select for an application.
3. To build a strong foundation for further study and implementation of power electronic circuits and systems.

Module	Details	Hrs
	Course Introduction: Concept of power electronics, power conversion & its significance, power electronics as an enabling technology in various applications of our day to day life.	**01**
01.	**Power Semiconductor Devices**	**7-9**
	Learning Objective/s: *Learner will acquire knowledge of various power electronic devices and its features, analyze data sheet and its losses to select a suitable device for power conversion..*	
	Contents: Characteristics & features of power diode, SCR, power BJT, power MOSFET, IGBT, Safe Operation Area (SOA), understanding datasheet of devices. Wide band gap devices, SiC & GaN and its applications. Comparison & selection of devices. Device losses: Conduction & Switching losses. **Self-Learning Topics:** Solve simple sums to enhance the understanding.	
	Learning Outcomes :	

	A learner will be able to *LO1.1 Apply fundamental concepts to plot the characteristics and identify the features of switching devices to select a device (PI-1.3.1).* *LO1.2 Apply electrical engineering concepts to find conduction and switching losses in devices (PI-1.4.1).* *LO1.3 Identify parameters and compare devices to choose them based on the requirements demanded by application (PI-2.1.2).* *LO1.4 Identify information from data sheets of switching devices to understand their operational limits(PI-2.2.2).*	
02.	**Auxiliary Circuits:**	**6-8**
	Learning Objective/s: *Learner will be able to demonstrate the ability to use and design various auxiliary circuits needed for the implementation of power electronic circuits..*	
	Contents: Need for gate driver circuits, design of Driver ICs, understanding its datasheets, floating power supply, level shifters, bootstrap drivers, isolated gate drivers, voltage & current sensing methods. Need for snubber circuits and its design, Heat sinks and EMI.	
	Self-Learning Topics: *Design of another other suitable driver ICs.*	
	Learning Outcomes : *A learner will be able to* *LO2.1. Apply fundamental concepts to identify the functions of gate driver circuits to select suitable gate driver circuit (PI-1.3.1).* *LO2.2. Apply electrical engineering concepts to select parameters of gate driver circuits and snubber circuits to meet the specific requirements (PI-1.4.1).* *LO2.3 Identify parameters of sensing circuits for sensing voltage and current to select appropriate sensing circuit for an application (PI-2.1.2).* *LO2.4 Identify and interpret data sheet parameters of driver ICs to select suitable driver IC (PI-2.2.2).*	
03.	**AC to DC Converters (Controlled Rectifiers)**	**6-8**
	Learning Objective/s: *Learner will be able to demonstrate the ability to analyze AC to DC power conversion circuits.*	
	Contents: Single phase, fully controlled full wave bridge rectifiers for R and R-L load, derivation of output voltage, two quadrant operation, issues of harmonics & poor power factor, relevant standards, concept of freewheel diode, need for PWM rectifier, working principle and applications, PWM Rectifier in traction.	
	Self-Learning Topics*: Other applications of controlled rectifiers.*	
	Learning Outcomes : *A learner will be able to* *LO3.1 Apply mathematical methods to derive the output voltage and current of controlled rectifiers (PI-1.1.1).*	

	LO3.2 Apply electrical engineering concepts and describe the working and draw output waveforms of controlled rectifiers (PI-1.4.1). *LO3.3 Extract the requirements from relevant standards related to power factor and harmonics in the input current of controlled rectifiers (PI-3.1.4).* *LO3.4 Identify the criteria to improve to power factor and harmonics in line with the limits given by relevant standards (PI-3.2.3).*	
04.	**DC-DC Converters**	**7-9**
	Learning Objective/s: *Learner will be able to analyze DC to DC power conversion circuits and its applications.*	
	Contents: Switched mode power supply and comparison with linear power supply, PWM operation, Buck, Boost, Buck-Boost dc to dc converters with resistive load and continuous conduction mode, Bidirectional dc to dc converters and its applications, DC-DC converter in power supply applications.	
	Self-Learning Topics: *Synchronous dc-dc converters.*	
	Learning Outcomes : *A learner will be able to* *LO4.1 Apply fundamental engineering concepts to identify the working and features of dc-dc converters(PI-1.3.1).* *LO4.2 Apply engineering concepts to derive the input to output voltage relation and understand various waveforms (PI-1.4.1).* *LO4.3 Identify various parameters to select energy storage elements in DC-DC converter (PI-2.1.2).* *LO4.4 Identify the features of DC-DC conversion to select them to meet the given requirements (PI-2.2.4).*	
05.	**DC–AC Converters**	**6-8**
	Learning Objective/s: *Learner will be able to understand and analyze DC to AC power conversion circuits.*	
	Contents: Single phase and Three phase voltage source Inverters, Square wave and sinusoidal PWM operation, concept of dead time, Harmonics in the inverter output voltage, Total Harmonic Distortion, relevant standards, Single phase current source inverters (CSI), comparison of VSI and CSI. Concept of multi-level inverter. Inverter in Uninterrupted Power supply.	
	Self-Learning Topics: *Multiple pulse PWM technique and comparison with SPWM.*	
	Learning Outcomes: *A learner will be able to* *LO5.1 Apply mathematical methods to derive the output voltage and current of inverters (PI-1.1.1).* *LO5.2 Apply electrical engineering concepts and describe the working and draw output waveforms of inverters (PI-1.4.1).* *LO5.3 Extract the requirements from relevant standards related to power factor and harmonics in the input current of inverters (PI-3.1.4).* *LO5.4 Identify the criteria to improve to power factor and harmonics in line with the limits given by relevant standards (PI-3.2.3).*	

06.	**Case Studies**	**5-7**
	Learning Objective/s: *To demonstrate the knowledge to analyse the given requirements, select suitable power electronic device and converter and communicate the selection to others effectively.*	
	Contents: Assimilate the information obtained about devices, auxiliary circuits and converters to do a case study of Power Factor Correction Circuits, DC-DC converter in portable equipment, Solar Power Conditioning unit, LED lamp driver circuits, any other power electronic application.	
	Self-Learning Topics: *Literature survey*	
	Learning Outcomes : *A learner will be able to* *LO6.1 Examine the requirements of the problem and methods to suggest various techniques for the solution (PI-4.1.2).* *LO6.2 Analyse various techniques to conclude the solution for the problem (PI-4.3.4).* *LO6.3 Analyse related information to choose the converters and energy storage elements (PI-9.1.1)* *LO6.4 Create a presentation and present it with proper justification (PI-9.1.3).*	
	Course Conclusion Course will conclude with the understanding of various power electronic devices, converters, systems and case studies. Emphasizing the fact that how this is a foundation course for so many other courses in Electrical Engineering.	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.1.1	*Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems*
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply electrical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.2.2	Identify, assemble and evaluate information and resources.
3.1.4	Extract engineering requirements from relevant engineering Codes and Standards such as IEEE,IEC etc.
3.2.3	Identify suitable criteria for the evaluation of alternate design solutions.
4.1.2	Examine the relevant methods, tools and techniques of experiment design, system calibration, data acquisition, analysis and presentation.
4.3.4	Synthesize information and knowledge about the problem from the raw data to reach appropriate conclusions.
9.1.1	Read, understand and interpret technical and non-technical information.
9.1.3	Create flow in a document or presentation - a logical progression of ideas so that the main point is clear.

Course Outcomes:

1. Apply the knowledge of various switching devices and interpret datasheets to select a suitable device for an application. LO1.1, LO1.2, LO1.3, LO1.4.
2. Identify the requirements and select auxiliary circuits of power electronic systems such as gate driver circuit, snubber circuits and sensing circuits. LO2.1, LO2.2, LO2.3, LO2.4.
3. Analyse the working of various power conversion circuits from AC to DC and DC to AC and its applications. LO3.1, LO3.2, LO3.3, LO3.4, LO5.1, LO5.2, LO5.3, LO5.4

4. Analyse the working of DC to DC power conversion and its applications. LO4.1, LO4.2, LO4.3, LO4.4.
5. Identify the requirements to select power electronic converters for various applications. LO6.1, LO6.2, LO6.3, LO6.4.

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
EEPCC407.1	3	3									
EEPCC407.2	3	3									
EEPCC407.3	3		3								
EEPCC407.4	3	3									
EEPCC407.5				3					3		
Average	3	3	3	3					3		

Text Books :

1. N. Mohan, T. M. Undeland, W.P Robbins, "Power Electronics, Converters, Applications & Design", Wiley India.
2. Joseph Vithayathil, "Power Electronics: Principles & Applications", McGraw Hill.
3. P.S. Bimbhra, "Power Electronics", Khanna Publishers.
4. M. H. Rashid, "Power Electronic: Circuits, Devices & Applications", Pearson education.
5. Daniel W. Hart, "Power Electronics", Mc GrawHill.

Reference Books :

1. R. W. Erickson and D Maksimovic, "Fundamental of Power Electronics", Springer, 2nd Edition.
2. P.C. Sen, "Power Electronics", Mc GrawHill.
3. M. H. Rashid, "Hand book of Power Electronics", PHI.
4. L. Umanand, "Power Electronics: Essentials & Applications", Wiley.

Other Resources :

1. NPTEL Course on Power Electronics, , Prof. B.G. Fernandes, Prof. Kishore Chatterjee, IIT Bombay https://nptel.ac.in/courses/108101038
2. NPTEL Course on Power Electronics, Prof. G.Bhuvaneshwari, Department of Electrical Engineering IIT Delhi https://archive.nptel.ac.in/noc/courses/noc20/SEM2/noc20-ee97/

IN-SEMESTER ASSESSMENT (50 MARKS)

1. **Continuous Assessment (20 Marks)**
   Suggested breakup of distribution
   01 MCQ test strictly as per GATE exam pattern / level + 1 Class test **(10 Marks)**
   Seminar: 05 Marks
   Regularity and active participation: 05 Marks

2. Mid Semester Exam (30 Marks)
Mid semester examination will be based on 40% to 50% syllabus

END SEMESTER EXAMINATION (50 MARKS)
End Semester Examination will be based on 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.

Course Type	Course Code	Course Name	Credits
PCC	EEPCC408	POWER SYSTEM ENGINEERING	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. EEPCC303- Elements of Power System

Program Outcomes addressed:

1. PO1-Engineering knowledge
2. PO2-Problem analysis
3. PO5-Engineering tool usage
4. PO6: The engineer and the world

Course Objectives:

1. To impart knowledge on symmetrical and unsymmetrical faults in power system.
2. To impart knowledge on power system transients due to switching in transmission line.
3. To introduce Insulation coordination to decide the lightning arrestor rating.
4. To introduce corona in transmission line.

Module	Details	Hrs
	Course Introduction Power Systems Engineering course deals with short circuit analysis, which provides currents and voltages in a power system during the fault condition. This information is needed to determine the required interrupting capacity of the circuit breakers and to design proper relaying system. It will ensure that personnel and equipment are protected from faults otherwise, it can be a serious threat to human life and can cause injury, extensive equipment damage, and costly downtime. Hence, the fundamental concepts of this course are essential for designing the electrical systems.	**01**
01.	**Symmetrical Fault Analysis**	**8-10**
	Learning Objective/s: *To apply knowledge of short circuit on synchronous machine and transmission line to analyse symmetrical faults in power system and perform simulation using modern tools*	
	Contents: Introduction to synchronous machine, basic construction, operation and equivalent circuit diagram, short circuit of synchronous machine: no load and loaded machine, transient on a transmission line, Selection of Circuit Breaker, short circuit MVA, Algorithm for short circuit studies, Z Bus formulation, symmetrical fault analysis using Z-bus.	

	Self-Learning Topics: Simulate symmetrical faults using software tools and analyze the results.	
	Learning Outcomes: *A learner will be able to* *LO1.1: Apply electrical engineering concepts to obtain equivalent circuit of synchronous machine and Z-bus of given power system (PI-1.3.1)* *LO1.2: Use basic principles of electrical engineering to solve short circuit problems in no-load and loaded condition of synchronous machine (PI-1.4.1)* *LO1.3: Identify and analyse symmetrical faults for a given power system network (PI-2.1.2)* *LO1.4: Formulate Z-bus model of power system to analyse symmetrical faults (PI-2.3.1)* *LO1.5: Identify modern engineering tools for modeling and analysis of symmetrical faults in power system (PI-5.1.1)*	
02.	**Symmetrical Components**	**4-6**
	Learning Objective/s: *To derive sequence components and draw sequence networks of transmission line, synchronous machine and transformer using symmetrical component technique*	
	Contents: Introduction, Symmetrical component transformation, sequence impedances and sequence network of transmission line, synchronous machine and transformer, power invariance, construction of sequence network of a power system	
	Learning Outcomes: *A learner will be able to* *LO2.1: Apply basic concepts in electrical engineering to formulate the symmetrical components of currents and voltages to solve problems in unbalanced power system (PI-1.3.1)* *LO2.2: Apply principles of symmetrical components to construct sequence networks of transmission line, synchronous machine and transformer for solving the problems in unbalanced power system. (PI-1.4.1)*	
03.	**Unsymmetrical Fault Analysis**	**9-11**
	Learning Objective/s: *To derive sequence network model and analyse different types of unsymmetrical faults in power system and simulate using modern tools*	
	Contents: Types of unsymmetrical faults, Analysis of shunt type unsymmetrical faults: single line to ground (SLG) fault, line to line (L-L) fault, double line to ground (LLG) fault	
	Self-Learning Topics: Simulate unsymmetrical faults using software tools and analyse results.	
	Learning Outcomes: *A learner will be able to* *LO3.1: Apply symmetrical components technique to solve problems of unsymmetrical faults in power system (PI-1.3.1)* *LO3.2: Apply basic principles to solve problems of unsymmetrical faults in power system (PI-1.4.1)* *LO3.3: Identify and analyse unsymmetrical faults in power system using symmetrical components (PI-2.1.2)*	

	LO3.4: Formulate model and analyse unsymmetrical faults in power system (PI-2.3.1) *LO3.5: Identify modern engineering tools for modeling and analysis of unsymmetrical faults (PI-5.1.1)*	
04.	**Sources of Power System Transients**	**7-9**
	Learning Objective/s: *To apply concepts of transients in power system and analyse arcing grounds, capacitance switching, current chopping and travelling waves*	
	Contents: Review of transients in simple circuits, recovery transient due to removal of short circuit, arcing grounds, capacitance switching, current chopping phenomenon. Travelling waves on transmission lines, wave equation, reflection and refraction of waves, typical cases of line terminations, attenuation, Bewley lattice diagram	
	Self-Learning Topics: ABCD parameters of transmission line	
	Learning Outcomes: *A learner will be able to* *LO4.1: Apply fundamental knowledge to solve problems due to transients in power system (PI-1.3.1)* *LO4.2: Apply basic concepts of electrical engineering to derive travelling wave equation for obtaining reflection and refraction waves in transmission line (PI-1.4.1)* *LO4.3: Identify and analyse arcing grounds, capacitance switching and current chopping in transmission line (PI-2.2.3)* *LO4.4: Formulate models to analyse typical cases of line terminations in transmission line (PI-2.3.1)*	
05.	**Lightning and Insulation Coordination**	**5-7**
	Learning Objective/s: *To analyse over voltages due to lightning and to find the rating of surge arrester to protect against lightning surges using insulation coordination in power system.*	
	Contents: **Lightning:** Shape of Lightning voltage wave, over voltages due to Lightning, Lightning protection problem, significance of tower footing resistance in relation to Lightning, insulator flashover and withstand voltages, protection against surges, surge arresters, surge capacitor, surge reactor and surge absorber, Lightning arrestors and protective characteristics, dynamic voltage rise and arrester rating. **Insulation Coordination:** - Volt time curve, basic approach to insulation co-ordination in power system, over voltage protection, ground wires, insulation coordination based on lightning, surge protection of rotating machines and transformers.	
	Self-Learning Topics: *Lightning phenomenon- mechanism of Lightning stroke*	

	Learning Outcomes: *A learner will be able to* *LO5.1: Identify and analyse over voltages due to lightning surge on transmission line (PI-2.2.3)* *LO5.2: Determine the tower footing resistance and rating of surge arrestor using insulation coordination to analyse protection of transmission line (PI-2.4.4)* *LO5.3: Identify tower footing resistance and rating of surge arrestor for public protection and safety. (PI-6.1.1)*	
06.	**Corona**	**4-6**
	Learning Objective/s: *To apply concept of electric discharge in air for understanding corona formation and calculate corona loss in transmission line*	
	Contents: Phenomenon of corona, Disruptive critical voltage, Visual critical voltage, corona loss, factors affecting corona loss, Radio interference due to corona, practical considerations of corona loss, corona in bundled conductor lines, corona ring	
	Self-Learning Topics: Nil	
	Learning Outcomes: *A learner will be able to* *LO6.1: Apply basic laws of engineering to calculate disruptive critical voltage, visual critical voltage during corona formation (PI-1.2.1)* *LO6.2: Use engineering concepts to calculate corona loss in transmission line and Identify factors affecting corona in transmission line (PI-1.4.1)*	
	Course Conclusion Calculation of symmetrical and unsymmetrical fault currents is important in selecting the circuit breaker rating in power system for protection. The knowledge of power system transients, insulation coordination and corona will be useful to build high voltage DC and AC transmission systems.	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.2.1	Apply laws of natural science to an engineering problem.
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply electrical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.3.1	Combine scientific principles and electrical engineering concepts to formulate model of a system that is appropriate in terms of applicability and required accuracy.
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis
5.1.1	Identify modern engineering tools such as computer aided drafting, modeling and analysis; techniques and resources for engineering activities
6.1.1	Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at global, regional and local level

Course Outcomes:

1. Apply basic principles to obtain equivalent circuit of synchronous machine and Z-bus for symmetrical fault analysis in power system *(LO1.1, LO1.2, LO1.3, LO1.4)*
2. Apply concepts of symmetrical components to construct sequence networks *(LO2.1, LO2.2).*
3. Identify and analyse unsymmetrical faults in power system using sequence networks *(LO3.1, LO3.2, LO3.3, LO3.4).*
4. Apply basic concepts to obtain travelling wave equation and line terminations in transmission line *(LO4.1, LO4.2, LO4.3, LO4.4)*
5. Identify and analyse insulation coordination to determine the lightning arrestor rating for protection of transmission line and calculate corona loss (LO5.1,LO5.2, LO5.3, LO6.1, LO6.2)
6. Identify modern engineering tools for modeling and analysis of symmetrical and unsymmetrical faults in power system *(LO1.5, LO3.5)*

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
EEPCC408.1	3	3									
EEPCC408.2	3										
EEPCC408.3	3	3									
EEPCC408.4	3	3									
EEPCC408.5		3				2					
EEPCC408.6					3						
Average	3	3			3	2					

Text Books:

1. D. P. Kothari, I. J. Nagrath, "Power System Engineering", 3e, Mc Graw Hill
2. Hadi Saadat, Power System Analysis, TMH publications
3. Stevenson and Grainger, Modern power system analysis, TMH publication, 1ed

Reference Books:

1. Turan Gonen, Modern power system analysis, Wiley
2. Power System Analysis by Arthur Bergen and Vijay Vittal
3. Power System Analysis and Design by J. Duncan Glover, M. S. Sarma and Thomas J. Overbye

Other Resources:

1. NPTEL Course on Power System Engineering by Prof. Debpriya Das, IIT Kharagpur, Link: https://nptel.ac.in/courses/108/105/108105104/
2. NPTEL Course on Power System Analysis by Dr. A.K. Sinha, IIT Kharagpur, Link: https://nptel.ac.in/courses/108/105/108105067/
3. NPTEL Course on Power System Generation, Transmission and Distribution by Prof. D.P. Kothari, IIT Delhi. Link: https://nptel.ac.in/courses/108102047

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

Suggested breakup of distribution

Numerical Assignment/s (min 20 problems): 05 Marks
Class test based on above numerical assignment: 05 Marks
Technical report writing/open book test: 05 marks

Regularity and Active Participation: 05 marks

2. Mid Semester Exam (30 Marks)

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

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on 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.

Course Type	Course Code	Course Name	Credits
LBC	EELBC403	POWER ELECTRONICS LABORATORY	01

Examination Scheme		
Continuous Assessment	**Practical /Oral**	**Total**
25	25	50

Pre-requisite :

1. EELBC301 - Electronics Lab
2. EEPCC407 - Power Electronics

Program Outcomes addressed:

1. PO2: Problem analysis
2. PO4: Conduct investigations of complex problems
3. PO8: Individual and Collaborative Team work
4. PO11: Life Long Learning

Course Objectives:

1. To impart knowledge on various parameters and characteristics of power electronic switching devices used for power conversion.
2. To provide skills to select parameters, implement and analyse the performance of auxiliary circuits needed for power electronic converters.
3. To provide skills to select parameters, implement and analyse the performance of various power electronic converters.

Module	Details	Hrs
01.	***Learning Objective/s:*** *To identify various parameters from datasheets of power electronic switching devices, plot the characteristics and analyse the features.*	**6**
	Theme for designing multiple experiments: 1. Test various power electronic switching devices, plot their characteristics and analyse their features.	
	Self-Learning Topics: *Watch videos on power electronic switching devices*	
	Learning Outcomes: *A learner will be able to* *LO1.1 Identify various parameters required for analyzing the performance of switching devices as a team (P.I.-2.1.2,8.2.2)* *LO1.2 Use systematic approach to implement the test circuit and evaluate its parameters as a team (PI-2.2.2, 8.2.2).* *LO1.3 Plot and analyze characteristics of switching devices such as power MOSFET, IGBT, WBG devices etc. (P.I.- 4.3.3)* *LO1.4 Compare the results obtained with the theoretical principles (P.I.-4.1.4)*	
02.	***Learning Objective/s:*** *To investigate the functioning of auxiliary circuits needed for the implementation of power electronic converters.*	**6**
	Theme for designing multiple experiments: Implement auxiliary circuits such as gate driver circuits, Snubber circuits etc.	
	Self-Learning Topics: *Watch videos on auxiliary circuits of power electronic converters*	

	Learning Outcomes: *A learner will be able to* *LO2.1 Identify the parameters to meet the requirements of auxiliary circuits such as gate driver circuits and snubber circuits (P.I.-2.1.2).* *LO2.2 Evaluate the requirements to select the parameters of the auxiliary circuit as a team (P.I.-2.2.2,8.3.1).* *LO2.3 Implement auxiliary circuit as a team, analyze the performance and draw conclusions as a team (P.I.-4.3.3,8.3.1)* *LO2.4 Compare the results obtained with the theoretical principles (P.I.-4.1.4)*	
03.	***Learning Objective/s:*** *To provide skills to implement and analyze the performance of various power electronic converters.*	**12**
	Theme for designing multiple experiments: 1.Implement power electronic converters to convert AC to DC and analyse the performance. 2.Implement power electronic converters to convert DC to AC and analyse the performance. 3.Implement power electronic converters to convert DC to DC and analyse the performance.	
	Self-Learning Topics: *Watch videos of different power electronic converters*	
	Learning Outcomes: *A learner will be able to* *LO3.1 Identify the parameters to meet the requirements of AC to DC or DC to AC or DC to DC converter (P.I.- 2.2.2).* *LO3.2 Evaluate the requirements to select the parameters of the converter (P.I.-2.2.2,8.3.1).* *LO3.3 Implement the converter as a team and use systematic procedures for collecting the required data. (P.I.- 4.3.1,8.3.1)* *LO3.4 Represent the collected data to evaluate its performance across parameter variations. (P.I.- 4.3.3).*	
04.	***Learning Objective/s:*** *To impart knowledge of a practical power electronic converter through demonstration of a hardware set up or simulate a power electronic converter.*	**06**
	Theme for designing multiple experiments: 1.Demonstration of hardware set up of any power electronic application and measurement of physical quantities. 2. Simulation of any power electronic converter.	
	Learning Outcomes: *A learner will be able to* *LO4.1 Identify parameters to solve the problem (PI-2.1.2,11.2.2).* *LO4.2 Identify and evaluate information (PI-2.2.2,11.3.1)* *LO4.3 Apply appropriate instrumentation to make measurements of practical power electronic application such as LED driver circuits, regulated power supply etc. (PI-4.1.3)* *LO 4.4 Use an appropriate tool for the simulation of a power electronic converter and analyze its performance (PI- 4.1.3).*	
	Minimum 2 experiments/demo/simulation from each module, and total at least 10 experiments/demonstration/simulation.	**30**

Performance Indicators:

P.I. No.	P.I. Statement
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.2.2	Identify, assemble and evaluate information and resources.
4.1.3	Apply appropriate instrumentation and/or software tools to make measurements of physical quantities.
4.1.4	Establish a relationship between measured data and underlying physical principles.
8.2.2	Treat other team members respectfully.
8.3.1	Present results as a team, with smooth integration of contributions from all individual efforts.
11.2.2	Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field
11.3.1	Source and comprehend technical literature and other credible sources of information

Course Outcomes: Learner will be able to

1. Use appropriate techniques to collect data to plot the characteristics and analyse the features of various power electronic switching devices. (LO1.1, LO1.2, LO1.3, LO1.4)
2. Apply the knowledge of auxiliary circuits to implement and analyse auxiliary circuits needed for power electronic converters. (LO2.1, LO2.2, LO2.3, LO2.4, LO3.1, LO3.2, LO3.3, LO3.4)
3. Analyse the requirements, select parameters, simulate and implement power electronic converters as a team. (LO4.1, LO4.2, LO4.3, LO4.4)

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
EELC403.1		3		3				3			
EELC403.2		3		3				3			
EELC403.3				3				3			3
Average		3		3				3			3

Text Books

1. Ned Mohan, Power Electronic Converters, John Wiley & sons.

2. P.S. Bimbhra, Power Electronics, Khanna Publishers.

Reference Books

1. Power Electronics Essentials and Applications, L. Umanand, Wiley
2. Data sheet of switching devices
3. Data sheet of ICs

Other Resources

1. Design and Simulation of Power Conversion Using Open Source Tools", Prof.L.Umanand, IISC, Bangalore https://archive.nptel.ac.in/noc/courses/noc20/SEM1/noc20-ee12/
2. Multisim software for simulation https://education.ni.com/teach/resources/967/power-electronics

CONTINUOUS ASSESSMENT (25 Marks)

Suggested breakup of distribution

- Lab Experiments: 10 Marks
- Internal Assessment: 10 marks

  Evaluating proficiency in the field by assessing the candidate's capability to execute connections or circuits, conduct experiments, accurately record test data, and derive meaningful conclusions through data analysis during regular laboratory session.

- Observation & Active Participation: 5 marks

END SEMESTER EXAMINATION (Practical/Oral Exam) (25 Marks)
Practical and Oral Examination:

Two examiners, one Internal and one External will do the evaluation.

- Students will be randomly allocated an experiment from the list of laboratory exercises and will be asked to draw circuit diagram, observation table with relevant formula. It will be checked by the examiners and evaluated out of 05 Marks.
- Then the student will be allowed to start with the performance of the experiment.
- Students will be given 1 hour to complete the circuit connections and take readings. The connections and output are verified by the examiners. The weightage is 05 Marks
- Students will do sample calculations, draw relevant graphs and write conclusion of the experiment. It will be checked by the examiners and evaluated out of 05 Marks.
- Students will then be appearing for Oral in front of both Internal and External examiners. The weightage of Oral will be of 10 Marks.

Course Type	Course Code	Course Name	Credits
LBC	EELBC404	CONTROL SYSTEM LABORATORY	01

Examination Scheme		
Continuous Assessment	**Practical /Oral**	**Total**
25	25	50

Pre-requisite:

1. EEPCC301- Engineering Mathematics-III
2. EEPCC302-Circuit and Signal Analysis

Program Outcomes addressed:

1. PO2: Problem analysis
2. PO4: Conduct investigations of complex problems
3. PO5: Engineering tool usage
4. PO8: Individual and Collaborative Team work:

Course Objectives:

1. To impart the knowledge on various components of closed loop control systems.
2. To impart the knowledge on modelling and transient and steady state analysis of closed loop control systems.
3. To impart the knowledge on the analysis of control system using Root-locus and Bode-plot technique with simulation platform.

Module	Details	Hrs
	Course Introduction This foundation course provides a comprehensive understanding of the basic principles and methodologies essential for designing, analyzing, and implementing control systems in various engineering applications.	
01.	***Learning Objective:*** *To investigate the functioning of various components of the given control system as a team.*	**06**
	Theme for designing multiple experiments: 1. Analyze the functioning of various components of the given open loop or closed loop control system	
	Learning Outcomes: *A learner will be able to* *LO1.1: Identify various components required for a control system, use systematic techniques to implement the system and evaluate its operation as a team. (P.I.-2.1.2, 2.2.2, 8.2.1,.8.3.1)* *LO1.2: Use a systematic approach as a team to gather data and analyze the system's performance across various parametric variations. (P.I.-4.1.4, 4.3.1)* *LO1.3: Formulate a mathematical model by observing and plotting the response with various inputs. (P.I.-4.1.4)*	
	Learning Objective:	

02.	*To investigate the behavior of the given control system as a team and to formulate an appropriate model of the system by examining its response.*	**10**
	Theme for designing multiple experiments: 2. Implement the given electrical system and analyze the transient and steady state behavior for various test input	
	Learning Outcomes: *A learner will be able to* *LO2.1: Implement the circuit and use systematic procedures to determine the transient and steady state parameters from the response as a team. (P.I.-4.3.1, 8.2.1,.8.3.1)* *LO2.2: Formulate the transfer function model from the response and compare the transfer function with the transfer function constructed from the circuit.(P.I.-2.3.1, 2.4.1, 4.1.4)* *LO2.3: Systematically analyze the response with change in parameters. (P.I.-4.1.4, 4.3.1)*	
03.	***Learning Objective:*** *To identify computational tool to sketch root locus and frequency response plots for the given system and analyze its behavior.*	**14**
	Theme for designing multiple experiments: 3. Use a simulation software to analyze the behavior of the given system utilizing various system models and computational tools, including analysis with and without compensator.	
	Learning Outcomes: *A learner will be able to* *LO3.1: Use suitable simulation software to implement transfer function model for the given system and analyze its behavior for change in pole location, addition of poles and zeros, change in time domain specifications etc. (P.I.-2.4.1,5.1.1, 5.1.2)* *LO3.2: Develop a program algorithm to plot root locus, Bode plot, or Nyquist plot by coding the transfer function of the provided system directly, allowing for thorough system analysis. (P.I.-2.4.2)* *LO3.3: Construct state space model from transfer function, determine the eigen values and analyze the system for stability. (P.I.-2.4.1)* *LO3.4: Formulate transfer function model for the given electrical system, implement the transfer function, include a suitable compensator and analyze the performance using a suitable simulation tool. (P.I.-2.4.1, 2.4.2, 5.1.1, 5.1.2)*	
	Minimum 2 experiments from each module, and total at least 10 experiments	**30**

Performance Indicators:

P.I. No.	P.I. Statement
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.2.2	Identify, assemble and evaluate information and resources.
2.3.1	Combine scientific principles and electrical engineering concepts to formulate model of a system that is appropriate in terms of applicability and required accuracy.
2.4.1	Apply engineering mathematics and computations to solve mathematical models.

2.4.2 Produce and validate results through skillful use of contemporary engineering tools and models
4.1.4 Establish a relationship between measured data and underlying physical principles

4.3.1 Use appropriate procedures, tools and techniques to conduct experiments and collect data

5.1.1 Identify modern engineering tools such as computer aided drafting, modeling and analysis; techniques and resources for engineering activities

5.1.2 Adapt the tools and techniques to solve engineering problems

8.2.1 Demonstrate effective communication, problem solving, conflict resolution and leadership skills

8.3.1 Present results as a team, with smooth integration of contributions from all individual efforts

Course Outcomes:

1. Investigate the given system, employ systematic data collection methods, and analyze the functioning of various components of the control system for the specific application as a team.*(LO1.1, LO1.2, LO1.3)*
2. Analyze the transient and steady state behavior of physical systems to standard test inputs. *(LO2.1, LO2.2, LO2.3)*
3. Use an appropriate simulation tool to analyze the behavior of the specified system, employing root locus and frequency response plots. *(LO3.1, LO3.2, LO3.3, LO3.4)*

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
EELBC404.1		3		3				3			
EELBC404.2		3		3				3			
EELBC404.3		3			3						
Average		3		3	3			3			

Text Books:

1. Control Systems Engineering, Norman S. Nise, Seventh Edition, 2015, John Wiley & Sons
2. Control Systems Engineering, I. J. Nagrath. M. Gopal, Seventh Edition, 2021, New Age International Publisher
3. Control Systems Engineering, Norman S. Nise, Seventh Edition, 2015, John Wiley & Sons

Reference Books:

1. Control Systems Engineering, S. K. Bhattacharya,Second Edition, 2015, Pearson.
2. Control Systems, Theory and applications, Smarajit Ghosh, 2013, Pearson

Other Resources:

1. 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/
2. Control Engineering By Prof. Ramkrishna Pasumarthy, Department of Electrical Engineering, IIT Madras :-Web link- https://nptel.ac.in/courses/108/106/108106098/

CONTINUOUS ASSESSMENT (25 Marks)

Suggested breakup of distribution

- Lab Experiments: 10 Marks
- Internal Assessment (10 marks)
  Evaluating proficiency in the field by assessing the candidate's capability to execute connections or circuits, conduct experiments, accurately record test data, and derive meaningful conclusions through data analysis during regular laboratory session.
- Observation & Active Participation: 5 marks

END SEMESTER ASSESSMENT (Practical/Oral Examination) (25 Marks)

Students will be randomly allocated an experiment from the list of laboratory exercises and will be asked to draw circuit/block diagram, observation table and write relevant formula. It will be checked by the examiners (Internal and External) and evaluated out of 05 Marks.

Then the student will be allowed to start with the performance of the experiment.

- Students will be allocated 1 hour to complete the circuit connections and take readings. The connections and output is then checked by both the examiners for its correctness. The weightage is 05 Marks
- Students will do sample calculations, draw graph if required and write conclusion of the experiment. It will be checked by the examiners (Internal and External) and evaluated out of 05 Marks.
- Students will then be appearing for Oral in front of both Internal and External examiners. The weightage of Oral will be of 10 Marks.

Two examiners, one Internal and one External will do the evaluation.

Course Type	Course Code	Course Name	Credits
LBC	EELBC405	MEASUREMENT AND INSTRUMENTS LABORATORY	01

Examination Scheme		
Continuous Assessment	**Practical /Oral**	**Total**
25	25	50

Pre-requisite :

1. ESC102-Basic Electrical Engineering
2. ESC203- Basic Electronics Engineering

Program Outcomes addressed:

1. PO2: Problem Analysis
2. PO4: Conduct investigations of complex problems
3. PO8: Individual and Collaborative Team work:

Course Objectives:

1. Provide hands on experience to use sensors, transducers and laboratory instruments for testing and measurement.
2. Develop the ability to identify, select and integrate suitable sensor/ transducers for any given applications.
3. Impart knowledge of measurements based on the sensors / transducers and the relevant instrumentation for practical purpose.

Module	Details	Hrs
	Course Introduction Sensors, transducers, and measuring instruments are indispensable tools for electrical engineers, enabling them to acquire data, control systems, ensure safety, improve efficiency, conduct research, maintain quality, and monitor the environment across a wide range of applications.	**02**
01.	**Sensors/ Transducers** ***Learning Objective/s:*** *Identify the various types of sensors/ transducers commonly used in practice based on their specifications, analyse and select the suitable one for specific application.* **Content:** **Sensors/ transducers** Types of Sensors/ transducers for measurement of various electrical/ non electrical parameters used in practice. Datasheet of sensors/ transducers, Understanding the specifications, Characterization / calibration of sensors/ transducers. Types / variants in sensors/ transducers for any parametric measurements, Selection and suitability of sensors/ transducers for given application(Sensors / Transducers used for Current (AC/DC), Voltage (AC/DC), L/C/R/Q, Temperature, Speed, Pressure etc.)	**08**

	Theme for designing multiple experiments: 1. Demonstration of various sensors/ transducers, applications based on them, characterization of the sensor using measuring lab instruments. 2. Testing of sensors/ transducers for a given application. 3. Characterization / calibration of sensors/ transducers 4. Selection of sensors/ transducers for a given application	
	Learning Outcomes: *A learner will be able to* *LO1.1 Identify different sensors/ transducers for an application. (PI-2.1.2,8.2.1)* *LO1.2 Select sensors/ transducers for an application. (PI-2.2.2,8.2.1)* *LO1.3 Interpret the specifications, datasheet parameters of sensors/ (PI-4.1.3,8.2.2)* *LO1.4 Characterize/calibrate of sensors/ transducers for given application using measuring laboratory instruments (PI-4.1.4,8.2.2)*	
02.	**Measuring Instruments**	**08**
	Learning Objective/s: *To identify the various types of measuring instruments commonly used in practice based on their specifications, analyze and select the suitable one for specific application.*	
	Content: **Use of Lab Equipment:** Standard Lab Instruments: Multi-meter, Power Supply, Function Generator, Tachometer, thermometer, clamp-on meter, DSO etc. (Study at least 2 such equipment) Special Measuring Instruments: True RMS multi-meter, Lux meter, Megger, LCRQ meter, Power Meter, Thermal Analyzer, Anemometer, Humidity Meter, Earthling Resistance meter, Insulation Resistance meter etc. (Study at least 2 such equipment) Special Lab Equipment: High Power DC Supply, Isolated DSO, Power Analyzer, Emulators etc. (Study at least one of such equipment) Students should be trained to use these classes of lab equipment with good expertise achieved. Students should clearly understand and differentiate the situations in which use of each of these equipment is best suitable. Identify, use and practice the measurement instruments using Standard Lab Equipment, Special Measuring Instruments and Special Lab Equipment. **Theme for designing multiple experiments:** 5. Identify, use and practice the measurement using Standard Lab Equipment. 6. Identify, use and practice the measurement using Special Measuring Instruments. 7. Identify, use and practice the measurement using Special Lab Equipment.	
	Learning Outcomes: *A learner will be able to* *LO2.1 Select measuring instruments for an application. (PI-2.1.2,8.2.1)* *LO2.2 Use measuring instruments for laboratory experiments (PI-2.2.2,8.2.1)* *LO2.3 Measure electrical parameters using appropriate instruments. (PI-4.1.3,8.2.2)* *LO2.4 Compare the same parameter using different measuring instruments. (PI-4.1.4,8.2.2)*	

03.	**Instrumentation**	**12**
	Learning Objective/s: *To demonstrate the skill to identify suitable instrumentation for the given application and analyse its performance.*	
	Content:	
	Voltage /Current (AC/DC) measurement with suitable sensor/ transducer and signal processing circuits with measurement of temperature/pressure /speed using with suitable sensor/ transducer and signal processing circuits and measurement of R/L/C using a bridge technique **Theme for designing multiple experiments:** 8. Measurement Voltage /Current (AC/DC) with suitable sensor/ transducer and signal processing circuits. 9. Measurement of temperature/pressure /speed with suitable sensor/ transducer and signal processing circuits. 10. Measurement of R/L/C using a bridge technique 11. Measurement of any one selected parameter of above experiments to implements in an application using sensors and measuring instruments.	
	Learning Outcomes: *A learner will be able to* *LO3.1 Identify the required sensor/ transducer from datasheet parameters for an application. (PI-4.1.3,8.2.2)* *LO3.2 Select suitable sensor/ transducer and measuring instruments for an application. (PI-2.1.2,8.2.1)* *LO3.3 Implement the circuit and measure the parameters using appropriate measuring instruments. (PI-2.2.2,8.2.1)* *LO3.4 Collect, characterize and analyze the result observed. (PI-4.1.4,8.2.2)*	
	Minimum 03 experiments from each module and total at least 10 experiments	**30**

Performance Indicators:

P.I. No.	P.I. Statement
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.2.2	Identify, assemble and evaluate information and resources.
4.1.3	Apply appropriate instrumentation and/or software tools to make measurements of physical quantities
4.1.4	Establish a relationship between measured data and underlying physical principles
8.2.1	Demonstrate effective communication, problem-solving, conflict resolution and leadership skills
8.2.2	Treat other team members respectfully

Course Outcomes: Learner will be able to

1. To select and use sensors/transducers for testing and measurement. *(LO1.1, LO1.3, LO1.4, LO2.1, LO2.2, LO2.3, LO2.4)*
2. To select and use measuring instruments for testing and measurement. *(LO1.1, LO1.3, LO1.4, LO2.1, LO2.2, LO2.3, LO2.4)*
3. To implement instrumentation for a selected application. (*LO3.1,LO3.2, LO3.3, LO3.4)*

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
EELC405.1		3		3				3			
EELC405.2		3		3				3			
EELC405.3		3		3				3			
Average		3		3				3			

Text Books:

1. Electrical & Electronic Measurements and Instrumentation, AK Sawhney,18th edition,2001, Dhanpat Rai & Sons
2. Modern Electronic Instrumentation and Measurement Techniques, Helfric and Cooper,3rd edition,1985, PHI
3. Electronic Instrumentation, H.S.Kalsi,Third Edition, 2006, Tata McGraw Hill

Reference Books:

1. Principle of Measurement & Instrumentation, Alan.S.Moris,3rd edition,2001,Prentice Hall of India
2. Electrical Measurement & Instrumentation, RS Sirohi & Radhakrisnan,4th edition,2005, New Age International
3. Sensors Handbook, Second Edition, RS Sirohi & Radhakrisnan, 2nd edition,2008, McGraw Hill

Other Resources :

1. Virtual Lab An Initiative of Ministry of Education Under the National Mission on Education through ICT http://vlab.co.in/broad-area-electronics-and-communications

CONTINUOUS ASSESSMENT (25 Marks)

Suggested breakup of distribution

- Lab Experiments: 10 Marks
- Internal Assessment (10 marks)
  Evaluating proficiency in the field by assessing the candidate's capability to execute connections or circuits, conduct experiments, accurately record test data, and derive meaningful conclusions through data analysis during regular laboratory session.
- Observation & Active Participation: 5 marks

END SEMESTER ASSESSMENT (Practical/Oral Examination) (25 Marks)

- Students will be randomly allocated an experiment from the list of laboratory exercises and will be asked to draw circuit diagram, observation table and write relevant formula. It will be checked by the examiners (Internal and External) and evaluated out of 05 Marks.

  Then the student will be allowed to start with the performance of the experiment.
- Students will be allocated 1 hour to complete the circuit connections and take readings. The connections and output is then checked by both the examiners for its correctness. The weightage is 05 Marks

- Students will do sample calculations, draw graph if required and write conclusion of the experiment. It will be checked by the examiners (Internal and External) and evaluated out of 05 Marks.
- Students will then be appearing for Oral in front of both Internal and External examiners. The weightage of Oral will be of 10 Marks.

Two examiners, one Internal and one External will do the evaluation.

Course Type	Course Code	Course Name	Credits
SBL	EESBL402	PCB FABRICATION AND CIRCUIT TESTING LABORATORY	02

Examination Scheme		
Continuous Assessment	End Semester Examination (ESE)	Total
50	50	100

Pre-requisite:

1. ESC102- Basic Electrical Engineering
2. ESC203- Basic Electronics Engineering
3. EEPCC407- Power Electronics

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem analysis
3. PO3: Design solutions for complex engineering problems
4. PO4: Conduct investigations of complex problems
5. PO5: Engineering tool usage
6. PO6: The Engineer and The World
7. PO10: Project Management and Finance
8. PO11: Life-Long Learning

Course Objectives:

1. To develop the skill set to work on real-life projects and its design.
2. To develop the required skill set to design, develop and assemble the PCB using the CAD tools.

Module	Detailed Contents	Hrs.
	Course Introduction This course is designed to provide a comprehensive understanding of the principles and practices involved in the design and fabrication of Printed Circuit Boards (PCBs). Through a combination of theoretical lectures, hands-on laboratory sessions, and practical projects, students will gain proficiency in using CAD software tools for design and simulation. Additionally, through project work, students will have an opportunity to apply their knowledge to different scenarios, fostering creativity, innovation, and problem-solving abilities.	**01**
01.	**Types of PCB**	**10**
	Learning Objective/s: *To compare the characteristics and applications of common PCB materials and difference between single-sided and multi-layer PCBs.*	
	Content: Types of PCBs: Single Sided (Single Layer), Multi-Layer (Double Layer) PCB Materials: Standard FR-4 Epoxy Glass, Multifunctional FR-4, Tetra Functional FR-4, NelcoN400-6, BT Epoxy Glass, Teflon , IPC Standard for PCB Materials	

	Theme for designing multiple experiments: 1. Demonstration of PCB fabrication facility.	
	Learning Outcomes: *A learner will be able to* *LO1.1 Identify different PCB materials such as FR-4 epoxy glass, Teflon, and NelcoN400-6 etc. (PI 1.3.1)* *LO1.2 Identify various types of PCB: single-sided, double-sided, and multi-layer PCBs, based on their structural characteristics and layout complexities. (PI 1.4.1)*	
02.	**Components and its Categories**	**10**
	Learning Objective/s: *To identify and categorize electronic components based on their functionality and application.*	
	Content: Types of Components: Active Components: Diode, Transistor, MOSFET/IGBT, LED, SCR, Integrated Circuits (IC's) Passive Components: Resistor, Capacitor, Inductor, Transformer, Speaker/Buzzer Component Package Types: Through Hole Packages, Axial lead, Radial Lead, Single Inline Package (SIP), Dual Inline Package (DIP), Transistor Outline (TO), Pin Grid Array (PGA), Metal Electrode Face (MELF), Leadless Chip Carrier (LCC), Small Outline Integrated Circuit (SOIC), Quad Flat Pack (QPF) and Thin QFP (TQFP), Ball Grid Array (BGA), Plastic Leaded Chip Carrier (PLCC).	
	Theme for designing multiple experiments: 2. Use of videos/ photographs & actual components to show electrical/ electronic components used in practice. 3. Identification of components, reading data sheets and handling components.	
	Learning Outcomes: *A learner will be able to* *LO2.1 Identify and classify electronic components, such as passive components, active components, and electromechanical components. (PI 1.3.1)* *LO2.2 Classify electronic components based on different component package type. (PI 1.4.1)* *LO2.3 Select appropriate component types and package styles based on circuit design requirements and space constraints. (PI 3.2.1, PI 11.2.1)*	
03.	**Introduction to CAD Tools**	**08**
	Learning Objective/s: *To gain proficiency in utilizing both open-source and commercial software for PCB design and simulation.*	
	Content: Introduction to open source and commercial software like: Proteus, Altium, Eagle, OrCAD, KiCAD, easy EDA etc.	
	Theme for designing multiple experiments: 4. Demonstration of CAD software tool for PCB design.	

	Learning Outcomes: *A learner will be able to* *LO3.1 Demonstrate the ability to create and modify schematic designs and PCB layouts using the CAD software tool. (PI 3.3.1, PI 5.1.2)* *LO3.2 Check for the suitability of different PCB design tools for specific project requirements.(PI 5.3.1, PI 11.2.1)*	
04.	**PCB Basic Artwork Designing**	**15**
	Learning Objective/s: *To develop the ability to create precise and optimized PCB layouts, incorporating component placement, routing techniques, and other design considerations.*	
	Content: Keywords & Their Description: Footprint, Vias, Tracks, PCB Track width/ size calculation formula, Schematic Entry, Net listing, PCB Layout Designing Description of PCB Layers: Electrical Layers: Top Layer, Bottom Layer Mechanical Layers: Board Outlines and Cutouts, Drill Details Documentation Layers: Components Outlines, Reference Designation, Text Prototype Designing: Design Rule Check (DRC), Electronic rule checking (ERC) Rules for Track: Track Length, Track Angle, Vias, Track Size.	
	Theme for designing multiple experiments: 5. Create a simple schematic layout to glow an LED using CAD software. 6. Create a schematic layout to achieve the desired voltage at the output using CAD software. (voltage divider network). 7. Draw a schematic & board layout of a low pass filter circuit using CAD software. 8. Design a 2-layer schematic & board layout for gate driver circuit using CAD software**.**	
	Learning Outcomes: *A learner will be able to* *LO4.1 Identify key PCB design terms such as footprint, vias, tracks, schematic entry, net listing, and PCB layout design while adhering to industry standards. (PI 3.1.6, PI 6.2.1, PI 11.2.1)* *LO4.2 Identify the different PCB layers, including electrical layers, mechanical layers, and documentation layers, in compliance with industry standards. (PI 6.1.1, PI 1.4.1)* *LO4.3 Apply knowledge of PCB design for track width/size calculation to design optimized PCB layouts. (PI 3.2.2)* *LO4.4 Analyze the importance of Design Rule Check (DRC) and Electronic Rule Check (ERC) in prototype PCB design.(PI 3.3.1)*	
05.	**Advanced PCB Artwork Design, Fabrication and Testing**	**16**
	Learning Objective/s: *To gain proficiency in advanced PCB design concepts and fabrication techniques adhering to IPC standards.*	
	Content: Creating Library & Components. Auto routing: Setting up Rules, Defining Constraints, Auto router Setup Post Designing & PCB.	

	Fabrication Process: Printing the Design, Etching, Drilling, Interconnecting and Packaging Electronic Circuits (IPC) Standards, Gerber file Generation, Soldering and De-soldering, Component Mounting PCB and Hardware Testing. IPC Standard for PCB Fabrication.	
	Theme for designing multiple experiments: 9. Create a component library (any one component mentioned by the subject In Charge) 10. Design a schematic & board layout of a 15 V regulator circuit using LM317. 11. Design a schematic & board layout of a DC-DC buck/ boost converter circuit. 12. Design, fabrication, and testing of a 12V dual power supply circuit using 7812 & 7912 voltage regulators. 13. Use the given components to design a PCB board for the given microcontroller/ DSP Board. (any other design details to be given by subject in charge)	
	Learning Outcomes: *A learner will be able to* *LO5.1 Apply post-design processes such as Gerber file generation. (PI 3.2.2, PI 11.2.1)* *LO5.2 Collaborate in teams to fabricate PCB circuits. (PI 10.3.1, PI 2.4.4)* *LO5.3 Work in teams to diagnose and resolve circuit faults using testing tools, ensuring reliability and timely completion (PI 2.4.3, PI 10.3.2)*	
	Minimum 03 experiments from 3, 4, 5 modules, and total at least 10 experiments	**60**

Performance Indicators:

P.I. No.	P.I. Statement
1.3.1	Apply fundamental engineering concepts to solve engineering problems
1.4.1	Apply Electrical engineering concepts to solve engineering problems.
2.4.3	Identify sources of error in the solution process, and limitations of the solution.
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis
3.1.6	Determine design objectives, functional requirements and arrive at specifications
3.2.1	Apply formal idea generation tools to develop multiple engineering design solutions
3.2.2	Build models/prototypes to develop a diverse set of design solutions
3.3.1	Apply formal decision-making tools to select optimal engineering design solutions for further development
5.1.2	Create/adapt/modify/extend tools and techniques to solve engineering problems
5.3.1	Discuss limitations and validate tools, techniques and resources
6.1.1	Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at the global, regional and local level
6.2.1	Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public
10.3.1	Identify the tasks required to complete an engineering activity, and the resources required to complete the tasks.
10.3.2	Use project management tools to schedule an engineering project, so it is completed on time and on budget.
11.2.1	Identify historic points of technological advance in engineering that required

practitioners to seek education in order to stay current

Course Outcomes:

1. Identify various types of Printed Circuit Boards (PCBs) and their materials based on fundamental principles of PCB design. *(LO1.1, LO1.2, LO4.2)*
2. Classify different electrical and electronic components along with their packages and footprints. *(LO2.1, LO2.2)*
3. Use of CAD tools and select suitable components and incorporate them into schematic and PCB layouts *(LO2.3, LO3.1, LO3.2)*
4. Analyse PCB layouts for precision, optimization, and compliance with standards. *(LO4.1, LO4.3, LO5.1)*
5. Work collaboratively in teams to demonstrate proficiency in PCB fabrication, testing, and debugging. *(LO5.2, LO5.3)*

CO-ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
EESBL402.1	3										
EESBL402.2	3										
EESBL402.3			3		3	3					3
EESBL402.4			3								
EESBL402.5		3								3	
Average	3	3	3		3	3				3	3

Text Books:

1. Simon Monk, Make Your Own PCBs with EAGLE: From Schematic Designs to Finished Boards, 1st Edition, McGraw-Hill Education
2. Matthew Scarpino, Designing Circuit Boards with EAGLE: Make High-Quality PCBs at Low Cost, 1st Edition Prentice Hall.
3. Archambeault and Drewniak James, PCB Design for Real-World EMI Control, Springer Publications

Reference Books:

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

Other Resources:

1. Electronic Packaging and Manufacturing by Prof. A Bhattacharya, Prof. Goutam Chakraborty, IIT Kharagpur :-Web link- https://nptel.ac.in/courses/112105267

CONTINUOUS ASSESSMENT (50)

1. Continuous Assessment (20 Marks)

Suggested breakup of distribution

1. Task assigned during Lab session: 5 Marks
2. Internal Assessment: 10 marks

   To develop schematic circuit design, wherein the basic circuit details will be given prior. Students are expected to research and collect required resources.

They can use the resources and complete the assigned work on the given date and time within the Institute premises in presence of faculty member.

3. Regularity and active participation: 5 marks

2. Practical Test (30 Marks)

1. Identify type of PCB single sided (single layer), multi-layer (double layer) /different materials (standard FR-4 epoxy glass, NelcoN400-6). (10 marks)
2. Identify various electrical/electronic components and their packages/ footprints. (10 marks): split up of marks is mentioned below:
    a. Active components (4 marks)
    b. Passive components (3 marks)
    c. Component package type (3 marks)
3. Demonstrate component selection from libraries in schematic editor/ CAD software tool and its interconnection. (10 marks): split up of marks is mentioned below
    a. Selection of appropriate components and their packages/ footprints. (5 marks)
    b. Connection of component with other circuit elements. (5 marks)

END SEMESTER ASSESSMENT (Pract. / Oral Exam) (50 Marks)

(Pract. (25 marks) + Oral (25 marks) = 50 marks

1. Practical (25 marks)

For the End semester exams, practical examination will be conducted. The detail of the end-semester evaluation is as follows.

a. Design Task

Students will be provided with the circuit requirement. They will be asked to create a detailed PCB design including schematic, component placement, and routing using software tools like Eagle **(15 marks).**

b. Simulation and Analysis

To evaluate their ability to interpret simulation results, identify potential issues, and optimize the design, they will be asked to create a PCB Layout using the given circuit diagram based on following instructions. **(10 marks)**

1. Use dimensions as 4x3 inches.
2. Calculate the track width and then proceed with routing.
3. Avoid jumper wires
4. Observe proper placement of components.
5. Label each component.

2. Oral (25 marks)

1. Conceptual Understanding (15 marks)

To evaluate the conceptual understanding, questions based on topics such as PCB materials, layers, routing techniques and other such design considerations will be asked. Also their ability to explain complex concepts clearly and connect theoretical knowledge to practical applications will be tested

2. Problem-solving Scenarios (10 marks)

Problem solving approach is evaluated based on critical thinking skills, and ability to propose effective solutions for the given problem. Two examiners, one Internal and one External will do the evaluation.

Course Type	Course Code	Course Name	Credits
MNP	EEMNP402	Mini Project- 1B	02 each

Program Outcomes addressed:

1. PO1 : Engineering knowledge
2. PO2 : Problem Analysis
3. PO3 : Design/Development of Solutions
4. PO4 : Conduct investigations of complex problems
5. PO5 : Engineering Tool Usage
6. PO6 : The Engineer the world
7. PO7 : Ethics
8. PO8 : Individual and Collaborative Team work
9. PO9: Communication
10. PO10: Project Management & Finance
11. PO11: Life-long learning

Course Objectives

1. To familiarize students about available infrastructure at Department/Institute level, online resources, plagiarism, expectations from MP 1A and 1B, etc.
2. To guide students in identifying societal or research needs and formulating them into problem statements.
3. To facilitate problem-solving in group settings.
4. To apply basic engineering principles to address identified problems.
5. To foster self-learning and research skills.

Course Outcomes

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

1. Identify problems based on societal or research needs and methodology for solving them.
2. Apply knowledge and skills to solve societal problems collaboratively.
3. Develop interpersonal skills necessary for teamwork.
4. Analyze, verify, and validate results effectively through various methodologies, including, test cases/benchmark data/theoretical/inferences/experiments/simulations, etc.
5. Evaluate the societal and environmental impacts of proposed solutions.
6. Adhere to standard engineering practices.
7. Excel in written and oral communication by technical report writing, oral presentation, and publishing results in
   - Research/white paper/article/blog writing/publication, etc.
   - Business plan for entrepreneurship product creation
   - Patent filing/copyright.
8. Gain technical competencies by participating in competitions, hackathons, etc.
9. Demonstrate lifelong learning capabilities through self-directed group projects.
10. Apply project management principles effectively.

Guidelines for the Mini Project

- At the beginning of semester-III, project guides are required to conduct around 4 hours' orientation sessions including following topics:
    - Familiarizing students about infrastructure available at Department/Institute level and how to use it.
    - How to identify societal problems and formulate project problem statement.
    - How to carry out literature survey.
    - What is plagiarism and what care needs to be taken while writing a report.
    - What is project report template and how it should be used.
    - What are expectations from mini-projects 1A and 1B.
- Mini project may be carried out in one or more form of following:
  Product preparations, prototype development model, fabrication of set-ups, laboratory experiment development, process modification/development, simulation, software development, integration of software (frontend-backend) and hardware, statistical data analysis, creating awareness in society/environment etc.
- Students must form groups of 3 to 4 members either from the same or from different departments.
- Groups should conduct surveys to identify needs and develop problem statements in consultation with faculty.
- An implementation plan in Gantt/PERT/CPM chart format covering weekly activities must be submitted.
- Each group must maintain a logbook to record weekly progress, to be verified by the faculty supervisor.
- Faculty input should emphasize guiding by faculty and self-learning by group members.
- Groups should propose multiple solutions, select the best one in consultation with the supervisor, and develop a working model.
- The solution to be validated with proper justification and report to be compiled in standard format of the Institute. Research papers, competition certificates may be submitted as part of annexure to the report.
- With the focus on self-learning, innovation, addressing societal/research/innovation problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality be carried out in two semesters by all the groups of the students.
- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above, gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on a case by case basis.

In-Semester Continuous Assessment and End-Semester Examination Guidelines

- The Head of the Departments will assign a guide to each of the mini-projects and shall form a progress monitoring committee. The guide will carry out weekly monitoring of the project's progress. The committee shall carry out in-semester project evaluation based on presentations with a minimum of two evaluations per semester.
- Assessment will be based on individual contributions, understanding, and responses to questions asked.

- Continuous Assessment marks distribution in semester III (50 marks):
- 05 marks for the Topic Approval Presentation in front of the progress monitoring committee
- 15 marks for the Mid-Semester Progress Presentation in front of the progress monitoring committee
- 25 marks for the Final Report & Presentation
- 05 marks for Regularity and Active participation

- Continuous Assessment marks distribution in semester IV (50 marks):
- 15 marks for the In-Semester Two Presentations
- 05 marks for the Participation in Project Competitions, TPP, etc.
- 25 marks for the Final Report & Presentation
- 05 marks for Regularity and Active participation

The review/progress monitoring committee will assess projects based on the following criteria.

Semester III:

- Theoretical solution completion, including component/system selection/design of software solution and cost analysis.
- Two reviews will occur:
- The first review will focus on finalizing the problem statement (topic approval).
- The second review will focus on finalizing the proposed solution.

Semester IV:

- Expected tasks include procuring components/systems, constructing a working prototype, and validating results based on prior semester work.
- Reviews will be conducted as follows:
- The first review will assess the readiness to build a working prototype.
- The second review will involve a poster presentation and demonstration of the working model in the last month of the semester.

In addition to the above-mentioned points, the following performance criteria shall be included during the in-semester continuous assessment:

- Quality of survey and need identification.
- Clarity and innovativeness in problem definition and solutions.
- Requirement gathering feasibility study, cost-effectiveness, and societal impact of proposed solutions.
- Completeness and full functioning of the working model.
- Effective use of skill sets and engineering norms.
- Verification & validation of the solutions/test cases.
- Individual contributions to the group.
- Clarity in written and oral communication.
- Participation in technical paper presentations/project competitions/hackathon competitions, etc.

End-Semester Examination in Semester IV (50 marks):

- Presentation and demonstration to internal and external examiners: 20 marks.

- Emphasis on problem clarity, innovativeness, societal impact, functioning of the model, skill utilization, and communication clarity: 30 marks**.**

Course Type	Course Code	Course Name	Credits
VEC	VEC402	ENVIRONMENT & SUSTAINABILITY	02

Program Outcomes addressed:

1. PO2 : Problem Analysis
2. PO6 : The Engineer & The World
3. PO7 : Ethics
4. PO11: Life-long learning

Course Objectives :

1. To provide students with foundational knowledge and understanding of environmental science principles and concepts.
2. To explore the principles of sustainability and their applications in various domains of engineering and technology.
3. To familiarize students with the legal and ethical considerations associated with environmental management and sustainability practices.
4. To equip students with practical skills and strategies for promoting renewable energy, energy efficiency, waste management, and environmental impact assessment.

Module	Details
01.	**Foundations of Environmental Sciences** Introduction to Environmental Science, Earth's Systems: Atmosphere, Hydrosphere, Lithosphere, Biosphere, Ecological Principles: Energy flow, Nutrient cycling, Biodiversity, Environmental Degradation: Pollution, Deforestation, Habitat loss, Environmental Monitoring and Data Analysis.
02.	**Sustainability Basics** Concepts of Sustainability and Sustainable Development, Sustainable Resource Management: Water, Air, Land, Sustainable Agriculture and Food Systems, Sustainable Transportation and Urban Planning, Sustainable Business Practices and Corporate Social Responsibility
03.	**Legal & Ethical Considerations** Environmental Laws and Regulations: National and International Perspectives, Environmental Policies and Governance Frameworks, Ethical Issues in Environmental Decision Making, Environmental Justice and Equity, Corporate Ethics and Environmental Responsibility
04.	**Renewable energy & Energy efficiency** Introduction to Renewable Energy Sources: Solar, Wind, Hydro, Biomass, Geothermal, Energy Conversion Technologies and Systems Energy Efficiency Measures and Strategies, Policy Support for Renewable Energy Deployment, Economic and Environmental Impacts of Renewable Energy

05.	**Waste management & recycling** Solid Waste Management: Collection, Treatment, Disposal, Recycling Processes and Technologies, E-waste Management and Hazardous Waste Handling, Circular Economy Principles, Waste Reduction Strategies: Source Reduction, Reuse, Repair
06.	**Environmental Impact Assessment** Introduction to Environmental Impact Assessment (EIA), EIA Process: Screening, Scoping, Impact Assessment, Mitigation, Monitoring, Methods and Tools for Impact Assessment: GIS, LCA, Risk Assessment, Case Studies of EIA in Various Sectors: Infrastructure, Energy, Mining, Construction, Role of Stakeholders in EIA Process
Total no. of hours: **30**	

Course Outcomes :

1. Gain a comprehensive understanding of key environmental science principles and their relevance to engineering disciplines.
2. Apply principles of sustainability to analyse and address environmental challenges in engineering projects and processes.
3. Demonstrate awareness of legal and ethical considerations in environmental decision-making and management practices.
4. Develop proficiency in implementing renewable energy technologies and energy-efficient practices in engineering designs and operations.
5. Acquire knowledge and skills in waste management, recycling, and circular economy principles for sustainable resource utilization.
6. Apply environmental impact assessment methods to evaluate and mitigate the environmental impacts of engineering projects and activities.

Text Books :

1. Environmental Science: Toward a Sustainable Future by Richard T. Wright and Dorothy F. Boorse (Publisher: Pearson Education)
2. Introduction to Environmental Engineering and Science by Gilbert M. Masters and Wendell P. Ela (Publisher: Pearson Education)
3. Renewable and Efficient Electric Power Systems by Gilbert M. Masters (Publisher: Wiley)

Reference Books :

1. Environmental Law Handbook by Thomas F. P. Sullivan, David R. Buente Jr., and Sally Fairfax, Bernan Press
2. Sustainability Science by Bert J. M. de Vries, Springer
3. Environmental Impact Assessment: Theory and Practice by Peter Wathern, Routledge

Other Resources:

1. NPTEL Course: Introduction to Environmetal Engineering & Science- Fundamental & Sustainability Concepts, Prof.Brajesh Kumar Dubey, Department of Multidisciplinary IIT Kharagpur :-Web link https://archive.nptel.ac.in/courses/127/105/127105018/

2. NPTEL Course: Environment And Development, By Prof. Ngamjahao Kipgen, IIT Guwahati, Web link- https://onlinecourses.nptel.ac.in/noc23_hs133/preview