CURRICULUM
&
SYLLABUS
2022 Scheme
(Autonomous)
Version 1.0

B.TECH
ELECTRICAL AND COMPUTER ENGINEERING

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

Mar Ivanios Vidyanagar, Nalanchira, Thiruvananthapuram – 695015

CURRICULUM AND DETAILED SYLLABI

FOR

B. TECH DEGREE PROGRAMME

IN

ELECTRICAL AND COMPUTER ENGINEERING

SEMESTERS VII & VIII

2022 SCHEME

(AUTONOMOUS)

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY
(Approved by AICTE, Autonomous Institution Affiliated to APJ Abdul Kalam Technological University)
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MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

B. TECH DEGREE PROGRAMME

IN

ELECTRICAL AND COMPUTER ENGINEERING

FOURTH YEAR SYLLABUS

2022 SCHEME

Items	Board of Studies (BOS)	Academic Council (AC)
Date of Approval	30.04.2025	28.05.2025

Head of Department
Chairman, Board of Studies

Principal
Chairman, Academic Council

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

Vision and Mission of the Institution

Vision:

To be an Institution moulding globally competent professionals as epitomes of Noble Values.

Mission:

To transform the Youth as technically competent, ethically sound and socially committed professionals, by providing a vibrant learning ambience for the welfare of humanity.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Vision and Mission of the Department

Vision:

To be a Centre of Excellence in Electrical & Electronics Engineering Education, Research and Application of knowledge to benefit the society at large.

Mission:

To mould quality Electrical Engineers, fostering creativity and innovation to address global issues.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Graduates will succeed as Engineering Professionals in Industry or as Entrepreneurs in Electrical and Computer Engineering and the related disciplines and exhibit an urge for innovation.

PEO2: Graduates will be able to adapt to the advances in Technology by acquiring knowledge and skills manifested through continuous learning and higher qualifications.

PEO3: Graduates will be serving community as socially committed individuals, exhibiting professional ethics in addressing the technical and engineering challenges.

PROGRAMME OUTCOMES (POs)

Engineering graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO1: To apply the knowledge in Electrical Engineering and Computer Engineering for the design, development testing and operation of Power and Energy Systems in the areas of Generation, Transmission, Conversion, Distribution and Utilization systems.

PSO2: To apply the knowledge in Electrical Engineering and Computer Engineering for the design, development and operation of Industrial systems in the areas of Automation, Control, Energy Management and Economic operation.

CURRICULUM

SEMESTER VII						
Slot	**Cate-gory Code**	**Course Number**	**Courses**	**L-T-P**	**Hours**	**Credit**
A	PCC	EL2U40A	Control Systems	2-1-0	3	3
B	PCC	EL2U40B	Power System Engineering	2-1-0	3	3
C	PEC	EL2UXXX	Program Elective III	3-0-0	3	3
D	OEC	EL0UXXX	Open Elective I	3-0-0	3	3
E	MNC	NC0U40A	Industrial Safety Engineering	2-1-0	3	--
T	PWS	EL2U49A	Seminar	0-0-3	3	2
U	PWS	EL2U49B	Project Phase I	0-0-6	6	2
R/M/H	VAC		Remedial/Minor/ Honors Course	0-1-6	7/4	4
TOTAL					**24/31/28**	**16/22**

PROGRAMME ELECTIVE III

Slot	Category Code	Course Number	Courses	L-T-P	Hours	Credit
B	PEC	EL2U41A	Software Engineering	3-0-0	3	3
		EL2U41B	Machine Learning	3-0-0	3	3
		EL2U41C	Energy Management	3-0-0	3	3
		EL2U41D	Fundamentals of Robotics	2-1-0	3	3
		EL2U41E	Real Time Operating Systems	3-0-0	3	3
		EL2U41F	Digital Signal Processing	3-0-0	3	3
		EL2U41G	Web Programming	3-0-0	3	3
		EL2U41H	Electric Drives	3-0-0	3	3

OPEN ELECTIVE I

Slot	Category Code	Course Number	Courses	L-T-P	Hours	Credit
C	OEC	EL0U41A	Electrical Drives and Control for Automation	3-0-0	3	3
		EL0U41B	Architectural Lighting Design and Control	3-0-0	3	3
		EE0U42B	Electric Vehicles	3-0-0	3	3
		EL0U41D	Renewable Energy Systems	3-0-0	3	3
		EL0U41E	Introduction to Flight Dynamics and Control	3-0-0	3	3
		EL0U41F	Introduction to Power Processing	3-0-0	3	3

SEMESTER VIII						
Slot	**Cate-gory Code**	**Course Number**	**Courses**	**L-T-P**	**Hours**	**Credit**
A	PEC	EL2UXXX	Program Elective IV	2-1-0	3	3
B	PEC	EL2UXXX	Program Elective V	2-1-0	3	3
C	PEC	EL2UXXX	Program Elective VI	2-1-0	3	3
D	HSC	HS0U40A	Industrial Economics & Foreign Trade	3-0-0	3	3
T	PCC	EL2U40C	Comprehensive Course Viva	1-0-0	1	1
U	PWS	EL2U49C	Project Phase II	0-0-12	12	4
R/M/H	VAC		Remedial/Minor/Honors course	0-1-6	7	4
TOTAL					**25/32**	**17/21**

PROGRAMME ELECTIVE IV

Slot	Category Code	Course Number	Courses	L-T-P	Hours	Credit
B	PEC	EL2U42A	Computer Vision	3-0-0	3	3
		EL2U42B	Programming Paradigms	3-0-0	3	3
		EL2U42C	Cryptography	3-0-0	3	3
		EL2U42D	Mechatronics	3-0-0	3	3
		EL2U42E	Computer Aided Design of Electrical Machine	3-0-0	3	3
		EL2U42F	Smart Grid Technologies	3-0-0	3	3
		EL2U42G	Data Analytics for Electrical Engineers	3-0-0	3	3
		EL2U42H	HVDC & FACTS	3-0-0	3	3

PROGRAMME ELECTIVE V

Slot	Category Code	Course Number	Courses	L-T-P	Hours	Credit
C	PEC	EL2U43A	Robotics and Artificial Intelligence	3-0-0	3	3
		EE1U45A	Electric and Hybrid Vehicles	3-0-0	3	3
		EL2U43C	Deep Learning	3-0-0	3	3
		EL2U43D	Nonlinear Systems	3-0-0	3	3
		EL2U43E	Solar PV Systems	2-1-0	3	3
		EL2U43F	Cloud Computing	3-0-0	3	3
		EL2U43G	Vehicular Networks and Communication	3-0-0	3	3
		EL2U43H	Power System Protection	3-0-0	3	3

PROGRAM ELECTIVE VI

Slot	Category Code	Course Number	Courses	L-T-P	Hours	Credit
D	PEC	EL2U44A	Digital Control Systems	2-1-0	3	3
		EL2U44B	Block Chain Technologies	3-0-0	3	3
		EL2U44C	Data Mining	3-0-0	3	3
		EL2U44D	Special Electric Machines	3-0-0	3	3
		EL2U44E	Software Testing	3-0-0	3	3
		EL2U44F	Bioinformatics	3-0-0	3	3
		EL2U44G	Computer Aided Electrical System Design	2-1-0	3	3
		EL2U44H	Power Quality	3-0-0	3	3

SYLLABUS

SEMESTER VII

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U40A	CONTROL SYSTEMS	PCC	2	1	0	3	2022

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW:

This course introduces the fundamental concepts and mathematical tools required for analysing and designing feedback control systems. It covers time-domain and frequency-domain techniques, stability analysis, classical controller design, and practical applications in areas such as electric vehicles, robotics, and renewable energy systems. Emphasis is placed on the intuitive understanding of system behaviour, aided by simulation and case studies.

iii) COURSE OUTCOMES

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

CO1	Explain the fundamental concepts, types, and structure of control systems and their real-world applications.	Understand
CO2	Calculate time response parameters of first and second order systems and determine steady-state errors using error constants.	Apply
CO3	Use the Routh-Hurwitz criterion and root locus techniques to assess system stability and the behaviour of control systems in time-domain.	Apply
CO4	Construct and interpret frequency response plots such as Bode, Polar, and Nyquist diagrams, and identify gain and phase margins for stability evaluation.	Apply
CO5	Analyze classical control methods and illustrate their application in real-world systems such as electric vehicles, robotics, and renewable energy systems using simulation tools.	Analyze

iv) SYLLABUS

Introduction to control systems – Modeling of physical systems using differential equations and transfer functions – Time domain analysis of first and second order systems – Steady-state error and error constants – Stability criteria and Routh-Hurwitz method – Root locus technique – Frequency domain analysis using Bode and Nyquist plots – PID controllers – Applications in EVs, robotics and renewable energy – Introduction to MATLAB/Simulink.

v) (a) TEXT BOOKS

1) Nagarath I. J. and Gopal M., *Control System Engineering*, 5th edition, New Age International Private Limited, 2021.
2) Ogata K, *Modern Control Engineering*, 5th edition, Pearson, 2009.
3) Nise N. S, *Control Systems Engineering*, 6th edition, Pearson, 2009.
4) Dorf R. C. and Bishop R. H, *Modern Control Systems*, 12th edition, Pearson Education, 2010.

(b) REFERENCES

1) Kuo B. C, *Automatic Control Systems*, 7th edition, Prentice Hall of India, 1995.
2) Desai M. D., *Control System Components*, Prentice Hall of India, 2008
3) Gopal M., *Control Systems Principles and Design*, 4th edition, McGraw Hill Education Private Limited, 2016.
4) Imthias Ahamed T. P, *Control Systems*, Phasor Books, 2016.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Control Systems** Open loop and closed loop systems, Examples of control systems, Feedback and its effect, Mathematical modeling of electrical and mechanical systems, Transfer function – concept and derivation.	8
II	**Time Domain Analysis** Standard test signals – step, ramp, impulse, Time response of first and second order systems, Time domain specifications – rise time, peak time, overshoot, settling time, Steady-state error and error constants. Introduction to P, PI, PD and PID controllers.	9
III	**Stability Analysis and Root Locus** Concept of stability – BIBO and asymptotic, Routh-Hurwitz criterion and special cases, Root locus technique – construction rules, Sketching root locus plots, Effect of addition of poles and zeros.	10
IV	**Frequency Domain Analysis** Frequency response characteristics, Bode plot – construction and interpretation, Gain margin and phase margin, Polar plot and Nyquist stability criterion – basic concept, Introduction to compensators – lag, lead (basic concept).	10
V	**Practical Applications and Simulation** Overview of control elements – sensors, actuators, Control applications in electric vehicles – motor drive and regenerative braking, Control in robotics – robotic arm and autonomous navigation, Control in renewable energy – MPPT in solar and pitch control in wind systems, Simulation using MATLAB/Simulink – demo or assignment-based tasks.	8
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U40B	POWER SYSTEM ENGINEERING	PCC	2	1	0	3	2022

i) PRE-REQUISITE: ES0U10D-Basics of Electrical and Electronics Engineering, PH0U10A- Engineering Physics A.

ii) COURSE OVERVIEW:

The goal of this course is to expose the students to the fundamental concepts of generation, transmission and distribution of electric power. The course also intends to deliver the basic concepts of power system protection including the different types of relays and circuit breakers.

iii) COURSE OUTCOMES

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

CO1	Explain the different forms of power generation schemes, the importance of power system protection and different types of Circuit Breakers and relays.	Understand
CO2	Solve for the various parameters related to economics of power generation and power factor improvement.	Apply
CO3	Solve for the inductance, capacitance, ABCD parameters and volume of conductor material required for the various types of power transmission schemes.	Apply
CO4	Solve for the various parameters related to overhead transmission lines and cables.	Apply
CO5	Solve current distribution problems related to various power distribution systems.	Apply

iv) SYLLABUS

Introduction - Generation of Electric Power - Overview of conventional generation schemes, Economics of Generation – Terminology - Power Factor Improvement using capacitors.

Power Transmission - Transmission Line Parameters: Resistance, inductance and capacitance of single phase, two wire and three phase lines, Modelling of Transmission Lines.

Introduction of Overhead transmission– Volume of conductor material required - Mechanical Characteristics of transmission lines – Insulators.

HVDC Transmission – Comparison, Types of DC Links - Power distribution systems – DC and AC distribution - Types.

Basics of power system protection – Circuit Breakers - Protective Relays – Principle and types.

v) (a) TEXT BOOKS

1) B. R. Gupta, *Power System Analysis and Design*, Wheeler Publishers, 7th revised edition, 2005.
2) J. B. Gupta, *A course in Electrical Power*, Kataria and Sons, 2013 edition.

3) C. L. Wadhwa, *Electrical Power System*, New Age International Publishers, 1st edition, 2016.
4) Grainer J.G., Stevenson W.D., *Power System Analysis*, Tata McGraw Hill, 1st edition, 2017.
5) Badri Ram, D. N. Vishwakarma, *Power System Protection and Switchgear*, Tata McGraw Hill, 2nd edition, 1994.

(b) REFERENCES

1) A. Chakrabarti, M. L. Soni, P. V. Gupta, U. S. Bhatnagar, *A text book on Power System Engineering,* Dhanpat Rai and Co., 2016 edition.
2) I. J. Nagarath & D. P. Kothari, *Modern Power System Analysis*, Tata McGraw Hill, 4th edition, 2011.
3) K. R. Padiyar, *FACTS Controllers in Power Transmission and Distribution*, New Age International, New Delhi, 2nd edition, 2016.
4) William D. Stevenson Jr, *Elements of Power System Analysis*, Tata McGraw Hill, 4th edition, 1982.
5) Sunil S. Rao, *Switchgear and Protection*, Khanna Publishers, 2nd edition, 2012.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction:** Typical layout of Power system Network. **Generation of Electric Power:** Overview of conventional generation schemes-Hydro, Thermal and Nuclear; Non-conventional Sources-Solar and Wind. Economics of Generation: Terminology-Load factor, diversity factor, Load curve; Numerical Problems. Need of power factor improvement, Power Factor Improvement using capacitors.	9
II	**Power Transmission:** Transmission Line Parameters: Resistance, inductance and capacitance of 1Φ, 2 wire lines, Inductance and capacitance of 3Φ lines-Symmetrical and unsymmetrical spacing-transposition - Numerical Problems. Modelling of Transmission Lines: Classification of lines-short lines-voltage regulation and efficiency - medium lines - nominal T and Π configurations - Ferranti effect.	10
III	**Introduction of Overhead transmission:** Conductors - types of conductors - copper, aluminium and ACSR conductors - Volume of conductor required for various systems of transmission. Mechanical Characteristics of transmission lines –Calculation of sag and tension-supports at equal heights - effect of wind and ice. Insulators - Different types - Voltage distribution, grading and string efficiency of suspension insulators. Corona – disruptive critical voltage -visual critical voltage, Factors affecting corona.	9

IV	**HVDC Transmission:** Comparison between AC & DC Transmission, Schematic Diagram of HVDC transmission, Types of DC links. **Power distribution systems:** Radial and Ring Main Systems - DC and AC distribution: Types of distributors - bus bar arrangement - Concentrated loading - Methods of solving distribution problems.	**8**
V	**Power System Protection:** Nature, causes and consequences of faults- Need for protection - Essential qualities of protection - Types of protection – Primary and back up protection. **Circuit breakers:** principle of operation - formation of arc - Arc quenching theory - Restriking Voltage - Recovery Voltage, RRRV; Types of Circuit Breakers: Air blast CB – Oil CB – SF6 CB – Vacuum CB – CB ratings. **Protective Relays:** Zones of Protection, Essential Qualities - Classification of Relays - Electro mechanical, Static Relays, Microprocessor Based Relays; Buchholz relay for transformer protection.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
NC0U40A	INDUSTRIAL SAFETY ENGINEERING	MNC	2	1	0	-	2020

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW: Objective of the course to impart knowledge of various safety management principles, various safety systems, various machine guarding devices, hazard identification techniques, energy sources, systems & applications and the need in the present context.

iii) COURSE OUTCOMES

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

CO1	Explain the theories of accident causation and preventive measures of industrial accidents.	Understand
CO2	Explain about personal protective equipments, its selection, safety performance, role of housekeeping and work permits in industry.	Understand
CO3	Explain different safety issues in construction industries.	Understand
CO4	Summarize various hazards associated with different machines and material handling.	Understand
CO5	Explain different hazard identification tools in industries with the knowledge of different types of chemical hazards.	Understand

iv) SYLLABUS

Need for safety. Safety and productivity. Definitions: Accident, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. Theories of accident causation. Safety organization- objectives, types, functions, Role of management,

Personal protection in the work environment, Types of PPEs, Personal protective equipment-respiratory and non-respiratory equipment. Performance: Frequency rate, severity rate, incidence rate, activity rate. Housekeeping: Responsibility of management and employees. Typical industrial models and methodology.

Introduction to construction industry and safety issues in construction Safety in various construction operations – Excavation and filling – Under-water works – Under-pinning & Shoring – Ladders & Scaffolds – Tunneling – Blasting – Demolition – Confined space – Temporary Structures. Ergonomics Hazards - Musculoskeletal Disorders and Cumulative Trauma Disorders.

Machinery safeguard-Point-of-Operation, Principle of machine guarding -types of guards and devices. Safety in turning, and grinding. Welding and Cutting-Safety Precautions of Gas welding and Arc Welding, Material Handling equipment-operation & maintenance. Hearing Conservation Program in Production industries.

Hazard and risk, Types of hazards –Classification of Fire, Types of Fire extinguishers. Identification of hazards: Inventory analysis, Fire and explosion hazard rating of process plants - Hazard and Operability study (HAZOP)) –Hazardous properties of chemicals, Material Safety Data Sheets.

v) (a) TEXT BOOKS

1) R.K Jain, *Industrial Safety: Health and Environment management systems*, Khanna Publications, 2000.
2) Paul S V, *Safety management System and Documentation training Programme Handbook*, CBS Publication 2000.
3) Krishnan N.V, *Safety management in Industry*, JaiCO Publishing House, New Delhi, 1997.

(b) REFERENCES

1) AIChE/CCPS, *Guidelines for Hazard Evaluation Procedures*, (2nd Edition), Centre for Chemical Process Safety, American Institute of Chemical Engineers, New York. 1992.
2) Alan Waring, *Safety management system*, Chapman & Hall, England, 1996.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Need for safety. Safety and productivity. Definitions: Accident, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. Theories of accident causation. Safety, organization- objectives, types, functions, Role of management, supervisors, workers, unions, government and voluntary agencies in safety. Safety policy. Safety Officer-responsibilities, authority. Safety committee-need, types, advantages.	**9**
II	Personal protection in the work environment, Types of PPEs, Personal protective equipment-respiratory and non-respiratory equipment. Standards related to PPEs. Monitoring Safety Performance: Frequency rate, severity rate, incidence rate, activity rate. Housekeeping: Responsibility of management and employees. Advantages of good housekeeping. 5 s of housekeeping. Work permit system- objectives, hot work and cold work permits. Typical industrial models and methodology. Entry into confined spaces. Technology generation and development, technology generation, process, technology development, importance of technology generation and development	**9**
III	Introduction to construction industry and safety issues in construction Safety in various construction operations – Excavation and filling – Under-water works – Under-pinning & Shoring – Ladders & Scaffolds – Tunneling – Blasting – Demolition – Confined space – Temporary Structures. Familiarization with relevant Indian Standards	**9**

	and the National Building Code provisions on construction safety. Relevance of ergonomics in construction safety. Ergonomics Hazards - Musculoskeletal Disorders and Cumulative Trauma Disorders.	
IV	Machinery safeguard-Point-of-Operation, Principle of machine guarding-types of guards and devices. Safety in turning, and grinding. Welding and Cutting-Safety Precautions of Gas welding and Arc Welding. Material Handling-Classification-safety consideration-manual and mechanical handling. Handling assessments and techniques- lifting, carrying, pulling, pushing, palletizing and stocking. Material Handling equipment-operation & maintenance. Maintenance of common elements- wire rope, chains slings, hooks, clamps. Hearing Conservation Program in Production industries	**9**
V	Hazard and risk, Types of hazards –Classification of Fire, Types of Fire extinguishers, fire explosion and toxic gas release, Structure of hazard identification and risk assessment. Identification of hazards: Inventory analysis, Fire and explosion hazard rating of process plants - The Dow Fire and Explosion Hazard Index, Preliminary hazard analysis, Hazard and Operability study (HAZOP)) – methodology, criticality analysis, corrective action and follow-up. Control of Chemical Hazards, Hazardous properties of chemicals, Material Safety Data Sheets.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U49A	SEMINAR	PWS	0	0	3	2	2022

i) COURSE OVERVIEW:

The Seminar course is designed to enhance the abilities of students in conducting literature surveys, staying informed about the latest advancements in their engineering discipline, preparing technical reports, and delivering effective presentations.

ii) COURSE OUTCOMES

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

CO1	Identify relevant academic documents from the literature related to their area of interest.	Apply
CO2	Examine and interpret academic documents from the literature in their area of interest.	Analyze
CO3	Develop a structured presentation based on an academic document.	Create
CO4	Demonstrate effective communication skills by delivering a presentation on an academic document.	Apply
CO5	Develop a well-structured technical report.	Create

iii) GUIDELINES

- The Department shall constitute an Internal Evaluation Committee (IEC) for the seminar, with the academic coordinator of the program serving as the Chairperson/Chairman and the seminar coordinator and seminar guide as members.
- All members of the IEC must be present during the seminar presentation of a student.
- The formation of the IEC and the allotment of guides shall be completed within one week after the End Semester Examination (or the last working day) of the previous semester.
- The guide shall provide necessary guidance to students regarding topic or paper selection.
- The seminar topic for undergraduate students should be current and broad-based rather than highly specific research work. The seminar topic should be closely related to the final-year project area. Each member of a project team may choose or be assigned seminar topics covering different aspects of the project area.
- Students shall select a topic or paper relevant to their discipline during the semester break.
- The selected topic or paper shall be finalized in the first week of the semester and submitted to the IEC.
- The IEC shall review and approve the selected topic or paper by the second week of the semester.
- The seminar report must include accurate references from credible, peer-reviewed published sources, which shall be verified.

iv) EVALUATION PATTERN

Total marks : 100 (only CIE)
Minimum marks required to pass : 50

Seminar Guide: 20 marks
(Background Knowledge – 10 (The guide shall give deserving marks for a candidate based on the candidate's background knowledge about the topic selected),
Relevance of the paper/topic selected – 10).

Seminar Coordinator: 20 marks
(Seminar Diary – 10 (Each student shall maintain a seminar diary and the guide shall monitor the progress of the seminar work on a weekly basis and shall approve the entries in the seminar diary during the weekly meeting with the student), Attendance – 10).

Presentation: 40 marks to be awarded by the IEC
(Clarity of presentation – 10, Interactions – 10 (to be based on the candidate's ability to answer questions during the interactive session of her/his presentation), Overall participation – 10 (to be given based on her/his involvement during interactive sessions of presentations by other students), Quality of the slides – 10).

Report: 20 marks to be awarded by the IEC
(Check for technical content, overall quality, templates followed, adequacy of references etc.).

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U49B	PROJECT PHASE I	PWS	0	0	6	2	2022

i) PREAMBLE:

The course "Project Work" is mainly intended to evoke the innovation and invention skills in a student. The course will provide an opportunity to synthesize and apply the knowledge and analytical skills learned, to be developed as a prototype or simulation. The project extends to 2 semesters and will be evaluated in the 7th and 8th semesters separately, based on the achieved objectives. One third of the project credits shall be completed in 7th semester and two third in 8th semester. It is recommended that the projects may be finalized in the thrust areas of the respective engineering stream or as interdisciplinary projects. Importance should be given to address societal problems and developing indigenous technologies.

ii) COURSE OVERVIEW:

The aim of this course is to apply engineering knowledge in solving practical problems, to foster innovation in design of products, processes or systems, and to develop creative thinking in finding viable solutions to engineering problems.

iii) COURSE OUTCOMES

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

CO1	Model and solve real world problems by applying knowledge across domains.	Apply
CO2	Develop products, processes or technologies for sustainable and socially relevant applications.	Apply
CO3	Function effectively as an individual and as a leader in diverse teams and to comprehend and execute designated tasks.	Apply
CO4	Plan and execute tasks utilizing available resources within timelines, following ethical and professional norms.	Apply
CO5	Identify technology/research gaps and propose innovative/creative solutions.	Analyse
CO6	Organize and communicate technical and scientific findings effectively in written and oral forms.	Apply

iv) GUIDELINES

1) Identify suitable projects relevant to the branch of study.
2) Form project team.
3) Identify a project supervisor.
4) In case of interdisciplinary projects, the faculty member(s) from the concerned department(s) are also the supervisor(s) for the students.

5) Present the project proposal before the assessment board (excluding the external expert) and get it approved by the board.
6) The preliminary work to be completed:
   a. Literature survey
   b. Formulation of objectives
   c. Formulation of hypothesis/design/methodology
   d. Formulation of work plan
   e. Seeking funds
   f. Preliminary Analysis/Modeling/Simulation/Experiment/Design/Feasibility study
   g. Preparation of Phase I report

Note: The same project should be continued in the eighth semester by the same project team.

v) ASSESSMENT PATTERN

Total: 100 marks (Minimum required to pass: 50 marks).

- Project progress evaluation by guide : 30 Marks
- Interim evaluation by the Evaluation Committee : 20 Marks
- Final Evaluation by the Evaluation Committee : 30 Marks
- Project Phase - I Report (By Evaluation Committee) : 20 Marks

(The evaluation committee comprises HoD or a senior faculty member, Project coordinator and Project supervisor).

vi) EVALUATION BY GUIDE

The guide/supervisor must monitor the progress being carried out by the project groups on regular basis. In case it is found that progress is unsatisfactory, it should be reported to the Department Evaluation Committee for necessary action. The presence of each student in the group and their involvement in all stages of execution of the project shall be ensured by the guide.

Project evaluation by the guide: 30 marks

This mark shall be awarded to the students in his/her group by considering the following aspects.

i) Topic selection: 2 marks
Innovativeness, social relevance etc.

ii) Problem definition: 2 marks
Identification of the social, environmental and ethical issues of the project problem.

iii) Purpose and need of the project: 3 marks
Detailed and extensive explanation of the purpose and need of the project.

iv) Project Objectives: 2 marks
All objectives of the proposed work are well defined, Steps to be followed to solve the defined problem are clearly specified.

v) Project Scheduling and Distribution of work among team members: 3 marks
Detailed and extensive scheduling with timelines provided for each phase of project. Work breakdown structure well defined.

vi) Literature Survey: 4 marks
Outstanding investigation in all aspects.

vii) Student's diary/Daily log: 7 marks

The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily/weekly activity diary the day-to-day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches and drawings related to the observations made by the students. The daily/weekly activity diary shall be signed after every day/week by the guide.

viii) **Individual Contribution: 7 marks**

The contribution of each student at various stages.

EVALUATION RUBRICS PROJECT PHASE I: INTERIM EVALUATION						
Sl. No.	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
PHASE 1 INTERIM EVALUATION (20 MARKS)						
1-a	Topic identification, selection, formulation of objectives and/or literature survey (Group assessment) [CO1]	10	• The team has failed to come with a relevant topic. • The review of literature provides very little of the background information on the relevant topic. • No critical analysis or identification of gaps is carried out. • Most of the statements are quoted directly and the team tried to gather information as such without verifying the authenticity. • No literature review was properly conducted and no objectives formed so far.	• The team has identified a topic. • The review of literature provides some of the background information and needs to be revised. • Critical analysis of the literature is missing and suggestions were given to improve the relevance and to identify the gaps. • Relevant references were missing and there is no clear evidence to explain the topic identified. • Identified some objectives but not strong enough to explain it.	• The selection of topic is relevant after brainstorming and good evidences are documented. • The review of literature is appropriate and most background information is provided. • The relevant references were clearly reviewed but there is scope of improvement • Objectives identified with good clarity but some objectives need to be improved.	• The topic selected is highly relevant to real world problem and is potentially innovative. • The team shows extreme interest in the topic and has conducted extensive literature survey in connection with the topic. • Literature review was also conducted well. • Identified gaps, problems and made inferences from literature review • The team has come up with clear objectives which are viable.
			(0 - 3 Marks)	(4 - 6 Marks)	(7 - 9 Marks)	(10 Marks)
1-b	Socio-environmental relevance/ Innovation/ Creativity (Group assessment) [CO2]	5	• The objective of the project has neither social nor environmental relevance. • The project does not involve elements of creativity and innovation.	• The objective of the project has least social or environmental relevance. • No major contributions in innovative aspects.	• The objective of the project is socially or environmentally relevant. • The project involves some elements of creativity and innovation.	• The objective of the project has great social/environmental relevance. • The objective is highly innovative and involves creativity.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)

1-c	Project Planning, Scheduling and Resources/ Tasks Identification and allocation. (Group assessment) [CO2]	5	• No evidence of planning or scheduling of the project. • The students did not have any idea on what materials / resources to be used in the project. • The students do not have any awareness on the budget required.	• Some evidence of a primary plan. • Some ideas on the materials /resources required. • The students have some idea on the finances required and they have not formalized a budget plan. • Some indication on task allocation among the team members.	• Good evidence of planning done. Materials were listed and thought out, but needs improvement. • Schedules prepared were not a detailed one. • Better task allocation among group members.	• Excellent evidence of innovative project planning. • Charts were used to depict detailed project scheduling. • Modern tools were used to track the project. • All materials / resources were identified and listed. • Detailed budgeting is done and each member knows well about their individual tasks.
			(0 -1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
Total – 20 marks						

EVALUATION RUBRICS PROJECT PHASE I: FINAL EVALUATION						
Sl. No.	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
PHASE I FINAL EVALUATION (30 MARKS)						
1-d	Formulation of Design / Methodology and Progress (Group assessment) [CO2]	5	• Team members have no idea about the design and the methodology adopted. • Team has no progress after the evaluation. • Extensive support required from the project supervisor to achieve a satisfactory execution of various stages of the project.	• The students have some knowledge on the design procedure to be adopted, and the methodologies. • Not made much progress in the design. • Needs assistance at various stages of the project.	• The team is comfortable with design methods adopted and have made some progress. • The methodologies were known to them to a larger extend. • Adherence to action plan and effective organization of activities. • Needs some assistance from faculty to arrive at feasible solutions to problems.	• The team is having a well-defined design methodology and Excellent knowledge in design procedure. • Good adherence to action plan and organization of activities effectively within the time frame. • Development and implementation of feasible solutions within the time period.
			(0 -1 Marks)	(2-3 Marks)	(4 Marks)	(5 Marks)

1-e	Individual and Teamwork Leadership (Individual assessment) [CO4]	10	• No active involvement in the project. • Quality of the work is uncertain. • The student does not show any interest in the project activities.	• The student shows some interest and participates in some of the activities. • Not a good team player. • Often listens to, shares with and sometimes supports the efforts of others.	• Provide productive suggestions for the betterment of the project. • Usually listens to and tries to keep people working well together as a team • The student shows good interest in project, and takes up tasks and attempts to complete them.	• Successful completion of the assigned part of the project maintaining time frame and shows quality in the work. • Shows excellent responsibility and leadership qualities. Making discussions with peers and supports each other. • Active involvement and provide productive suggestions in interactions with the supervisor.
			(0 - 3 Marks)	(4 - 6 Marks)	(7 - 9 Marks)	(10 Marks)
1-f	Preliminary Analysis/ Modeling / Simulation/ Experiment / Design/ Feasibility Study (Individual & group assessment). [CO3]	10	• The team has not done any preliminary work with respect to the project area. • Lacks of proper knowledge in the topic. • They need to improve a lot. • Less ability for self-learning.	• The team has started doing some preliminary work with respect to the project. • Finds difficult to answer complex questions related to the project work. • Limited knowledge about the modern tool used in the project.	• The team has done good amount of preliminary investigation • They can improve further. • Can handle complex questions with relative ease. • Adequate knowledge of the modern tool used in the project.	• Student is thoroughly familiar with the topic and can respond confidently and spontaneously to complex questions. • Adequate knowledge of the modern tool used in the project. • The team has completed the required preliminary work and Excellent progress in the project.
			(0 - 3 Marks)	(4 - 6 Marks)	(7 - 9 Marks)	(10 Marks)

1-g	Documentation and presentation/ Communication. (Individual & group assessment). [CO3]	5	• Presentation lacks clarity. • Student lack familiarity with the topic. • The individual student contributes only occasionally in the discussions. • The team did not document the work at all. • No weekly discussion with the faculty supervisor and poor maintenance of log book. • The presentation was light in content and dull in appearance.	• Slight difficulty in communicating the contents in English • Interaction with the guide is minimal. • Overall quality needs to be improved • Individual performance desires to be enhanced. • Performance is satisfactory.	• Presentation is clearly structured and appropriate to the audience. • Maintains a log book and most of the project details were documented but needs improvement. • The individual presentation and performance are very good.	• Presentation is well structured and follows the conventions in the field. • Maintains a log book and most of the project details were documented well. • Good eye contact, no direct reading from paper. • Contents properly communicated in good English. • The presentation is done professionally and with great clarity • The performance is excellent.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
Total – 30 marks						

	EVALUATION RUBRICS_PROJECT PHASE I: REPORT EVALUATION					
Sl. No.	**Parameters**	**Marks**	**Poor**	**Fair**	**VERY GOOD**	**Outstanding**
	PHASE I FINAL EVALUATION (20 MARKS)					
1-h	Report [CO3]	20	• The prepared report is shallow and not as per standard format. • Lack of effort in preparation.	• Project report follows the standard format to some extent. • Language needs to be improved. • All references are not cited properly.	• Systematic documentation and is following the standard format. • Organization of the report is good. • Most of references are cited properly.	• The report is very well organized. • All referencescited properly. • Language is excellent and follows standard styles.
			(0 - 7 Marks)	(8 -12 Marks)	(14 - 19 Marks)	(20 Marks)

PROGRAMME ELECTIVE III

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U41A	SOFTWARE ENGINEERING	PEC	3	0	0	3	2022

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW:

This course aims to provide students with a comprehensive understanding of software engineering, blending theoretical concepts with practical application. It introduces diverse software process models—including traditional and agile methodologies—while emphasizing the importance of human aspects and project management. Students will learn to gather, document, and validate software requirements; design robust architectures using UML, design patterns, and UX principles; and develop and rigorously test Java-based applications.

iii) COURSE OUTCOMES

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

CO1	Explain various software process models and their impact on software development.	Understand
CO2	Illustrate, document, and validate comprehensive software requirements.	Understand
CO3	Develop software architectures and component-level designs that ensure maintainability and usability.	Apply
CO4	Apply software testing techniques and quality assurance practices to ensure the reliability and effectiveness of software systems.	Apply
CO5	Explain software quality assurance principles, configuration management processes, and DevOps practices to ensure software reliability and maintainability.	Understand

iv) SYLLABUS

Software process models – Waterfall, Prototyping, Evolutionary, Unified, Agile – Agile teams and human aspects of software engineering. Requirement engineering – Gathering, negotiating, monitoring, and validating requirements – Scenario-based, class-based, functional, and behavioral modeling. Software design concepts – Architectural design, component-level design, user experience design, design patterns, and best practices. Software testing – Verification and validation, unit and integration testing, web application testing, white-box and black-box testing, review techniques, and test automation. Software quality assurance – Statistical SQA, Six Sigma, ISO 9000 standards, configuration management, version control, and risk management. DevOps practices – Continuous integration, continuous deployment, and software maintenance.

v) (a) TEXT BOOKS

1) Roger S. Pressman, Bruce R. Maxim (2020), *Software Engineering: A Practitioner's Approach*, Ninth Edition, McGraw - Hill Education, ISBN 978 - 1 - 260 - 54800 - 6.

2) Ian Sommerville (2016), *Software Engineering*, Tenth Edition, Pearson Education Ltd, ISBN 10: 1-292-09613-6.

(b) REFERENCES

1) Rajib Mall (2014), *Fundamentals of Software Engineering*, 4th edition, PHI Learning Pvt Ltd, ISBN: 978-81-203-4898-1.
2) Rod Stephens (2015), *Beginning Software Engineering*, John Wiley & Sons, Inc., ISBN: 978-1-118-96914-4.
3) Carlo Ghezzi, Mehdi Jazayari, Dino Mandrioli (2015), *Fundamentals of Software Engineering*, Second Edition, PHI, ISBN: 9789332555396, 9332555397.
4) Bernd Bruegge and Allen Dutoit (2013), *Object-Oriented Software Engineering: Practical Software Development Using UML, Patterns, and Java*, 3rd edition, Pearson Education, ISBN: 1292037091, 9781292037097.
5) Robert K. Wyzocki (2013), *Effective Project Management*, 7th edition, WILEY - Dreamtech India Pvt. Ltd, ISBN: 978-1-118-72916-8.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Software Engineering Fundamentals-**The Nature of Software - Software Process Models: Waterfall Model - Prototyping Process Model - Evolutionary Process Model - Unified Process Model - Agile Process Models - Agile Teams and Frameworks: Scrum - Other Agile Frameworks - Recommended Process Models - Human Aspects of Software Engineering - Professional Ethics in Software Development - Introduction to Software Project Management.	**8**
II	**Requirements Engineering and Modeling-**Requirement Engineering: Establishing the Groundwork - Requirements Gathering Techniques - Developing Use Cases - Building the Analysis Model - Negotiating Requirements - Requirements Monitoring - Validating Requirements - Modeling Techniques: Scenario-Based Modeling - Class-Based Modeling - Functional Modeling - Behavioral Modeling - Requirements Documentation and Management - Introduction to Requirements Management Tools.	**9**
III	**Software Design Concepts** Design Process: Design Concepts - Design Models - Architectural Design: Software Architecture - Agility and Architecture - Architectural Styles - Architectural Design Process - Component-Level Design: Designing Class-Based Components - Conducting Component-Level Design - Specialized Component-Level Design - Component Refactoring - User Experience (UX) Design: User Experience Design Elements - The Golden Rules of UI Design - User Interface Analysis and Design - User Experience Analysis - Design Evaluation - Usability and Accessibility Considerations - Introduction to Design Patterns.	**10**

IV	**Software Testing and Quality Assurance** Fundamentals of Testing: Verification and Validation - Unit Testing - Integration Testing - Testing Web Applications: Content Testing - User Interface Testing - Component-Level Testing - Navigation Testing - Configuration Testing - Security Testing - Performance Testing - Testing Techniques: White Box Testing - Black Box Testing - Review Techniques: Informal and Formal Technical Reviews - Introduction to Test Automation Tools.	**9**
V	**Software Quality Assurance and Configuration Management** Software Quality Assurance (SQA): Statistical Software Quality Assurance - Six Sigma and ISO 9000 Quality Standards - Software Configuration Management (SCM): SCM Process and Activities - Version Control Systems - Change Management - Risk Management in Software Projects - Introduction to DevOps Practices - Continuous Integration and Continuous Deployment (CI/CD).	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U41B	MACHINE LEARNING	PEC	3	0	0	3	2022

i) PRE-REQUISITE: EL2U31E: Programming in Python

ii) COURSE OVERVIEW: The goal of this course is to introduce the fundamental concepts of Machine Learning and types of Machine learning algorithms.

iii) COURSE OUTCOMES

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

CO1	Explain the basic concepts of Machine Learning and Python	Understand
CO2	Explain the basic concepts of various Machine Learning Algorithms	Understand
CO3	Apply Supervised and Unsupervised Machine learning algorithms using Python Programming	Apply
CO4	Explain various advanced Machine Learning Algorithms and its applications in various domains	Understand
CO5	Make use of machine learning algorithms for real world applications	Apply

iv) SYLLABUS

Machine Learning and Python – EDA and Data Preprocessing, Data Visualization, Basics of Statistics and Types of Machine Learning Algorithms. Supervised, Unsupervised and Reinforcement learning, Principal Component Analysis. Advanced Techniques in Machine Learning: Ensemble Methods and Model Optimization, Applications of Machine Learning in various domains.

v) (a) TEXT BOOKS

1) McKinney W. (2012), *Python for Data Analysis*. O'Reilly Media: Sebastopol.
2) Bishop C. M. (2010), *Pattern Recognition and Machine Learning*, Springer.
3) Mueller A. C. & Guido S. (2016), *Introduction to Machine Learning with Python*, O'REILLY' Publishers.
4) Géron, A. (2019), *Hands-On Machine Learning with Scikit-Learn, Keras and TensorFlow*, O'Reilly Media: Sebastopol

(b) REFERENCES

1) Buduma N. & Locascio N (2017), *Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithm*, O'REILLY' Publishers.
2) Shai Shalev-Shwartz and Shai Ben-David (2017), "*Understanding Machine Learning*", Cambridge University Press.
3) Simon Haykin (2010), "*Neural networks and learning machines*", 3rd Edition. Pearson Education India.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Python and Machine Learning: Introduction to Python: Data Types in Python, NumPy and Pandas, Data Visualization using Python, Basic Exploratory Data Analysis: EDA & Data Preprocessing, Plots and graphs: Matplotlib, Seaborn and Plotly. Introduction to Machine Learning and Machine Learning Algorithms (Supervised, Unsupervised, Reinforcement learning), Statistical Learning: Basics of Applied Statistics.	9
II	Supervised Learning: Introduction to Supervised Learning Algorithm: Linear Regression - Linear relationship, Types of correlation, Assumptions of Linear regressions, Errors and Best Fit Line, Logistic Regression: Logistic function & Sigmoid Curve, Confusion matrix - Accuracy, Precision, Recall, Specificity, Model evaluation. Classifiers: Naïve Bayes Classifier, KNN Classifier and Support Vector Machine (SVM)	9
III	Unsupervised Learning: Introduction to Unsupervised Learning: Clustering Concept & K-Mean Clustering - Distance measures, Types of clustering: Hierarchical Clustering: Distance calculation between data points, Cluster and dendrograms formation, Cophenetic correlation. Principle Component Analysis (PCA): Principal component Covariance matrix, PCA for dimensionality reduction	9
IV	Advanced Techniques in Machine Learning: Decision Tree: Decision Tree Classifier Gini Index Pruning, Ensemble Techniques: Bagging, Boosting, Random Forest. Feature Engineering and Cross-Validation: k-fold cross-validation, stratified cross-validation. Model Performance Measures & Hyperparameter tuning: Grid search, random search.	9
V	Introduction to Deep Learning and applied Machine Learning - Basics of Neural networks, Computer vision and Natural Language Processing. ML and DL toolbox in MATLAB. Application of Machine learning algorithms using Python: Implementing Regression Models in MATLAB & Python, Fault Detection in Power Systems using CNNs & Decision Trees, Real-time Fault Prediction in Electrical Machines, Deploying ML/DL Models for Real-World engineering systems (Any relevant case studies with sample datasets and toolkits)	9
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Cate-gory	L	T	P	Credit	Year of Introduction
EL2U41C	ENERGY MANAGEMENT	PEC	3	0	0	3	2022

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW:

The main goal of this course is to enable the students to understand the concept of energy management and energy management opportunities. The course helps the students to understand the different methods used for the economic analysis of energy projects.

iii) COURSE OUTCOMES

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

CO1	Explain the significance of energy management and planning.	Understand
CO2	Summarize energy management opportunities in electric lighting, transformers and motor loads.	Understand
CO3	Identify energy efficiency improvement opportunities in industries and commercial establishments.	Apply
CO4	Explain demand side management techniques.	Understand
CO5	Develop the economic feasibility of the energy conservation measures.	Apply

iv) SYLLABUS

Energy Management - General Principles and Planning. Energy management opportunities in Lighting, Transformers and Motors.

Energy management in industries and commercial establishments- energy conservation opportunities in boilers, steam and furnace. Heat recovery schemes.

Demand side Management- techniques of DSM. Load management, load priority technique, peak clipping, peak shifting, valley filling, strategic conservation, energy efficient equipment.

Cogeneration. Energy Economics: Economic analysis: methods. Computer aided Energy Management Systems.

v) (a) TEXT BOOKS

1) Craig B. Smith, Kelly E Parmenter, *Energy management principles: Applications, Benefits, Savings*, 2nd edition, Pergamon Press, 2001.
2) Charles M. Gottschalk, *Industrial energy conservation*, John Wiley & Sons, 1996.
3) D. Yogi Goswami, Frank Kreith, *Energy Management and Conservation Handbook*, 2nd edition, CRC Press, 2007.
4) G.G. Rajan, *Optimizing energy efficiencies in industry*, Illustrated edition, Tata McGraw Hill, Pub. Co., 2001.

(b) REFERENCES

1) IEEE recommended practice for energy management in industrial and facilities.
2) IEEE std 739 - 1995 (Bronze book).
3) M. Jayaraju and Premlet, *Introduction to Energy Conservation and Management*, 3rd edition, Phasor Books, 2008.
4) Paul O'Callaghan, *Energy Management*, 1st edition, McGraw Hill Book Co., 1993.
5) Wayne C. Turner, *Energy Management Hand Book* - The Fairmount Press, Inc., 1997.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Energy Management**: General principles of Energy management and Energy management planning. Peak Demand controls, Methodologies. **Energy Efficiency in Lighting**: Modern energy efficient light sources, life and efficacy comparison with older light sources, energy conservation in lighting, use of sensors and lighting automation.	9
II	**Energy Efficiency in Motors:** Development of energy efficient motors and the present status, techniques for improving energy efficiency, necessity for load matching. **Energy efficiency in Transformers:** Present maximum efficiency standards for power and distribution transformers, design measures for increasing efficiency in electrical system components.	9
III	**Energy Management in Industries and Commercial Establishments**: Boiler - working principle - blow down, energy conservation opportunities in boiler. Identifying opportunities for energy savings in steam distribution. General fuel economy measures, energy conservation opportunities in furnaces - Case study. **Heat Recovery Systems**: Waste heat recovery system - Energy saving opportunities. Cogeneration-Types and Schemes, Optimal operation of cogeneration plants- Case study.	11
IV	**Demand side Management (DSM):** Introduction to DSM, benefits of DSM, Different techniques of DSM - time of day pricing, multi-utility power exchange model, time of day models for planning. Load management, load priority technique, strategic conservation, energy efficient equipment. **Cogeneration-**Types and Schemes, Optimal operation of cogeneration plants- Case study.	9
V	**Energy Economics**: Economic analysis methods, cash flow model, time value of money, pay-back period, average rate of return method, present value method, life cycle costing approach. Computer aided Energy Management Systems (EMS) – Basic Concepts.	7
	Total hours	45

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U41D	FUNDAMENTALS OF ROBOTICS	PEC	2	1	0	3	2022

i) PRE-REQUISITE: EE1U30I: Introduction to Control Engineering

ii) COURSE OVERVIEW: This course introduces students to the foundational principles and technologies that enable robotic systems. It provides a multidisciplinary approach to explore the modeling, control, and application of robots.

iii) COURSE OUTCOMES

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

CO1	Identify the anatomy and specifications of robots for typical application.	Understand
CO2	Select the appropriate sensors and actuators for robots.	Apply
CO3	Identify robotic configuration and gripper for a particular application.	Apply
CO4	Solve forward and inverse kinematics of robotic manipulators.	Apply
CO5	Develop trajectories in joint space and Cartesian space.	Apply
CO6	Develop the dynamic model of a given robotic manipulator and its control strategy.	Apply

iv) SYLLABUS

Definitions, Types of Robots, Anatomy of a robotic manipulator, open kinematic vs closed kinematic chain, degrees of freedom, Robot considerations for an application, Robot Applications.

Sensors and Actuators Sensor classification, Internal sensors, External sensors, Selection of sensors. Actuators for robots, Electric actuators, Linear actuators, selection of motors; Hydraulic actuators, Pneumatic Actuators.

Robot configurations, features of SCARA, PUMA Robots; Classification of robots based on motion control methods and drive technologies

Classification of End effectors. Kinematics and Motion Planning - Robot Coordinate Systems, Kinematic parameters, D-H representation, Direct Kinematics. The Arm equation- forward and inverse Kinematics of typical robots upto 3 DOF, Motion Planning.

Dynamics and Control of Robots - Dynamic model of a robot using Lagrange's equation, dynamic modeling of 1 DOF robot, PID control of a single link manipulator- Computed torque control.

v) (a) TEXT BOOKS

1) S K Saha, *Introduction to Robotics*, Tata McGraw Hill, 2nd edition, 2017.

2) Robert. J. Schilling, *Fundamentals of robotics – Analysis and control*, Prentice Hall of India, 1st edition, 1990.
3) R K Mittal and I J Nagrath, *Robotics and Control*, Tata McGraw Hill, New Delhi, 1st edition, 2003.
4) John. J. Craig., *Introduction to Robotics* (*Mechanics and control*), Pearson Education Asia, 3rd edition, 2004.
5) Saeed B. Nikku, *Introduction to Robotics*, Pearson Education, 2nd edition, 2010.
6) Rachid Manseur, *Robot Modeling and Kinematics*, Lakshmi publications, 2nd edition, 2008.

(b) REFERENCES

1) Ashitava Ghosal, *Robotics-Fundamental concepts and analysis*, Oxford University press, 2006.
2) S. R. Deb, *Robotics Technology and Flexible Automation*, 2nd edition, 2017.
3) Boltans W., *Mechatronics*, Pearson Education, 6th edition, 2016.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction:** Definitions - Robots, Robotics; Types of Robots- Manipulators, Mobile Robots - wheeled & Legged Robots, Aerial Robots; Anatomy of a robotic manipulator - links, joints, actuators, sensors, controller; open kinematic vs closed kinematic chain; degrees of freedom. **Robot specifications for an application** - number of axes, work volume, capacity & speed, stroke & reach, Repeatability, Precision and Accuracy, Operating environment, point to point control or continuous path control. **Robotic Applications:** Industrial Applications - Material handling, welding, Spray painting, Machining. Non-industrial - medical, mining, space, defense, security, domestic, entertainment.	**8**
II	**Sensor for robots** - classification - touch, force, proximity, vision sensors. Internal sensors - Position sensors, velocity sensors, acceleration sensors, Force sensors. Vision - Elements of vision sensor, image acquisition, image processing; Selection of sensors. **Actuators for robots -** classification - Electric, Hydraulic, Pneumatic actuators; their advantages and disadvantages; Electric actuators- Stepper motors, DC motors, DC servo motors and their drivers, AC motors, Linear actuators, selection of motors Hydraulic actuators - Components and typical circuit, advantages and disadvantages; Pneumatic Actuators - Components and typical circuit, advantages and disadvantages.	**10**
III	**Grippers for Robots-** Classification - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers, factors affecting selection of grippers.	**9**

	Robot classification Classification based on Robot configurations - PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots. Classification of robots based on motion control methods and drive Technologies.	
IV	**Robot Coordinate System s-** Fundamental and composite rotations, homogeneous coordinates and transformations. **Robot Kinematics** - Kinematic parameters, D-H representation, Direct Kinematics. The Arm equation- forward Kinematic analysis of a typical robots up to 3 DOF. Inverse Kinematics of a typical 3 DOF robot. **Motion Planning** - joint space trajectory planning-cubic polynomial, linear trajectory with parabolic blends; Cartesian space planning, Point to point vs continuous path planning.	**9**
V	**Dynamics and Control of Robots** Dynamics - Dynamic model of a robot using Lagrange's equation, dynamic modeling of 1 DOF robot **Control Techniques -** Transfer function and state space representation, Performance and stability of feedback control. PID control of a single link manipulator, selection of PID controller gains; nonlinear nature of manipulators, and need for nonlinear control techniques, Computed torque control, Gravity control.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U41E	REAL TIME OPERATING SYSTEMS	PEC	3	0	0	3	2022

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW: To understand RTOS, its basic structure, building blocks, various operations and to summarize the different scheduling algorithms used in RTOS.

iii) COURSE OUTCOMES

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

CO1	Summarize the key characteristics, components, and task management techniques in real-time operating systems, including synchronization and interrupt handling.	Understand
CO2	Explain various real-time scheduling algorithms and techniques for managing task dependencies, and compare dynamic and static scheduling approaches in real-time systems.	Understand
CO3	Develop and integrate inter-task communication mechanisms and synchronization techniques in real-time systems, addressing issues like deadlock, live lock, and priority inversion.	Apply
CO4	Apply RTOS kernel design, memory management, and file system implementation to a case study of real-time systems like MicroC/OS-II or FreeRTOS.	Apply
CO5	Infer real-world applications of RTOS in industries such as automotive, aerospace, and IoT, and compare FreeRTOS with commercial RTOS for embedded system integration.	Understand

iv) SYLLABUS

Introduction to Real-Time Operating Systems: RTOS characteristics, task states, task synchronization (semaphores, message queues), interrupt handling.

Task Scheduling in Real-Time Systems: Aperiodic and periodic scheduling (EDF, RMS, DMS), task precedence constraints, dynamic vs static scheduling.

Inter-Task Communication and Synchronization: Message queues, pipes, event registers, synchronization (semaphores, mutexes), deadlock and priority inversion.

RTOS Design and Implementation: RTOS kernel structure, memory management, task scheduling, case studies (MicroC/OS-II or FreeRTOS).

Real-Time Systems Applications and Commercial RTOS: FreeRTOS, RT Linux, control system applications (e.g., adaptive cruise control), real-time networking protocols (CAN, TCP/IP).

v) (a) TEXT BOOKS

1) Phillip A. Laplante, *Real-Time Systems: Design and Analysis*, 4th edition, Wiley, 2011.
2) Frank Vahid and Tony Givargis, *Embedded Systems Design: A Unified Hardware/Software Introduction*, Wiley India Pvt. Limited, 2006.
3) Albert M. K. Cheng, *Real-Time Systems: Scheduling, Analysis, and Verification*, Wiley India Pvt. Limited, 2002.
4) Jean J. Labrosse, *MicroC/OS-II: The Real-Time Kernel*, 2nd edition, McGraw Hill, 2002.

(b) REFERENCES

1) Rajib Mall, *Real-Time Operating Systems: Concepts and Practice.*
2) *FreeRTOS: Real-Time Operating System* by Richard Barry (Official FreeRTOS book).
3) Jonathan W. Valvano, *Designing Embedded Systems and the Internet of Things (IoT) with the ARM mbed*.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Real-Time Operating Systems:** Definition and characteristics of Real-Time Systems**,** Types of Real-Time Systems (Hard vs Soft vs Firm)**,** Structure of RTOS and key components (kernel, scheduler, memory management) Task Management: Task States: Ready, Running, Blocked, Suspended Task Synchronization Techniques: Semaphores, Mutexes, Message Queues Interrupt Handling: Concept of Interrupts and Exceptions in RTOS, Handling Hardware and Software Interrupts, Priority of Interrupts and Nested Interrupts	**9**
II	**Task Scheduling in Real-Time Systems:** Scheduling Algorithms: Aperiodic Task Scheduling: Earliest Deadline First (EDF), Least Laxity First (LLF) Periodic Task Scheduling: Rate Monotonic Scheduling (RMS), Deadline Monotonic Scheduling (DMS) Precedence Constraints in Scheduling: Handling Task Dependencies and Precedence Constraints (EDF with precedence), Critical Path Analysis in Task Scheduling Dynamic vs Static Scheduling: Comparison and analysis of dynamic and static scheduling algorithms in real-time systems.	**9**
III	**Inter-Task Communication and Synchronization:** Inter-Task Communication Mechanisms: Message Queues, Pipes, and Event Registers-Signals and Shared Memory in Real-Time Systems Synchronization in Real-Time Systems: Semaphores (Counting and Binary), Mutexes and their usage in preventing race conditions, Producer-Consumer Problem in RTOS	**9**

	Real-Time Systems Communication Challenges: Deadlock and Livelock Prevention-Priority Inversion Problem and Solutions	
IV	**Real-Time Operating System Design and Implementation**: RTOS Kernel Design: Kernel Structure and Components (Scheduler, Resource Management), Task Management and Kernel Primitives RTOS Design for Embedded Systems: Memory Management in RTOS Real-Time File Systems: FAT and Real-Time File Systems (RTFS) Case Study of RTOS Implementation: MicroC/OS-II or FreeRTOS Design Example, Implementing tasks, scheduling, and interrupt handling in an RTOS	**9**
V	**Real-Time Systems Applications and Commercial RTOS:** FreeRTOS and Linux for Real-Time Systems: FreeRTOS Architecture and Features, RT Linux and its applications, Comparison between FreeRTOS and commercial RTOS for embedded systems Control Systems in RTOS: Adaptive Cruise Control and its RTOS implementation, Real-Time Systems in Automotive and Aerospace applications RTOS in IoT and Networked Systems: Real-time networking (CAN, TCP/IP) for IoT applications, Synchronization and Communication in Networked Real-Time Systems	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U41F	DIGITAL SIGNAL PROCESSING	PEC	3	0	0	3	2022

i) PRE-REQUISITE: EE1U30C: Signals and Systems

ii) COURSE OVERVIEW: This course introduces the Discrete Fourier transform (DFT) and its computation using direct method and Fast Fourier transform (FFT). Techniques for designing Infinite Impulse Response (IIR) and Finite Impulse Response (FIR) filters from given specifications are also introduced. Various structures for realization of IIR and FIR filters are discussed. Detailed analysis of finite word-length effects in fixed point DSP systems is included. Architecture of a digital signal processor is also discussed.

iii) COURSE OUTCOMES

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

CO1	Apply Discrete Fourier and Fast Fourier transforms on discrete time signals.	Apply
CO2	Model various structures for realization of IIR and FIR discrete-time systems.	Apply
CO3	Develop IIR filters using impulse invariant and bilinear transformation methods.	Apply
CO4	Develop FIR filters using frequency sampling method and window function method.	Apply
CO5	Explain the architecture of digital signal processors and finite word length effects.	Understand

iv) SYLLABUS

Discrete-Fourier Transform - Frequency domain sampling - Discrete Fourier transform (DFT), inverse DFT (IDFT) - properties of DFT -Filtering of long data sequences - Fast Fourier transform (FFT). Realization of IIR and FIR Systems - Introduction to FIR and IIR systems - Realization of IIR systems - conversion of lattice to direct form and vice-versa - signal flow graphs and transposed structures - Realization of FIR systems. IIR Filter Design - Design of IIR filters - frequency transformation in analog domain - design of LP, HP, BP, BS IIR digital filters using impulse invariance and bilinear transformation. FIR Filter Design and Representation of Numbers - IEEE 754 32-bit single precision floating point representation. Finite Word Length Effects and Digital Signal Processors - Digital signal processor architecture based on Harvard architecture (block diagram) - applications of DSP.

v) (a) TEXT BOOKS

1) John G. Proakis & Dimitris G. Manolakis, *Digital Signal Processing Principles, Algorithms & Applications*, Fourth edition, Pearson Education / Prentice Hall, 2007.
2) P. Ramesh Babu, *Digital Signal Processing*, Fourth Edition Scitech Publications (India) Pvt Ltd, 2011.
3) Emmanuel C. Ifeachor, & Barrie W. Jervis, *Digital Signal Processing*, Pearson Education / Prentice Hall, 13th Edition, 2013.

4) Alan V. Oppenheim, Ronald W. Schafer & Hohn. R. Back, *Discrete Time Signal Processing*, Pearson Education, 2nd edition, 2005.

(b) REFERENCES

1) Li Tan, *Digital Signal Processing, Fundamentals & Applications*, Academic Press,1st Edition, 2008.
2) D.Ganesh Rao&Vineeta P Gejji, *Digital Signal Processing, A simplified Approach*, Sanguine Technical Publishers, 2nd Edition, 2008.
3) Johny R. Johnson, *Introduction to Digital Signal Processing*, PHI, 2006.
4) P. P. Vaidyanathan, *Multirate Systems & Filter Banks*, Prentice Hall, Englewood Cliffs, NJ, 1993.
5) S. K. Mitra, *Digital Signal Processing, A Computer Based Approach*, Tata McGraw-Hill, 1998.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Discrete-Fourier Transform**-Review of signals and systems - Frequency domain sampling - Discrete Fourier transform (DFT) inverse DFT (IDFT) - properties of DFT -Filtering of long data sequences - over-lap save method, over-lap add method -Fast Fourier transform (FFT)- radix -2 decimation-in-time FFT (DITFFT) algorithm, Radix-2 decimation-in-frequency FFT (DIFFFT) algorithm.	**10**
II	**Realization of IIR and FIR Systems**-Introduction to FIR and IIR systems - Realization of IIR systems direct form 1, direct form 2, cascade form, parallel form, lattice structure for all-pole system, lattice-ladder structure conversion of lattice to direct form and vice-versa - signal flow graphs and transposed structures Realization of FIR systems direct form, cascade form, lattice structure, linear phase realization.	**8**
III	**IIR Filter Design** -Conversion of analog transfer function to digital transfer function impulse invariant transformation and bilinear transformation warping effect. Design of IIR filters low-pass, high-pass, band-pass, band-stop filters Butterworth and Chebyshev filter frequency transformation in analog domain - design of LP, HP, BP, BS IIR digital filters using impulse invariance and bilinear transformation.	**9**
IV	**FIR Filter Design And Representation Of Numbers**-Impulse response of ideal low pass filter linear phase FIR filter frequency response of linear phase FIR filter Design of FIR filter using window functions (LP, HP, BP, BS filters) Rectangular, Bartlett, Hanning, Hamming and Blackmann only FIR filter design based on frequency sampling approach (LP, HP, BP, BS filters).Representation of numbers-fixed point representation - sign-magnitude, one's complement, two's complement - floating point representation - IEEE 754 32-bit single precision floating point representation.	**9**

V	**Finite Word Length Effects and Digital Signal Processors**-Finite word length effects in digital Filters input quantization quantization noise power steady-state output noise power coefficient quantization overflow techniques to prevent overflow - product quantization error rounding and truncation round-off noise power limit cycle oscillations zero input limit cycle oscillations overflow limit cycle oscillations signal scaling. Digital signal processor architecture based on Harvard architecture (block diagram), comparison of fixed-point and floating-point processor applications of DSP.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U41G	WEB PROGRAMMING	PEC	3	0	0	3	2022

i) PRE-REQUISITE: EL2U30F Computer Communication and Network Security

ii) COURSE OVERVIEW: This course introduces Web Programming, covering front-end development with HTML, CSS, and JavaScript, and back-end development using Node.js with databases. Students will also explore React.js or Angular for building responsive applications, along with web deployment and basic security measures. By the end, they will gain hands-on experience in developing and deploying web applications.

iii) COURSE OUTCOMES

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

CO1	Explain the fundamental concepts of web development and programming	Understand
CO2	Apply UI frameworks, perform form validation, manage data storage, and fetch API data in web applications	Apply
CO3	Apply backend technologies, manage databases, consume APIs, and integrate frontend with backend	Apply
CO4	Summarize the key features of front-end frameworks in modern web development	Understand
CO5	Apply basic security principles and web hosting techniques to deploy a functional web application	Apply

iv) SYLLABUS

Web Development Fundamentals – Introduction to web technologies, need for web development, basics of web programming, challenges in modern web development, applications of web technologies.

HTML and CSS – Structure and styling of web pages, elements, attributes, semantic HTML, responsive design principles, introduction to Bootstrap and CSS frameworks.

JavaScript and Interactivity – JavaScript fundamentals, DOM manipulation, event handling, ES6 features, asynchronous JavaScript, and introduction to front-end libraries.

Back-end Development – Server-side programming with Node.js, Express.js framework, working with databases (SQL and NoSQL), API development, authentication, and session management.

Web Deployment and Security – Hosting web applications, deployment strategies, version control with Git, security best practices, common web vulnerabilities, and performance optimization.

v) (a) TEXT BOOKS

1) Jon Duckett, *HTML and CSS: Design and Build Websites*, First Edition, Wiley, 2011.
2) Robin Nixon, *Learning PHP, MySQL & JavaScript: With jQuery, CSS & HTML5*, Fifth Edition, O'Reilly Media, 2018.
3) Ethan Brown, *Web Development with Node and Express: Leveraging the JavaScript Stack*, First Edition, O'Reilly Media, 2014.

4) Julie C. Meloni, Pearson, *Sams Teach Yourself -PHP, MySQL & JavaScript All in One*, 5th edition.

(b) REFERENCES

1) Kyle Simpson, *You Don't Know JS* (book series), O'Reilly Media, 2015.
2) Robert W Sebesta, *Programming the World Wide Web*, Pearson Education Inc, 8th Edition.
3) Eric van der Vlist, Danny Ayers, Erik Bruchez, Joe Fawcett, Alessandro Vernet, *Wrox-Professional Web 2.0 Programming*, Wiley-India edition.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Fundamentals of Web Technologies - Introduction to Web and Internet Technologies - Basics of the Internet and the World Wide Web, HTTP, HTTPS, DNS, Domain & Hosting, Difference between Static & Dynamic Websites. HTML – Structuring Web Pages - HTML Tags, Forms, Tables, Lists, Semantic Elements, Embedding Media: Images, Audio, Video, iframes, HTML5 Features (Canvas, SVG, Forms, Input Types). Introduction to JavaScript basics - Variables, Data Types, Operators, Control Statements (Loops, Conditions), Functions, DOM Manipulation, Event Handling.	**10**
II	**Interactive Front-End Development** - UI Frameworks & Styling: Introduction to Bootstrap & Tailwind CSS, Using Bootstrap Components (Navbar, Buttons, Cards), CSS Animations & Transitions. **Form Validation & Error Handling:** Client-side Form Validation with JavaScript/jQuery, User Input Handling & Error Messages, Client-side vs. Server-side Validation. **Web Storage & Local Data Handling:** Local Storage, Session Storage, Cookies, JSON Data Handling, Basic CRUD Operations using Web Storage. **Fetching & Displaying Data**: Introduction to APIs & JSON, Fetching API Data & Displaying on UI, Simple Hands-on Project (e.g., To-Do List, Weather App).	**8**
III	Backend Development & Databases - Introduction to Backend Technologies - Role of Servers in Web Applications, Overview of Server-Side Languages (Node.js / PHP / Python Flask). Basics of HTTP & REST APIs - GET, POST, PUT, DELETE Methods, Creating and Consuming APIs. Database Management - SQL vs NoSQL Databases (MySQL / MongoDB), Performing CRUD Operations (Create, Read, Update, Delete). Connecting Frontend & Backend - Fetching Data using APIs, User Authentication & Session Management.	**8**
IV	Web Security & Performance Optimization - Web Security & Authentication - User Authentication (OAuth, JWT, Sessions), Security Threats: CSRF, XSS, SQL Injection Prevention. Real-time Communication with Web Sockets - Introduction to Web Sockets for	**7**

	Live Chat, Notifications. Performance Optimization & SEO - Minification, Lazy Loading, Code Splitting, SEO Best Practices & Google Page Speed Insights.	
V	Full-Stack Development & Deployment - Introduction to Full-Stack Development - Overview of MERN, MEAN, LAMP Stacks, Choosing the Right Tech Stack. Building a Simple Web Application - Integrating Frontend, Backend, and Database, Hands-on: Developing a Small Project (e.g., Blog, To-Do App). Web Deployment & Version Control - Hosting on GitHub Pages, Firebase, Heroku, Introduction to Git, GitHub, CI/CD Pipelines.	**12**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U41H	ELECTRIC DRIVES	PEC	3	0	0	3	2022

i) PRE-REQUISITE: EL2U30D Power Electronics and Drives, EL2U30C Electrical Machines

ii) COURSE OVERVIEW: The goal of this course is to expose the students to the basic concepts of Electric Drives. It also includes the speed control methods of DC and AC drives. The course also provides an insight on the basic concepts of space vector

iii) COURSE OUTCOMES

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

CO1	Explain the transient and steady state aspects electric drives.	Understand
CO2	Apply the appropriate configuration of controlled rectifiers for the speed control of DC motors.	Apply
CO3	Apply chopper-fed DC motor drives for various quadrants of operation.	Apply
CO4	Illustrate the various speed control techniques of induction motors.	Understand
CO5	Explain different speed control methods of synchronous motor drives.	Understand

iv) SYLLABUS

Block diagram of electric drives- fundamental torque equations, types of load – classification of load torque, four quadrant operation of drives, Equivalent values of drive parameters - steady state stability.

Rectifier control of DC drives- separately excited DC motor drives using single-phase and three phase-controlled rectifiers - dual converter control of DC motor - circulating current mode.

Chopper control of DC drives - two quadrant and four quadrant chopper drives - motoring and regenerative braking -closed loop speed control for separately excited dc motor.
Three phase induction motor drives: Stator voltage control - Stator frequency control – v/f control - static rotor resistance speed control– static slip power recovery scheme.

Concept of space vector – Clarke and Park transformation – field orientation principle – Introduction to direct vector control of induction motor drives-Synchronous motor drives self-controlled mode – load commutated CSI fed synchronous motor.

v) (a) TEXT BOOKS

1) G. K. Dubey, *Fundamentals of Electric Drives*, Narosa publishers, second edition, 2001
2) Bimal K. Bose, *Power Electronics and Motor Drives*, Academic press, An Imprint of Elsevier, 2006.

(b) REFERENCES

1) Vedam Subrahmanyam, *Electric Drives Concepts and Applications*, MC Graw Hill Education, second edition, 2011, New Delhi.
2) Dr. P. S. Bimbhra, *Power Electronics*, Khanna publishers, fifth edition, 2012.
3) Ned Mohan, Tore M Undeland, William P Robbins, *Power electronics converters applications and design*, John Wiley and Sons Inc.,3rd edition, 2009.
4) Muhammad H.Rashid, *Power Electronics, Devices, Circuits and Applications*, Pearson, 3rd edition, 2014.
5) R Krishnan, *Electric Motor Drives: Modeling, Analysis, and Control*, Prentice Hall, 2001.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to electric drives – block diagram – advantages of electric drives – dynamics of motor load system, fundamental torque equations, types of load – classification of load torque, four quadrant operation of drives, Equivalent values of drive parameters- steady state stability.	**9**
II	Rectifier control of DC drives- separately excited DC motor drives using controlled rectifiers- single-phase fully controlled rectifier fed drives (discontinuous and continuous mode of operation), critical speed - single-phase semi converter fed drives (continuous mode of operation) - three-phase semi converter and fully controlled converter fed drives (continuous mode of operation) - dual converter control of DC motor - circulating current mode.	**9**
III	Chopper control of DC drives - two quadrant and four quadrant chopper drives - motoring and regenerative braking - chopper fed DC series motor drive - closed loop speed control for separately excited dc motor.	**9**
IV	Three phase induction motor drives: Stator voltage control - Stator frequency control – v/f control - below and above base speed – Voltage Source Inverter (VSI) fed v/f control using sine-triangle PWM - static rotor resistance speed control employing chopper – static slip power recovery speed control scheme for speed control below and above synchronous speed.	**9**
V	Concept of space vector- block diagram – Clarke and Park transformation – field orientation principle – Introduction to direct vector control of induction motor drives – decoupling of flux and torque components - Synchronous motor drives – v/f control – open loop control – self-controlled mode – load commutated CSI fed synchronous motor.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

OPEN ELECTIVE I

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL0U41A	ELECTRICAL DRIVES AND CONTROL FOR AUTOMATION	OEC	3	0	0	3	2022

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW: This course introduces the principles of electric drives and their role in control and automation systems. It covers the working, characteristics, and applications of DC machines, transformers, induction motors, synchronous machines, and special motors. The course also explores modern motor control techniques, including PLC-based motor control, digital controllers, and industrial automation applications. Case studies on electric drives in robotics, CNC machines, and electric vehicles provide insights into real-world applications.

ii) COURSE OUTCOMES

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

CO1	Explain the working principles, characteristics, and performance of DC machines, transformers, and induction motors.	Understand
CO2	Explain the construction, operation, and applications of synchronous machines, stepper motors, and servo motors.	Understand
CO3	Explain various motor control techniques, including servo control, digital controllers, and PLC-based motor control.	Understand
CO4	Explain the role of electric drives in industrial automation, robotics, and electric vehicles, supported by case studies.	Understand
CO5	Explain emerging trends in IoT-enabled motor control, AI-based predictive maintenance, and Industry 4.0 applications.	Understand

iv) SYLLABUS

DC generators – EMF equation – types of excitations – armature reaction – OCC and load characteristics – DC motors: principle, torque equation, types, characteristics, efficiency, and applications.

Transformers - Principle of operation, EMF equation, vector diagrams, losses and efficiency, OC and SC tests, equivalent circuit, auto transformers – applications.

Alternators – EMF equation – voltage regulation – synchronous motors – stepper motors – BLDC and PMSM motors – servo motors – applications in automation.

Motor control techniques – servo control – digital controllers – VFDs – DSP-based controllers – PLCs – automation case studies.

Electric drives in automation – robotics – CNC machines – electric vehicles – HVAC systems – IoT-based motor control – Industry 4.0 applications.

v) (a) TEXTBOOKS

1) P.S. Bimbhra, *Electrical Machinery*, Khanna Publishers, 7th Edition, 2011.

2) J.B. Gupta, *Theory and Performance of Electrical Machines*, S.K. Kataria & Sons, 15th Edition, 2021.
3) Hughes & Drury, *Electric Motors and Drives: Fundamentals, Types and Applications*, Elsevier, 5th Edition, 2019.
4) B.L. Theraja & A.K. Theraja, *A Textbook of Electrical Technology - Volume II*, S. Chand, 24th Edition, 2019.
5) D.P. Kothari & I.J. Nagrath, *Electric Machines*, McGraw-Hill, 5th Edition, 2017.

(b) REFERENCES

1) V.K. Mehta & Rohit Mehta, *Principles of Electrical Machines*, S. Chand, 3rd Edition, 2018.
2) R.K. Rajput, *Electrical Machines*, Laxmi Publications, 6th Edition, 2019.
3) Kenjo & Sugawara, *Stepping Motors and Their Microprocessor Control*, Clarendon Press, 2nd Edition, 1994.
4) R. Krishnan, *Electric Motor Drives: Modeling, Analysis, and Control*, Prentice Hall, 1st Edition, 2001.
5) P.C. Sen, *Principles of Electric Machines and Power Electronics*, Wiley, 3rd Edition, 2013.
6) John W. Webb & Ronald A. Reis, *Programmable Logic Controllers: Principles and Applications*, Pearson, 5th Edition, 2014.
7) G.K. Dubey, *Fundamentals of Electrical Drives*, Narosa Publishing House, 2nd Edition, 2002.
8) Ion Boldea & Syed A. Nasar, *Electric Drives*, CRC Press, 2nd Edition, 2005.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**DC Machines** DC generators - Principle of operation – EMF equation – types of excitations – armature reaction – open circuit characteristics (OCC) and load characteristics – applications of DC generators. DC motors - Principle of operation – torque equation – types and characteristics – losses and efficiency – industrial applications.	9
II	**Transformers** Principle of operation – EMF equation – vector diagrams – losses and efficiency – open circuit (OC) and short circuit (SC) tests – equivalent circuit – efficiency calculations – maximum efficiency – all-day efficiency – auto transformers – industrial applications.	9
III	**Special Motors** Principle of alternators – EMF equation – voltage regulation by EMF method. Synchronous motors – principle of operation and starting methods. Stepper motors: principle of operation, types, and applications. BLDC and PMSM motors: construction, working, and applications. Servo motors and their role in automation.	9

IV	**Motor Control Techniques** Introduction to motor controllers – servo control – digital controllers – variable frequency drives (VFDs) – DSP-based motor controllers – programmable logic controllers (PLCs) in motor control – industrial automation using motor controllers – case studies in robotics and CNC machines.	**9**
V	**Electric Drives in Automation** Applications of electric drives in robotics, CNC machines, and electric vehicles – motor control in HVAC systems – IoT-enabled motor control – AI-based predictive maintenance – Industry 4.0 applications – case studies on automation and smart manufacturing.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 arks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL0U41D	RENEWABLE ENERGY SYSTEMS	OEC	3	0	0	3	2022

i) **PRE-REQUISITE: Students who have taken EE0M30K MINOR are not eligible to take this course**.

ii) **COURSE OVERVIEW**: The goal of this course is to expose the students to learn the concepts of solar thermal and solar electric systems. It illustrates the operating principles of wind, and ocean energy conversion systems and the features of biomass and small hydro energy resources. The course describes the concepts of fuel cell and hydrogen energy technologies.

iii) **COURSE OUTCOMES**

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

CO1	Illustrate the use of various renewable energy-based power generation scheme.	Understand
CO2	Explain the concepts of solar thermal and solar electric systems.	Understand
CO3	Illustrate the operating principles of wind, and ocean energy conversion systems.	Understand
CO4	Outline the features of biomass and small hydro energy resources.	Understand
CO5	Explain the concepts of fuel cell and hydrogen energy technologies.	Understand

iv) **SYLLABUS**

Introduction, Classification of Energy Resources- Conventional Energy Resources and Non-Conventional Energy Resources.

Principle of Conversion of Solar Radiation into Heat – Solar thermal collectors. – Flat plate collectors. Solar concentrators Solar Thermal Electric Power Generation, Solar Photovoltaic – Solar Cell fundamentals

Solar PV Systems – stand-alone and grid connected- Applications. Ocean Thermal Energy Conversion, Open Cycle (Claude cycle), Closed Cycle

Site-selection criteria- Biofouling - Wind Energy Conversion Systems wind speed measurement-Classification of WECS- types of rotors. wind power equation -Betz limit.

Electrical Power Output and Capacity Factor of WECS -Environmental impacts. Small Hydro Power - Classification as micro, mini and small hydro projects. Basic concepts and types of turbines- selection considerations.

Fuel Cell-principle of operation- Hydrogen energy - hydrogen production, electrolysis - thermo chemical methods - hydrogen storage and utilization.

v) (a) TEXT BOOKS

1) C.S.Solanki, *Solar Photovoltaic: Fundamentals Technologies And Applications*, Prentice-Hall Of India Pvt. Limited, 3rd Edition, 2015.
2) Rai. G.D, *Non-conventional Energy Sources*, Khanna publishers,6th Edition, 2017.
3) Rao S. and B. B. Parulekar, "Energy Technology", Khanna Publishers, 1999.

(b) REFERENCES

1) G.N. Tiwari, "Solar Energy-Fundamentals, Design, Modelling and Applications", Narosa Publishers, 2002.
2) Earnest J. and T. Wizelius, "Wind Power Plants and Project Development", PHI Learning, 2011.
3) Sab S. L., "Renewable and Novel Energy Sources", MI. Publications, 1995.
4) Sawhney G. S., "Non-Conventional Energy Resources", PHI Learning, 2012.
5) Tiwari G. N., "Solar Energy- Fundamentals, Design, Modelling and Applications", CRC Press, 2002.
6) A.A.M. Saigh (Ed), "Solar Energy Engineering", Academic Press, 1977
7) Abbasi S. A. and N. Abbasi, "Renewable Energy Sources and Their Environmental Impact", Prentice Hall of India, 2001.
8) Boyle G. (ed.), "Renewable Energy - Power for Sustainable Future", Oxford University Press, 1996
9) Earnest J. and T. Wizelius, "Wind Power Plants and Project Development", PHI Learning, 2011.
10) F. Kreith and J.F. Kreider: "Principles of Solar Engineering", McGraw Hill, 1978.
11) Khan B.H, "Non-Conventional Energy resources", Tata McGraw Hill, 2009.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction, Classification of Energy Resources- Conventional Energy Resources - Availability and their limitations- Non-Conventional Energy Resources – Classification, Advantages, Limitations; Comparison. SOLAR THERMAL SYSTEMS- Principle of Conversion of Solar Radiation into Heat – Solar thermal collectors. – Flat plate collectors. Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector). SOLAR ELECTRIC SYSTEMS - Solar Thermal Electric Power Generation – Solar Photovoltaic – Solar Cell fundamentals - characteristics, classification, construction. Solar PV Systems – stand-alone and grid connected - Applications.	**11**

II	ENERGY FROM OCEAN - Ocean Thermal Energy Conversion (OTEC)- Principle of OTEC system - Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle. Site-selection criteria- Biofouling - Advantages & Limitations of OTEC. TIDAL ENERGY – Principle of Tidal Power- Components of Tidal Power Plant (TPP)- Classification-single basin - double basin types – Limitations - Environmental impacts.	**10**
III	WIND ENERGY – Introduction - Basic principles of Wind Energy Conversion Systems (WECS) wind speed measurement-Classification of WECS - types of rotors. wind power equation - Betz limit. Electrical Power Output and Capacity Factor of WECS- Advantages and Disadvantages of WECS -site selection criteria.	**9**
IV	BIOMASS ENERGY – Introduction - Biomass fuels - Biomass conversion technologies - Urban waste to Energy Conversion- Biomass Gasification - Biomass to Ethanol Production- Biogas production from waste biomass - factors affecting biogas generation- types of biogas plants – KVIC and Janata model - Biomass program in India.	**8**
V	SMALL HYDRO POWER- Classification as micro, mini and small hydro projects - Basic concepts and types of turbines- selection considerations. EMERGING TECHNOLOGIES: Fuel Cell-principle of operation – classification- conversion efficiency and losses - applications. Hydrogen energy - hydrogen production - electrolysis - thermo chemical methods - hydrogen storage and utilization.	**7**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL0U41E	INTRODUCTION TO FLIGHT DYNAMICS AND CONTROL	OEC	3	0	0	3	2022

i) PRE-REQUISITE: MA0U10B: Vector Calculus, Differential Equations and Transforms

ii) COURSE OVERVIEW: The main goal of this course is to present the fundamentals of aerodynamics of flight and its motion. This course discusses the various control surfaces and systems in an aircraft. It gives an insight into the performance measures, dynamics, static and dynamic stability of aircrafts.

iii) COURSE OUTCOMES

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

CO1	Develop state space and transfer function models of an LTI system.	Apply
CO2	Apply time domain techniques to analyse the stability of a linear system	Apply
CO3	Explain the basic concepts of flight, aircraft aerodynamics and flight mechanics.	Understand
CO4	Explain the various control surfaces and performance measures in flight control systems	Understand
CO5	Solve for various performance measures in aircraft	Understand
CO6	Describe the concepts of static and dynamic stability, various modes and control of aircraft.	Understand

iv) SYLLABUS

Introduction to open loop and closed loop control systems - Transfer function - Time domain analysis - Introduction to state space - controllability & observability.

Concept of stability - Routh Hurwitz stability criterion - Root locus - Stability analysis using Root Locus

Introduction to Aerodynamics - Aerodynamic flows. Airfoil nomenclature - Wing geometry - Aerodynamic forces and moments - aerodynamic coefficients - Control surfaces - Wind tunnels. Drag Polar - Equation of motion of aircraft - Rate of climb - range and endurance - gliding flight - landing performance - V-n diagram.

Static and dynamic stability - Longitudinal and lateral dynamics – Autopilots - Displacement autopilots - Stability augmentation system.

v) (a) TEXT BOOKS

1) John D Anderson Jr., *Introduction to Flight*, McGraw Hill International, 6th edition, 2017.
2) Katsuhiko Ogata, *Modern Control Engineering*, Prentice Hall of India, New Delhi, 5th edition, 2010.
3) Robert C Nelson, *Flight Stability and Automatic Contro*l, McGraw-Hill Education, 2nd edition, 1996.

(b) REFERENCES

1) Bernard Etkin, *Dynamics of flight Stability and Control*, John Wiley and Sons Inc. 7th edition, 2011.
2) Nagarath I. J. and Gopal M, *Control System Engineering*, New Age International, 6th edition, 2017.
3) Nise N. S., *Control Systems Engineering*, Wiley Eastern, 6th edition, 2010.
4) Richard S.Shevell, *Fundamentals of Flight* Pearson Education Inc., 2nd edition, 2004.
5) R.F Stengel, *Flight dynamics*, Princeton University Press, Princeton, N.J., USA, 2004.
6) John D Anderson *Aircraft Performance & Design*. McGraw-Hill Education, 1999.
7) A C Kermode, *Flight Without Formulae*, Pearson Education Inc., 5th edition, 2004.
8) Thomas R. Yechout, *Introduction to Aircraft Flight Mechanics: Performance, Static Stability, Dynamic Stability, Feedback Control and State-Space Foundations*, AIAA Education Series, 2014.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to control system: Open loop and closed loop control systems - Transfer function of LTI systems – characteristic equation – Type and order of system. Time domain analysis of control systems: Standard test signals – Transient and steady state responses – first and second order systems – time domain specifications – step responses of first and second order systems. Introduction to state space: state equation of linear continuous time systems – Eigen values and Eigen vectors of system matrix – concept of controllability & observability – relationship between state equations and transfer function.	8
II	**Concept of stability:** Bounded Input Bounded Output stability – stability of feedback system – location of poles and stability – Routh Hurwitz stability criterion. **Root locus:** General rules for constructing Root loci – stability from root loci – effect of addition of poles and zeros. **Introduction to Aerodynamics:** standard atmosphere – definition of altitudes–density, pressure and temperature altitudes. Aerodynamic flows – inviscid and viscous flows – incompressible and compressible flows – Mach number – laminar and turbulent flows – Reynolds number.	10
III	**Airfoils**: Airfoil nomenclature – symmetric and cambered airfoils – generation of lift. Wing geometry –aspect ratio – chord line – angle of attack. Aerodynamic forces and moments– aerodynamic coefficients – lift, drag and moment coefficients– lift curve, drag curve – stalling of airfoil. Control surfaces: elevator – aileron – rudder – dihedral angle and its effects – flaps and slots – spoilers.	9

	Flow similarity – Wind tunnels – open and close wind tunnels.	
IV	**Aircraft Performance**: Drag Polar – Equation of motion of aircraft for level, un–accelerated flight. Thrust and power required for level, un–accelerated flight– thrust and power available – condition for maximum velocity. Rate of climb– gliding flight– time to climb – range and endurance – takeoff performance – landing performance – Turning flight – wing loading – load factor – V-n diagram.	**9**
V	**Aircraft Stability and Control**: Static and dynamic stability – conditions for longitudinal static stability. Longitudinal and lateral dynamics (linear state space model) – Longitudinal dynamic modes - short period, phugoid. Lateral and directional dynamic stability – Spiral divergence and dutch roll (concepts only -mathematical derivations not needed) **Autopilots**: Control surface actuator – Displacement autopilots – pitch displacement autopilot – attitude hold and velocity hold control systems – block diagrams – Stability augmentation system.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL0U41F	INTRODUCTION TO POWER PROCESSING	OEC	3	0	0	3	2022

i) **PRE-REQUISITE:** MA0U10B Vector Calculus, Differential Equation and Transforms, ES0U10D Basics of Electrical and Electronics Engineering.

ii) **COURSE OVERVIEW**: The goal of this course to enhance the problem-solving skills by using various techniques to solve different types of AC and DC circuits. Time Domain analysis will help students to understand the transient and the steady-state response of R, L, C circuits. The course also aims to introduce two port network modelling and network functions.

iii) **COURSE OUTCOMES**

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

CO1	Explain the power semiconductor devices and wide bandgap devices.	Understand
CO2	Explain the operation of AC-DC rectifiers, DC-DC converters, DC-AC inverters, AC voltage controllers, and the impact of Total Harmonic Distortion.	Understand
CO3	Explain the working of electric motor drives, including 4-quadrant DC motor control and v/f control of induction motors, along with industrial applications.	Understand
CO4	Illustrate the power electronics applications in renewable energy systems, including solar PV, wind energy, energy storage, grid integration, microgrids, and smart grids.	Understand
CO5	Explain power supplies and power electronics in electric vehicles, powertrain, charging technologies and energy storage solutions.	Understand

iv) **SYLLABUS**

Power semiconductor devices – Diode, SCR, MOSFET, IGBT – operation and characteristics, wide bandgap devices (SiC, GaN), applications in renewable energy and transportation.

Single-phase fully controlled rectifier (R, RL load), DC-DC converters – Buck, Boost, Buck-Boost, single-phase full bridge inverter – square-wave operation, sinusoidal PWM, THD, introduction to AC voltage controllers.

Electric drives – block diagram, 4-quadrant DC motor, v/f control of induction motor, industrial applications – heating, lighting, robotics, traction, aerospace.

Solar PV systems – off-grid, on-grid, MPPT, wind energy systems, energy storage – lithium-ion batteries, hydrogen fuel cells, grid integration, microgrids.

Linear and switched-mode power supplies (SMPS), EV classifications – HEV, PHEV, BEV, powertrain schematic, EV charging – fast/wireless, energy storage – lithium-ion batteries, hydrogen fuel cells, future trends.

v) a) TEXTBOOKS

1) Ned Mohan, Tore M. Undeland, William P. Robbins, *Power Electronics: Converters, Applications, and Design*, Wiley, 3rd Edition, 2002.
2) Muhammad H. Rashid, *Power Electronics: Circuits, Devices & Applications*, Pearson, 4th Edition, 2013.
3) P.S. Bimbhra, *Power Electronics*, Khanna Publishers, 6th Edition, 2018.
4) Gopal K. Dubey, *Fundamentals of Electrical Drives*, Narosa Publishing, 2nd Edition, 2010.
5) Andrzej M. Trzynadlowski, *Introduction to Modern Power Electronics*, 3rd Edition, Wiley, 2015.
6) Iqbal Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2003.

b) REFERENCES

1) Robert W. Erickson, Dragan Maksimovic, *Fundamentals of Power Electronics*, Springer, 2nd Edition, 2001.
2) M.D. Singh, K.B. Khanchandani, *Power Electronics*, McGraw Hill, 2nd Edition, 2007.
3) Bimal K. Bose, *Modern Power Electronics and AC Drives*, Pearson, 1st Edition, 2001.
4) R. Krishnan, *Electric Motor Drives: Modeling, Analysis, and Control*, Pearson, 1st Edition, 2001.
5) Chetan Singh Solanki, *Solar Photovoltaics: Fundamentals, Technologies, and Applications*, PHI Learning, 3rd Edition, 2021.
6) James Larminie, John Lowry, *Electric Vehicle Technology Explained*, Wiley, 2nd Edition, 2012.
7) Ali Emadi, *Advanced Electric Drive Vehicles*, CRC Press, 1st Edition, 2014.
8) D.P. Kothari, K.C. Singal, Rakesh Ranjan, *Renewable Energy Sources and Emerging Technologies*, PHI Learning, 2nd Edition, 2011.
9) Jahangir Hossain, Hemanshu Roy Pota, *Renewable Energy Integration*, Academic Press, 1st Edition, 2014.
10) Daniel M. Mitchell, *DC-DC Switching Regulator Analysis*, McGraw Hill, 1st Edition, 1988.
11) Abbasi S. A. and N. Abbasi, *Renewable Energy Sources and their Environmental Impact*, Prentice Hall of India, 2001.
12) Sawhney G. S., *Non-Conventional Energy Resources*, PHI Learning, 2012.
13) *Non-conventional energy sources*, NPTEL lecture by Prof. Prathap Haridoss, IIT Chennai.
14) Abad, Gonzalo, *Power electronics and electric drives for traction applications*. USA: Wiley, 2017.

c) Additional Online Learning Resources

NPTEL Courses (IITs, IISc):

- *Introduction to Power Electronics* (IIT Delhi)
- *Fundamentals of Electric Drives* (IIT Madras)
- *Energy Storage & Renewable Energy Systems* (IIT Delhi)

MIT OpenCourseWare:

- *Power Electronics (ocw.mit.edu/courses/electrical-engineering-and-computer-science)*

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Fundamentals of Power Processing** Introduction to power processing – Elements of power electronics – Power semiconductor devices – Uncontrolled, semicontrolled, and fully controlled switches – Diode, SCR, MOSFETs, IGBTs: Principle of operation – Advantages of wide bandgap devices: SiC, GaN – Applications of power electronics in modern systems.	9
II	**Power Conversion Circuits** AC-DC conversion: Single-phase fully controlled SCR-based bridge rectifier with R and RL load (continuous mode only) – Principle of operation and waveforms – DC-DC Converters (Non-isolated): Buck, Boost, Buck-Boost converter – Circuit operation, voltage gain, and waveforms in continuous conduction mode – DC-AC conversion: Single-phase half and full bridge inverter with R load – Square-wave operation – Types of PWM: Single pulse, multiple pulse, sinusoidal PWM – Total harmonic distortion (THD) – AC-AC conversion: Single-phase AC voltage controller with R load – Waveforms.	9
III	**Electric Drives & Industrial Applications** Electric motor drives: Introduction – Block diagram of an electric drive – 4-quadrant operation of a separately excited DC motor – Circuit diagram and waveforms – Induction motor drives: Principle of operation – v/f control – Power electronics applications in industrial systems: Heating, lighting, robotics, automation – Power electronics in aerospace and railway traction systems.	9
IV	**Power Processing in Renewable Energy Systems** Solar photovoltaic (PV) systems: Principle of operation – Off-grid and on-grid solar systems – Block diagram – Maximum power point tracking (MPPT) – Wind energy conversion systems (WECS): Working principle – Grid integration – Energy storage technologies: Lithium-ion batteries, lead-acid batteries, supercapacitors, hydrogen fuel cells – Microgrids and smart grids: Concept and applications.	9
V	**Power Processing in Power Supplies & Electric Vehicles** Power supplies: Principle of operation – Linear power supply, switched-mode power supply (SMPS) – Power supply requirements: Isolation, protection, regulation – Electric vehicles (EVs): Introduction to HEV, PHEV, BEV – Block schematic of power train – Energy storage in EVs: Li-ion batteries, hydrogen fuel cells – Charging technologies: Fast charging, wireless charging – Future trends in power electronics: AI, IoT, wide bandgap devices	9
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

MINORS/HONOURS

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL0M49A/ EL0M49B	MINI PROJECT	VAC	0	1	6	4	2022

i) PREAMBLE:

A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The objective of Project Work is to enable the student to take up investigative study in the broad field of Electrical and Electronics Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on a group of three/four students, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. Each project assignment should typically include the following:

- Survey and study of relevant published literature on the assigned topic.
- Preparation of an action plan for conducting the investigation, including team roles and responsibilities.
- Development of a preliminary approach to the problem related to the assigned topic
- Documentation of block-level design.
- Conducting preliminary analysis, modeling, simulation, experimentation, design, or feasibility study.
- Preparation of a written report on the study conducted, for presentation to the department.

ii) COURSE OUTCOMES

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

CO1	Identify engineering problems and formulate appropriate solutions.	Apply
CO2	Plan project activities and coordinate effectively within a team to meet deadlines.	Apply
CO3	Evaluate proposed solutions through theoretical analysis and experimental validation.	Evaluate
CO4	Develop technical reports and demonstrate effective communication skills.	Create
CO5	Present technical content clearly and justify ideas with logical reasoning.	Evaluate

iii) COURSE PLAN

In this course, each group consisting of three/four members is expected to design and develop a moderately complex software/hardware system with practical applications. This should be a working model. The basic concept of product design may be taken into consideration. Students should identify a topic of interest in consultation with Faculty-in-charge of mini project /Advisor. Review the literature and gather information pertaining to the chosen topic. State the objectives and develop a methodology to achieve the objectives. Carryout the design/fabrication or develop codes/programs to achieve the objectives. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on a minimum of two reviews. The review committee may

be constituted by the Head of the Department. A project report is required at the end of the semester. The product has to be demonstrated for its full design specifications. Innovative design concepts, reliability considerations, aesthetics/ergonomic aspects taken care of in the project shall be given due weight.

iv) CONTINUOUS ASSESSMENT EVALUATION PATTERN

The End Semester Evaluation (ESE) will be conducted as an internal evaluation based on the product, the report and a viva- voce examination, conducted by a 3-member committee appointed by Head of the Department comprising HoD or a senior faculty member, academic coordinator for that program and project guide/coordinator. The Committee will be evaluating the level of completion and demonstration of functionality/specifications, presentation, oral examination, working knowledge and involvement.

The Continuous Internal Evaluation (CIE) is conducted by evaluating the progress of the mini project through minimum of TWO reviews. At the time of the 1st review, students are supposed to propose a new system/design/idea, after completing a thorough literature study of the existing systems under their chosen area. In the 2nd review students are expected to highlight the implementation details of the proposed solution. The review committee should assess the extent to which the implementation reflects the proposed design. A well coded, assembled and completely functional product is the expected output at this stage. The final CIE mark is the average of 1st and 2nd review marks.

A zeroth review may be conducted before the beginning of the project to give a chance for the students to present their area of interest or problem domain or conduct open brain storming sessions for innovative ideas. Zeroth review will not be a part of the CIE evaluation process.

v) CONTINUOUS INTERNAL EVALUATION (CIE) PATTERN

Attendance	:	10 marks
Marks awarded by Guide	:	15 marks
Project Report	:	10 marks
Evaluation by the Committee	:	40 marks
Total	:	**75 marks**

vi) END SEMESTER EXAMINATION (ESE) PATTERN

Level of completion	:	10 marks
Demonstration of functionality	:	25 marks
Project Report	:	10 marks
Viva-voce	:	20 marks
Presentation	:	10 marks
Total	:	**75 marks**

vii) MARK DISTRIBUTION

Total Marks	CIE	ESE
150	75	75

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2H40A	AIRCRAFT DYNAMICS & CONTROL	VAC	4	0	0	4	2022

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW: This course provides an introduction to the fundamental principles of aircraft motion, dynamic modeling, and control system design as applied to aerospace vehicles. Students will gain theoretical insights into flight dynamics and the application of classical and modern control strategies in aviation.

iii) COURSE OUTCOMES

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

CO1	Explain the concept of aircraft configurations and the physics of flight.	Understand
CO2	Develop the equations of motion for flight.	Apply
CO3	Model the static and dynamic stability of aircraft.	Apply
CO4	Apply control theory to model and design aircraft control systems.	Apply
CO5	Summarize avionics systems relevant to flight dynamics and control.	Understand

iv) SYLLABUS

Introduction to Aircraft and Flight Mechanics: Basic flight mechanics, Aircraft structures, and components. Forces and moments on an aircraft. Coordinate systems, 6 Degrees of Freedom (DoF), and generalized motion.

Aircraft Kinematics and Equations of Motion: Rigid body kinematics and rotation sequences. Euler angles and angular velocity transformation. Newton-Euler equations of motion. Derivation of 6-DOF equations for rigid aircraft. Linearization of equations, Trimmed flight and equilibrium conditions.

Static and Dynamic Stability of Aircraft: Static stability, Dynamic stability. Dynamic modes of motion. Time-domain analysis of modes. State-space formulation for stability analysis. Control surface effects on stability

Aircraft Control Systems and Feedback Principles: Control surfaces, Flight control system configurations, Classical control methods (PID, lead-lag), Stability augmentation systems (SAS), Control augmentation systems (CAS), Control design using root locus and frequency response.

Avionics and Embedded Flight Control Concepts: Basics of avionics and flight instrumentation. Flight sensors, Actuation systems, Digital control system architecture in aircraft. Fault tolerance and redundancy in flight control.

v) (a) TEXT BOOKS:

1) John D. Anderson, Jr., *Introduction to Flight*, 8th Edition (or latest), McGraw-Hill Education,

2) Robert C. Nelson, *Flight Stability and Automatic Control*, 2nd Edition, McGraw-Hill Education, 2017.
3) Bernard Etkin & Lloyd Duff Reid, *Dynamics of Flight: Stability and Control,* 3rd edition, Wiley, 1995.
4) Brian L. Stevens & Frank L. Lewis, *Aircraft Control and Simulation,* 2nd edition, Wiley, 2003.
5) Cary R. Spitzer (Editor), *Avionics: Development and Implementation,* 2nd edition, CRC Press, 2006.

(b) REFERENCES

1) Shevell, Richard S., *Fundamentals of Flight*, Second Edition, Pearson Prentice-Hall, Upper Saddle River, NJ, 1989.
2) McCormick, Barnes W., *Aerodynamics, Aeronautics and Flight Mechanics*, Second Edition, John Wiley and Sons, Inc., Canada, 1995.
3) Stevens, B. L. and Lewis, F. L., *Aircraft Control and Simulation*, Second Edition, John Wiley and Sons, Inc., Hoboken, New Jersey, 2003.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Aircraft and Flight Mechanics:** Evolution and classification of aircraft. Basic flight mechanics: Lift, drag, thrust, and weight. Aircraft structures and components. Forces and moments on an aircraft. Coordinate systems: Body, wind, and inertial axes. 6 Degrees of Freedom (DoF) and generalized motion. Angle of attack, sideslip angle, and flight path angle.	**12**
II	**Aircraft Kinematics and Equations of Motion:** Rigid body kinematics and rotation sequences. Euler angles and angular velocity transformation. Newton-Euler equations of motion. Derivation of 6-DOF equations for rigid aircraft. Linearization of equations: small disturbance theory. Longitudinal and lateral-directional dynamic models. Trimmed flight and equilibrium conditions.	**12**
III	**Static and Dynamic Stability of Aircraft:** Static stability: longitudinal, lateral, and directional. Dynamic stability: stability derivatives and criteria. Dynamic modes of motion: State space representation: Short-period and phugoid, Dutch roll, spiral, roll subsidence (Concepts and basic equations only). Time-domain analysis of modes. State-space formulation for stability analysis. Control surface effects on stability.	**12**
IV	**Aircraft Control Systems and Feedback Principles:** Overview of aircraft control systems. Control surfaces: elevator, rudder, aileron. Flight control system configurations: manual, automatic.	**12**

	Introduction to classical control methods (PID, lead-lag), Stability augmentation systems (SAS), Control augmentation systems (CAS), Control design using root locus and frequency response.	
V	**Avionics and Embedded Flight Control Concepts:** Basics of avionics and flight instrumentation. Flight sensors: gyroscopes, accelerometers, IMUs, pitot tubes. Actuation systems: servos, fly-by-wire systems. Avionics buses: ARINC 429, MIL-STD-1553. Digital control system architecture in aircraft. Overview of certification standards: DO-178C, DO-254. Fault tolerance and redundancy in flight control.	**12**
	Total hours	**60**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2H40B	DEEP LEARNING	VAC	3	1	0	4	2022

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW:

This course aims to introduce the learner to an overview of the concepts and algorithms involved in deep learning. Deep learning is a subfield of machine learning, a subfield of artificial intelligence. Basic concepts and application areas of machine learning, deep networks, convolutional neural network, recurrent neural network, advanced computer vision and natural language processing techniques are covered here. This is a foundational program that will help students understand the capabilities, challenges, and consequences of deep learning and prepare them to participate in the development of leading-edge AI technology. They will be able to gain the knowledge needed to take a definitive step in the world of AI.

iii) COURSE OUTCOMES

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

CO1	Explain the fundamental concepts of Deep Learning, neural networks, and optimization techniques.	Understand
CO2	Apply Convolutional Neural Networks for image classification, object detection, and segmentation tasks	Apply
CO3	Make use of advanced Computer Vision techniques for feature extraction and image generation.	Apply
CO4	Develop Natural Language Processing models and perform sentiment analysis	Apply
CO5	Apply state-of-the-art Transformer-based models for text processing applications	Apply

iv) SYLLABUS

Fundamentals of Deep Learning, Key components - Data, models, objective functions, optimization algorithms, Learning algorithm. Supervised learning, Unsupervised learning, Reinforcement learning, Historical Trends in Deep Learning. Overfitting, underfitting, hyper parameter tuning. Neural Networks. Gradient Descent solution for Perceptron, Multilayer perceptron. Introduction to optimization linear least squares. Stochastic gradient descent, Building ML algorithms and challenges. Convolutional Neural Networks. Practical challenges of common deep learning architectures. Case study-pretrained models. Recurrent neural networks, recurrent networks, recursive neural networks, modern RNNs LSTM and GRU, Practical use cases for RNNs. Applications - computer vision, speech recognition, natural language processing. Research Areas - auto encoders, representation learning, boltzmann machines, deep belief networks.

v) (a) TEXT BOOKS

1) Ian Goodfellow, YoshuaBengio, Aaron Courville, Deep Learning, MIT Press 2015 ed.

2) Aston Zhang, Zachary C. Lipton, Mu Li, and Alexander J. Smola, Dive into Deep Learning, August 2019.
3) Aggarwal, Charu C, Neural Networks and Deep Learning, Springer International Publishing AG, part of Springer Nature 2018.

(b) REFERENCES

1) Russell Reed, Robert J Marksll, Neural Smithing: Supervised Learning in Feedforward Artificial Neural Networks, Bradford Book, 2014.
2) Mohit Sewak, Md. Rezaul Karim, Pradeep Pujari, Practical Convolutional Neural Networks, Packt Publishing, 2018.
3) Sudharsan Ravichandran, Hands-On Deep Learning Algorithms with Python, Packt Publishing, 2019.
4) Francois Chollet, Deep Learning with Python, Manning Publications Co., 2018.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Deep Learning and Neural Networks, Perceptron, Activation Functions, and Backpropagation, Gradient Descent and Optimization Algorithms (SGD, Adam, RMSprop), Loss Functions and Regularization Techniques. Introduction to TensorFlow & PyTorch, Hyperparameter Tuning, Weight Initialization, and Batch Normalization	**10**
II	Computer Vision - Convolutional Neural Networks (CNNs) Working with Images: Digitization, Sampling, and Quantization, Convolutional Neural Networks (CNN) - Architecture and Layers, Pooling Layers, Dropout, and Data Augmentation, Case Studies: LeNet, AlexNet, VGGNet, ResNet, and MobileNet, Transfer Learning and Fine-tuning Pretrained Models, Object Detection: Region Proposals, YOLO, SSD, Image Segmentation: U-Net, Mask R-CNN, Semantic vs. Instance Segmentation. Hands-on Case study: Image Classification & Object Detection using CNNs.	**10**
III	Advanced Computer Vision & Generative Models Feature Extraction & Transfer Learning Applications, Siamese Networks for Image Similarity and Metric Learning, Generative Adversarial Networks (GANs) - Concepts and Training, Variational Autoencoders (VAEs) for Image Generation. Hands-on Case Study: GAN Implementation and Style Transfer.	**13**
IV	Natural Language Processing (NLP) - Introduction to NLP and Text Preprocessing, Tokenization, Lemmatization, Stemming, Stop-word Removal, Word Embeddings: Word2Vec, GloVe, Fast Text, Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM), Bidirectional LSTMs and GRUs, Sentiment Analysis, Named Entity Recognition (NER), Part-of-Speech (POS) Tagging. Hands-on: Implementing Word Embeddings and LSTM-based Sentiment Analysis.	**13**

V	Advanced NLP - Transformers and Large Language Models Introduction to Attention Mechanisms & Self-Attention, Transformers and BERT (Bidirectional Encoder Representations from Transformers), GPT (Generative Pre-trained Transformer) Models, Neural Machine Translation and Sequence-to-Sequence Models, Speech Recognition and Text-to-Speech Models, Applications: Chatbots, Text Summarization, and Question Answering Systems. Hands-on: Implementing BERT for Text Classification.	**14**
	Total hours	**60**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Cate-gory	L	T	P	Credit	Year of Introduction
EL2H40C	OPERATION AND CONTROL OF AC/DC SMART GRIDS	VAC	4	0	0	4	2022

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW: The aim of this subject is to offer the students acquire a comprehensive idea on various aspects of smart grid operation and control.

iii) COURSE OUTCOMES

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

CO1	Explain the technologies used in Smart Grid	Understand
CO2	Apply storage technologies and protection schemes in Smart Grid	Apply
CO3	Explain the operation and control of Microgrids	Understand
CO4	Develop the simulation and case study of Microgrids	Apply

iv) SYLLABUS

Review of Smart Grid, Smart Grid Architecture- Components and Architecture of Smart Grid Design, Introduction to energy storage devices, Different types of energy storage technologies, Monitoring and Protection of Smart Grids, DC Microgrid Topologies, DC Microgrid Protection Devices, Applications of DC, Challenges in DC Microgrid, Overview of AC Microgrid controls, AC-DC Distribution Network., Structure of AC-DC distribution network, Classifications of buses, Overview of Load-Flow analysis, Planning aspects of smart grid, Demand side management- Demand response, Energy management, Planning of smart grid systems, Simulation and Case study.

v) (a) TEXT BOOKS

1) Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, ISBN: 978-0-47062761-7, Wiley
2) James Momoh, Smart Grid: Fundamentals of Design and Analysis, ISBN: 978-0-470-889398, Wiley
3) R. C. Durgan, M. F. Me Granaghen, H. W. Beaty, “Electrical Power System Quality”, McGraw-Hill
4) Chris Mi, M. Abul Masrur, David Wenzhong Gao, “Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives”, 2011, Wiley publication.

(b) REFERENCES

1) Danda B. Rawat; Chandra Bajracharya, “Cyber security for smart grid systems: Status, challenges and perspectives”, IEEE Southeast Con 2015, DOI: 10.1109/SECON.2015.7132891.
2) Pillitteri, V. and Brewer, T. (2014), “Guidelines for Smart Grid Cyber security”, NIST Interagency/Internal Report (NISTIR), National Institute of Standards and Technology, Gaithersburg, MD, [online], https://doi.org/10.6028/NIST.IR.7628r1.

3) G.T.Heydt, Electric Power Quality, Stars in a Circle Publications, 2nd Edition.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Review on Smart Grid** - Environmental impact and Climate Change, Economic Issues. **Smart Grid Architecture:** Components and Architecture of Smart Grid, Overview of technologies used in Smart Grid, Fundamental components of Smart Grid – Transmission Automation –Distribution Automation –Renewable Integration, Advanced metering infrastructure.	12
II	**Energy Storage:** Introduction to energy storage devices, Different types of energy storage technologies, Analytical modelling of energy storage devices, Optimal sizing and siting of storages. Battery management system (BMS). **Monitoring and Protection:** Intelligent Electronic Devices (IED) and their application for monitoring & protection, Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU). Islanding detection techniques, Smart grid protection- Adaptive protection scheme- Different types of relays.	12
III	**Modelling of DC Smart Grid Components:** DC Microgrid Topologies, Key Energy Sources, Types of Loads, Switch Mode Power Converters (Buck Boost and Fly back), DC Microgrid Communication, DC Microgrid Protection Devices, Challenges in DC Microgrid. **Control of DC Microgrid**: Types of control - Decentralized control, Distributed control, Centralized control.	12
IV	**Operation and control of AC Microgrid:** Introduction, Need for Microgrid Control, Hierarchical Controls, Intelligent Control Techniques, Overview of AC Microgrid controls. **System Analysis of AC/DC Smart Grid:** AC-DC Distribution Network., Structure of AC-DC distribution network, Classifications of buses, Overview of Load-Flow analysis, AC-DC Load-Flow Analysis -Challenges, Power converter modelling, Distributed Generations modelling, Basic Steps for Load Flow Formulation of AC-DC Distribution Network.	12
V	**Smart Grid Planning**: Planning aspects of smart grid, Demand side management- Demand response, Demand Response Analysis of Smart Grid, Energy management, Planning of smart grid systems. **Simulation and Case study:** AC Microgrid, DC Microgrid, AC-DC Hybrid Microgrid	12

	Total hours	**60**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2H40D	SMART GRID AND INTERFACING	VAC	4	0	0	4	2022

i) PRE-REQUISITE: ES0U10D Basics of Electrical and Electronics Engineering**,** EL2U30D Power Electronics and Drives

ii) COURSE OVERVIEW: The course aims to provide students with a conceptual introduction to smart grids, its architecture, components and communication technologies. It also aims to provide an insight about the need for energy storage, devices and technologies available and their applications.

iii) COURSE OUTCOMES

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

CO1	Explain the need, benefits and functions of smart grid and its various components	Understand
CO2	Explain the various Smart Grid Technologies	Understand
CO3	Explain various energy storages technologies in smart grid	Understand
CO4	Explain the application of IoT in smart grid	Understand
CO5	Explain the various communication technologies used in smart grid	Understand

iv) SYLLABUS

Introduction to Smart Grids and Smart Grid Components Reference architecture – Smart meters – Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU).

Smart Grid Technologies Smart Substations – IEC 61850 Substation Architecture, Smart Appliances.

Energy Storage Technologies Role of Energy Storage Systems – Applications – Overview of energy storage technologies.

Electrical energy storage Types – Characteristics and Specifications of Battery Storage – Mobile Energy Storage Systems – V2G and G2V operation, Hybrid Storage.

IoT applications in Smart Grid– IoT based home automation- Automobile IoT

Communication and Cloud Computing HAN, NAN, SANET – Communication Protocols – Cloud architecture of smart grid.

v) (a) TEXT BOOKS

1) Ali Keyhani, *Design of Smart Power Grid Renewable Energy Systems*, Wiley-IEEE Press, 2011.
2) James Momoh, Smart *Grid: Fundamentals of Design and Analysi*s, Wiley-IEEE Press, 2015.
3) Francisco Díaz-González, Andreas Sumper, Oriol Gomis-Bellmunt, Energy Storage in Power Systems. Wiley Publication, 2016.

(b) REFERENCES

1) Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, "*Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals*", Theory and Design, CRC Press, 2004.
2) Faisal M., Hannan M. A., Ker P. J., Hussain A., Mansor M. B., Blaabjerg F., "*Review of Energy Storage System Technologies in Microgrid Applications: Issues and Challenge*s," in *IEEE Access*, vol. 6, pp. 35143-35164, 2018. doi: 10.1109/ACCESS.2018.2841407.
3) Yilmaz M., Krein P. T., "Review of Battery Charger Topologies, Charging Power Levels, and Infrastructure for Plug-In Electric and Hybrid Vehicles," IEEE Transactions on Power Electronics, vol. 28, no. 5, pp. 2151-2169, May 2013, doi: 10.1109/TPEL.2012.2212917.
4) Ma R., Chen H., Huang Y., Meng W., "Smart Grid Communication: Its Challenges and Opportunities," in IEEE Transactions on Smart Grid, vol. 4, no. 1, pp. 36-46, March 2013, doi: 10.1109/TSG.2012.2225851.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Smart Grid**: Evolution of Electric Grid-Conventional Grid vs Smart Grid -Need and Definitions of Smart Grid-Benefits, Challenges and Key Application Areas of Smart Grid. **Smart Grid Components:** Smart Grid Reference Architecture-Introduction to Smart Meters, Real Time Pricing- Intelligent Electronic Devices (IED) and their application for monitoring & protection, Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU)	**12**
II	**Smart Grid Technologies:** Smart Substations, Substation Automation, IEC 61850 Substation Architecture, Automatic Meter Reading(AMR), Advanced Metering Infrastructure (AMI) Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation.	**12**
III	**Energy Storage Technologies**: Role of Energy Storage Systems-Applications - Overview of energy storage technologies - Thermal, Mechanical, Chemical, Electrochemical, Electrical - Comparison of Various Storage Technologies-Criteria for Selection of Storage. **Mobile Storage Systems**: Electric Vehicle, G2V, V2G. Basic concepts of Hybrid Energy storage systems.	**12**
IV	**IoT applications in Smart Grid**: Definition and Characteristics of IoT, Physical Design of IoT: Things in IoT, IoT Protocols. Energy management and smart grid applications IoT based home automation, Smart metering for electricity consumers. IoT based weather stations, **Automobile IoT**: Electric vehicles-platform and software.	**12**

V	**Communication Networks for Smart Grid**: Interoperability and connectivity - Home Area Network (HAN), Neighborhood-Area Networks (NANs), Sensor and Actuator Networks (SANETs)-Communication Protocols. **Cloud computing in Smart Grid**: Private, public and Hybrid cloud. Cloud architecture of smart grid.	**12**
	Total hours	**60**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

SEMESTER VIII

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
HS0U40A	INDUSTRIAL ECONOMICS AND FOREIGN TRADE	HSC	3	0	0	3	2022

i) PRE-REQUISITE: NIL

ii) COURSE OVERVIEW:

The course enables students to make better economic decisions in wage employment and entrepreneurship using economic alternatives and investment alternatives.

iii) COURSE OUTCOMES

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

CO1	Explain the problem of scarcity of resources, consumer behaviour and the equilibrium condition of demand and supply.	Understand
CO2	Demonstrate the production function and equilibrium condition of a producer	Understand
CO3	Survey the impact of market competition in the functional requirement of a firm and pricing of goods and services.	Analyze
CO4	Infer the overall performance of the economy, the regulation of economic fluctuations and its impact on various sections in the society.	Analyze
CO5	Compare the profitability of projects and economic performance of business with the help of capital budgeting methods.	Evaluate
CO6	Determine the current impact of global economic policies on the business opportunities of a firm	Analyze

iv) SYLLABUS

Scarcity and choice - Basic economic problems- PPC – Firms and its objectives – types of firms – Utility – Law of diminishing marginal utility – Demand and its determinants – law of demand – elasticity of demand – measurement of elasticity and its applications – Supply, law of supply and determinants of supply – Equilibrium – Changes in demand and supply and its effects – Consumer surplus and producer surplus (Concepts) – Taxation and deadweight loss.

Production function – law of variable proportion – economies of scale – internal and external economies – Isoquants, isocost line and producer's equilibrium – Expansion path – Technical progress and its implications – Cobb-Douglas production function - Cost concepts – Social cost: private cost and external cost – Explicit and implicit cost – sunk cost - Short run cost curves - long run cost curves – Revenue (concepts) – Shutdown point – Break-even point.

Perfect and imperfect competition – monopoly, regulation of monopoly, monopolistic completion (features and equilibrium of a firm) – oligopoly – Kinked demand curve – Collusive oligopoly (meaning) – Non-price competition – Product pricing – Cost plus pricing – Target return pricing – Penetration pricing – Predatory pricing – Going rate pricing – Price skimming. Principles of taxation - Direct Tax – Indirect Tax – GST. Concepts of demonetization. Cryptocurrency.

Circular flow of economic activities – Stock and flow Gross. National Income – Concepts - Methods of measuring national income – Inflation- causes and effects – Measures to control inflation. Monetary and fiscal policies – Business financing- Bonds and shares - Money market and Capital market – Stock market – Demat account and Trading account - SENSEX and NIFTY. Capital Budgeting - Methods of Investment analysis - Pay back, ARR, NPV, IRR and B/C ratio.

Advantages and disadvantages of international trade - Absolute and Comparative advantage theory - Heckscher - Ohlin theory - Balance of payments – Components – Balance of Payments deficit and devaluation – Trade policy – Free trade versus protection – Tariff and non-tariff barriers.

v) REFERENCE

1) Gregory N Mankiw, *Principles of Micro Economics*, Cengage Publications, 2015.
2) Gregory N Mankiw, *Principles of Macro Economics*, Cengage Publications, 2012.
3) Dwivedi D.N., *Macro Economics*, Tata McGraw Hill, New Delhi, 2018.
4) Mithani D M, *Managerial Economics*, Himalaya Publishing House, Mumbai, 2017.
5) Tulsian, *Financial Management* S Chand & Company 2017.
6) Francis Cherunilam, *International Economics*, McGraw Hill, New Delhi, 2017.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Scarcity and choice - Basic economic problems- PPC – Firms and its objectives – types of firms – Utility – Law of diminishing marginal utility – Demand and its determinants – law of demand – elasticity of demand – measurement of elasticity and its applications – Supply, law of supply and determinants of supply – Equilibrium – Changes in demand and supply and its effects – Consumer surplus and producer surplus (Concepts) – Taxation and deadweight loss.	**8**
II	Production function – law of variable proportion – economies of scale – internal and external economies – Isoquants, isocost line and producer's equilibrium – Expansion path – Technical progress and its implications – Cobb-Douglas production function - Cost concepts – Social cost: private cost and external cost – Explicit and implicit cost – sunk cost - Short run cost curves - long run cost curves – Revenue (concepts) – Shutdown point – Break-even point.	**8**
III	Perfect and imperfect competition – monopoly, regulation of monopoly, monopolistic completion (features and equilibrium of a firm) – oligopoly – Kinked demand curve – Collusive oligopoly (meaning) – Non-price competition – Product pricing – Cost plus pricing – Target return pricing – Penetration pricing – Predatory pricing – Going rate pricing – Price skimming. Principles of taxation - Direct Tax – Indirect Tax – GST. Concepts of demonetization. Cryptocurrency	**9**
IV	Circular flow of economic activities – Stock and flow Gross. National Income – Concepts - Methods of measuring national income – Inflation-causes and effects – Measures to control inflation. Monetary and fiscal policies – Business financing- Bonds and shares -Money market and Capital market – Stock market – Demat account and Trading account -	**11**

	SENSEX and NIFTY. Capital Budgeting - Methods of Investment analysis - Pay back, ARR, NPV, IRR and B/C ratio.	
V	Advantages and disadvantages of international trade - Absolute and Comparative advantage theory - Heckscher - Ohlin theory - Balance of payments – Components – Balance of Payments deficit and devaluation – Trade policy – Free trade versus protection – Tariff and non-tariff barriers.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance : 10 marks

CA Exams (2 numbers) : 25 marks

Assignment/Project/Case study etc. : 15 marks

Total : **50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U40C	COMPREHENSIVE COURSE VIVA	PCC	1	0	0	1	2022

vii) COURSE OVERVIEW:

The objective of this Course viva is to ensure the basic knowledge of each student in the most fundamental core courses in the curriculum. The viva voce shall be conducted based on the core subjects studied from third to eighth semester. This course helps the learner to become competent in placement tests and other competitive examinations.

viii) GUIDELINES

1) The course should be mapped with a faculty and practice sessions for solving questions based on the core courses in the curriculum shall be arranged.
2) The Comprehensive Viva Voce will be conducted along with the Final Project Phase II evaluation and assessed by the same three-member committee, comprising the Project Coordinator, an expert from the industry or a research institute, and a senior faculty member from a sister department.
3) The pass minimum for this course is 25.
4) The mark will be treated as internal and should be uploaded along with internal marks of other courses.

ix) MARK DISTRIBUTION

Total marks : 50 (only CIE)
Minimum marks required to pass: 25

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U49C	PROJECT PHASE II	PWS	0	0	12	4	2022

i) PRE-REQUISITE: EL2U49B: Project Phase I

ii) COURSE OVERVIEW: The goal of this course is to enable students to apply engineering knowledge in practical problem solving. It equips them to foster innovation in design of products, processes or systems. Also creates an urge to develop creative thinking in finding viable solutions to engineering problems. It also aims to provide a good training for the student(s) in R&D work and technical leadership.

iii) COURSE OUTCOMES

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

CO1	Extend knowledge in solving the real-life engineering problems	Understand
CO2	Plan the project effectively (Analysis / modelling / simulation / design / problem solving / experiment).	Apply
CO3	Validate the prototype / process. (Demonstration and testing)	Analyse
CO4	Comprehend and write effective reports, make effective presentations.	Apply
CO5	Develop professional ethics and communicate effectively.	Apply

iv) GUIDELINES

1. Detailed Analysis /Modelling /Simulation /Problem Solving / for implementation as needed.
2. Final development of product/process, testing, results, inferences, conclusions and future directions.
3. Preparing a paper for Conference presentation/Publication in Journals, based on the quality/quantity of work as adjudged by the evaluation committee.
4. Preparing a report in the standard format for being evaluated by the dept. evaluation committee.
5. Preparing presentations for assessments at various stages.

v) ASSESSMENT PATTERN

Minimum required to pass: 75 marks

Project progress evaluation by Project Supervisor	:	30
Two interim evaluations by the Evaluation Committee (25 marks for each evaluation)	:	50
Quality of the report evaluated by the Evaluation committee	:	30
Final evaluation by a three-member committee	:	40
Total marks	**:**	**150**

The interim evaluation committee comprises HoD or a senior faculty member, Project coordinator and Project supervisor.

The final evaluation committee comprises Project coordinator, Expert from Industry/research Institute and a Senior faculty from a sister department. The same committee will conduct comprehensive course viva for 50 marks.

vi) EVALUATION BY GUIDE

The guide/supervisor must monitor the progress being carried out by the project groups on regular basis. In case it is found that progress is unsatisfactory, it should be reported to the Department Evaluation Committee for necessary action. The presence of each student in the group and their involvement in all stages of execution of the project shall be ensured by the guide.

Project evaluation by the guide: 30 marks

This mark shall be awarded to the students in his/her group by considering the following aspects.

ix) Project Scheduling and Distribution of work among team members: 5 marks
Detailed and extensive scheduling with timelines provided for each phase of project. Work breakdown structure well defined.

x) Literature Survey: 4 marks
Outstanding investigation in all aspects

xi) Student's diary/Daily log: 7 marks
The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily/weekly activity diary the day to day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches and drawings related to the observations made by the students. The daily/weekly activity diary shall be signed after every day/week by the guide.

xii) Individual Contribution: 9 marks
The contribution of each student at various stages.

xiii) Completion of the project: 5 marks

The students should demonstrate the project to their respective guide. The guide shall verify the results and see that the objectives are met.

EVALUATION RUBRICS for PROJECT Phase II: Interim Evaluation - 1						
No.	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
PHASE-II INTERIM EVALUATION - 1 (25 MARKS)						
2-a	Novelty of idea, and Implementation scope [CO1] [Group Evaluation]	**5**	• The project does not involve elements of creativity and innovation and it's a non-implementable idea. • The work presented so far is not at all the original contribution by the team.	• No major contributions in innovative aspects. Some of the aspects of the proposed idea can be implemented. • There is still lack of originality in the work done so far by the team. • No improvements.	• The project involves some elements of creativity and innovation. It's an implementable project idea. • There is some evidence for the originality of the work done by the team. • The team is doing some independent learning.	• The objective is highly innovative and involves creativity. • Original work done by the team is not yet stated anywhere else and could be a patentable / publishable work.
			(0 - 1 Mark)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-b	Effectiveness of task distribution among team members. [CO2] [Group Evaluation]	**5**	• No task distribution among team members and do not have any awareness on what to do. • The students did not have any idea on what materials / resources to be used in the project.	• Some indication on task allocation among the team members but not effectively distributed, • Some team members do not have any idea of the responsibilities assigned. • Some identified tasks were not followed independently well.	• Good evidence of planning done. Materials were listed and thought out, but needs improvement. • Better task allocation among group members but some group members heavily loaded. • Mostly the duty is being tracked by the individual members.	• Excellent means of task identification and each member knows well about their individual tasks. • All members are assigned tasks in an equal manner. • The individual members are ensuing the tasks in an outstanding manner.
			(0 - 1 Mark)	(2 - 3 Marks)	(4 Marks)	(5 Marks)

2-c	Adherence to project schedule. [CO3] [Group Evaluation]	**5**	• No weekly discussion with the faculty supervisor. • No indication of sustained planning or scheduling of the project. • They do not have any idea on the budget required even after the phase I. • Project log book not maintained. –	• Maintains a log book and some of the project details were documented. Regular updating is not satisfactory. • There is some improvement in the primary plan prepared during phase I. • The students have not formalized a budget plan. • Schedules were not prepared. –	• Maintains a log book and most of the project details were documented but needs improvement. • Good sign of planning done and being trailed up to a good extent after phase I. • Detailed Schedules were not prepared and needs improvement.	• Good adherence to action plan and organization of activities effectively within the time frame. • Excellent indication of widespread project planning and follow-up since phase I. • Tasks are restructured and incorporated in the schedule. • Weekly discussion with the faculty supervisor and proper maintenance of log book.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-d	Interim Results. [CO2] [Group assessment]	**5**	• No interim results to show.	• The team showed some interim results, but they are not complete needs improvements.	• The interim results showed were good and mostly reliable with respect to the current stage but still needs upgrading.	• There were substantial interim results which evidently shows the progress of work.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-e	Presentation [CO4, CO5] [Individual assessment]	**5**	• The presentation was light in content and dull in appearance. • Very poor presentation. • No interim results.	• Presentation is average. • The student has only a weak idea about the task.	• Good overall presentation. • Presentation is clearly structured and quality is good. • Student has good idea about the team's project.	• Excellent presentation. • The presentation is done professionally and with great clarity. • Student has excellent knowledge of the project.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
Total – 25 marks						

EVALUATION RUBRICS for PROJECT Phase II: Interim Evaluation 2						
No.	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
PHASE-II INTERIM EVALUATION - 2 (25 MARKS)						
2-f	Application of engineering knowledge [CO2] [Individual Assessment]	**10**	• Have very little idea as how to choose and use modern engineering tools. • The student does not know how to apply engineering knowledge on the design and the methodology adopted. • Application of engineering knowledge in the project is poor.	• Difficulty to identify the skills and modern engineering tools that could be used in achieving the objectives. • The student able to apply some basic knowledge and not able to show the design procedure and the methodologies adopted.	• Able to correctly identify the skills and modern engineering tools applicable to the project work. • The student is able to show application of engineering knowledge in the design and methodologies to a good extent possible.	• Proper selection and effective use of possible techniques, skills and modern engineering tools applicable to the project work. • Excellent knowledge in design procedure. • The student is able to apply engineering knowledge to the problem and develop solutions.
			(0 3 Marks)	(4 6 Marks)	(7 - 9 Marks)	(10 Marks)
2-g	Involvement of individual members [CO3] [Individual Assessment]	**5**	• No active involvement in the project. • The student does not show any interest. • No Individual participation in the project work.	• The student shows some extent of individual contribution. • Limited to some of the tasks.	• Provide productive suggestions for the betterment of the project. • The individual contribution is obvious. • The student has good volume of contribution in main activities of the project.	• Active involvement and provide productive suggestions in interactions with the supervisor. • Student acting as the prime technical lead and has excellent contribution to the project.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-h	Results and inferences upon execution [CO3] [Group Assessment]	**5**	• Expected outcomes are not achieved yet. • The team is incapable to originate any inferences on the issues observed. • Any kind of remarks or	• Only a few of the expected outcomes are achieved. • Limited inferences are made on the observed issues. • No additional work suggested.	• Many of the expected outcomes are achieved. • Many observations and inferences are made and attempts are taken to identify the issues.	• Most of the specified outcomes are met. • Extensive studies are done and inferences drawn. Most of the issues are addressed and solutions suggested.

			studies are not made.		• Some suggestions are made for further work.	• Clear and effective suggestions made for further work.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-i	Documentation and presentation. [CO4] [Individual assessment]	**5**	• Presentation lacks clarity. • The individual student has no idea on the presentation. • The presentation is of poor quality.	• Overall presentation quality needs to be improved • Individual performance desires to be enhanced. • Performance is satisfactory.	• Presentation is clearly structured and appropriate to the audience. • The individual presentation and performance are very good.	• Presentation is well structured and follows the conventions in the field. • The individual's presentation is done professionally and the performance is excellent.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
Total – 25 marks						

EVALUATION RUBRICS for PROJECT Phase II: Final Evaluation						
No	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
PHASE-II FINAL EVALUATION (40 MARKS)						
2-j	Engineering knowledge. [CO1] [Group Assessment]	10	• Have very little idea as how to choose and use modern engineering tools. • The student does not know how to apply engineering knowledge on the design and the methodology adopted. • Application of engineering knowledge in the project is poor.	• Difficulty to identify the skills and modern engineering tools that could be used in achieving the objectives. • The student able to apply some basic knowledge and not able to show the design procedure and the methodologies adopted.	• Able to correctly identify the skills and modern engineering tools applicable to the project work. • The student is able to show application of engineering knowledge in the design and methodologies to a good extent possible.	• Proper selection and effective use of possible techniques, skills and modern engineering tools applicable to the project work. • Excellent knowledge in design procedure. • The student is able to apply engineering knowledge to the problem and develop solutions.
			(0 - 3 Marks)	(4 - 6 Marks)	(7 - 9 Marks)	(10 Marks)
2-k	Relevance of the project with respect to societal and/or industrial needs. [Group Assessment] [CO2]	5	• The project has neither social nor industrial relevance.	• The project has some relevance with respect to social/ industrial application. • The team has not taken much effort to explore further,	• The project is relevant to the society /industry. • The team is mostly fruitful in interpreting the problem into an engineering requirement.	• The project is exceptionally relevant to society/industry. • The team has made outstanding contribution in resolving the problem.
			(0 - 1 Mark)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-i	Innovation / novelty / Creativity [CO2] [Group Assessment]	5	• The project does not involve elements of creativity and innovation and it's a non-implementable idea. • The work presented so far is not at all the original contribution by the team.	• No major contributions in innovative aspects. Some of the aspects of the proposed idea can be implemented. • There is still lack of originality in the work done so far by the team.	• The project involves some elements of creativity and It's an implementable project. • Some sign for the originality of the work done by the team. • Could be transformed into a product.	• The objective is highly innovative and involves creativity. • Original work done by the team is not yet stated anywhere else and could be a patentable / publishable work.
			(0 - 1 Mark)	(2 - 3 Marks)	(4 Marks)	(5 Marks)

2-m	Quality of results / conclusions / solutions. [CO3] [Group Assessment]	10	• Expected outcomes are not achieved yet. • The team is incapable to originate any inferences on the issues observed. • Any kind of remarks or studies are not made.	• Only a few of the expected outcomes are achieved. • Limited inferences are made on the observed issues. • No additional work suggested.	• Many of the expected outcomes are achieved. • Many observations and inferences are made and attempts are taken to identify the issues. • Some suggestions are made for further work.	• Most of the specified outcomes are met. • Extensive studies are done and inferences drawn. Most of the issues are addressed and solutions suggested. • Clear and effective suggestions made for further work.
			(0 - 3 Marks)	(4 - 6 Marks)	(7 - 9 Marks)	(10 Marks)
2-n	Presentation - Part I Preparation of slides. [CO4] [Group Assessment].	5	• Presentation lacks clarity and not in proper format. • The individual student has no idea on the presentation. • The presentation is of poor quality.	• Overall presentation follows proper style formats to some extent. • Language needs to be improved. • All references are not cited properly. • Presentation slides needs to be more professional.	• Presentation is clearly structured and follows proper style format. • Organization of the slides is good. • Most of references are cited properly. • Some of the results are not clearly shown. There is scope for improvement.	• Presentation is well structured and slides are exceptionally good. • The presentation Neatly organized. • All references cited properly. • Figures, Tables and equations are properly numbered, Results are clearly highlighted and its readable
			(0 - 1 Mark)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
	Presentation - Part II: Individual Communication [CO5] [Individual Assessment].	5	• The student is not communicating properly. • Poor response to questions.	• The student is able to explain some of the content. • The student requires a lot of efforts to get to the idea. • There are language issues.	• Good presentation/ communication by the student. • The student is able to explain most of the content very well. • A few areas where the student shows lack of preparation. • Language is better.	• Clear and concise communication showed by the student. • Presentation is outstanding. • Very confident and tackles all the questions without hesitation. • Exceptional qualities of a good communicator.
			(0 - 1 Mark)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
Total – 40 marks						

EVALUATION RUBRICS for PROJECT Phase II: Report Evaluation						
Sl. No.	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
PHASE-II PROJECT REPORT (30 MARKS)						
2-o	Report [CO4]	30	• The prepared report is shallow and not as per standard format. • Lack of effort in preparation.	• Project report follows the standard format to some extent. • Language needs to be improved. • All references are not cited properly.	• Systematic documentation and is following the standard format. • Organization of the report is good. • Most of references are cited properly.	• The report is very well organized. • All referencescited properly. • Language is excellent and follows standard styles.
			(0 - 11 Marks)	(12 - 18 Marks)	(19 - 28 Marks)	(29 - 30 Marks)
Total – 30 marks						

PROGRAMME ELECTIVE IV

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U42A	COMPUTER VISION	PEC	3	0	0	3	2022

i) PRE-REQUISITE: EL2U41F Digital Signal Processing

ii) COURSE OVERVIEW: This course provides an introduction to core concepts in image processing and computer vision, including techniques for image enhancement, segmentation, and feature extraction. It covers methods for analyzing motion, 3D structure, and object recognition. Emphasis is placed on practical applications in real-time systems such as surveillance and automated recognition.

iii) COURSE OUTCOMES

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

CO1	Explain basic image processing techniques for improving image quality.	Understand
CO2	Apply morphological operations and shape analysis techniques to process binary images and extract object features.	Apply
CO3	Make use of feature detection and segmentation techniques to process and segment images effectively.	Apply
CO4	Apply motion analysis and 3D reconstruction methods to extract scene information from images.	Apply
CO5	Utilize object recognition techniques and classification methods for tasks such as face detection and real-time visual analysis.	Apply

iv) SYLLABUS

Review of image processing techniques - Digital filters, Mathematical morphology, connectedness, object labelling and counting, Boundary descriptors – Chain codes. Properties of Binary Regions, Feature Detection and Image Synthesis, Edge detection, Normalized cuts, Graph cuts, energy-based methods, Hough Transform-Line and curve detection, Shape from X, Photometric stereo, Texture Occluding contour detection. Motion Analysis, Optical Flow, Structure from motion, Object recognition, Bayes rule and ML methods. Eigen faces, Face detection, Face recognition, Application, Examples of real time applications.

v) (a) TEXT BOOKS

5) E. R. Davies, Computer and Machine Vision -Theory Algorithm and Practicalities, Academic Press, 2012
6) Aston Richard Szeliski, Computer Vision: Algorithms and Applications, ISBN 978-1-84882-935-0, Springer 2011.
7) David Forsyth and Jean Ponce, Computer Vision: A Modern Approach, Pearson India, 2002.

(b) REFERENCES

5) Simon Goodfellow, Bengio, and Courville, Deep Learning, MIT Press, 2006.

6) Daniel Lelis Baggio, Khvedchenia Ievgen, Shervin Emam, David Millan Escriva, Naureen Mahmoo, Jason Saragi, Roy Shilkrot, Mastering OpenCV with Practical Computer Vision Projects, Packt Publishing Limited, 2012
7) Simon J D Prince, Computer Vision: Models, Learning, and Inference, Cambridge University Press, 2012.
8) R. J. Schalkoff, Digital Image Processing and Computer Vision, John Wiley, 2004.
9) D. L. Baggio et al., ―Mastering OpenCV with Practical Computer Vision Projects, Packt Publishing, 2012.
10) Jan Erik Solem, ―Programming Computer Vision with Python: Tools and algorithms for analyzing images‖, O'Reilly Media, 2012. Learning with Python, Manning Publications Co.,2018.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Basic Image Processing Techniques**: Image filtering, Image enhancement: Low pass and high pass filters, Homomorphic filtering, Point operators - histogram equalization, Neighborhood operators, Thresholding.	**10**
II	**Mathematical Morphology**- erosion, dilation, opening, closing, and hit-or-miss transform for binary image analysis, binary shape analysis -connected components, labelling, counting objects, Boundary descriptors – chain codes, Geometric features- aspect ratio, compactness, area, and perimeter, Statistical shape properties: shape analysis using moments and central moments	**9**
III	**Feature detection and image segmentation**: Edge detection – Canny algorithm, line and curve detection – Hough Transform, active contours, corner detection – Harris corner detector. Region based Segmentation-split and merge algorithm, Energy based segmentation - graph cuts, normalized cuts. Mean shift and mode finding.	**9**
IV	**Motion and 3D construction**: Shape from X - Shape from shading, Photometric stereo, Texture Occluding contour detection. Motion Analysis- Regularization theory, Optical flow: Horn-Shunck method, Lucas-Kanade method. Structure from motion	**9**
V	**Object Recognition and Real-Time Vision Applications**: Principal Component Analysis (PCA), Support Vector Machines (SVM), Linear Discriminant Analysis (LDA), Bayesian and Maximum Likelihood methods, face detection and recognition: techniques for detecting and recognizing faces using image processing. Real-time applications: surveillance, scene analysis.	**8**
	Total hours	**45**

ix) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

x) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U42B	PROGRAMMING PARADIGMS	PEC	3	0	0	3	2022

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW:

The course offers learners a comprehensive understanding of the core principles of modern programming languages and the key design philosophies behind them. It covers topics such as names, bindings, and scope; statement-level control structures; subprograms; object-oriented programming support; exception handling; concurrency control; functional programming; and logic programming. Learners gain the knowledge needed to critically evaluate existing and emerging programming languages, select the most suitable language for a specific task, apply language-specific structures to organize code effectively, classify languages based on their features, and contribute to the design of next-generation programming languages.

iii) COURSE OUTCOMES

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

CO1	Explain the criteria for evaluating programming languages and compare Imperative, Functional and Logic programming languages	Understand
CO2	Utilize primitive and user-defined data types, type conversions, and expressions to implement type-safe code.	Apply
CO3	Build computational problem solutions by integrating control flow structures and subprograms.	Apply
CO4	Explain the characteristics of Object-Oriented Programming Languages	Understand
CO5	Compare concurrency constructs in different programming languages	Understand

iv) SYLLABUS

Study of programming language concepts, programming domains, evaluation criteria, and language design trade-offs. Implementation methods, names, variables, binding, scope, lifetime, and referencing environments. Data types including primitive, character strings, user-defined ordinal types, arrays, records, lists, pointers, and references. Type checking, strong typing, type equivalence, expressions, assignment statements, and type conversions. Control structures: selection, iteration, unconditional branching, and guarded commands. Subprograms: design issues, referencing environments, parameter passing, closures, and coroutines. Object-oriented programming concepts, inheritance, dynamic binding, C++ support, and implementation. Exception handling concepts and design. Concurrency at subprogram level using semaphores, monitors, and message passing. Introduction to functional programming with LISP and Scheme, comparison with imperative languages, and basics of logic programming with Prolog.

v) (a) TEXT BOOKS

1) Robert W Sebesta, *Concepts of Programming Languages*, 10th Edition, Pearson, 2012.
2) Scott M L, *Programming Language Pragmatics*, 3rd Edition, Morgan Kauffman Publishers, 2009.
3) Tucker A. B. and R. E. Noonan, *Programming Languages: Principles and Paradigms*, 2nd Edition, TMH, 2007.

(b) REFERENCES

1) Kenneth C. Louden, *Programming Languages: Principles and Practice*, 2nd Edition, Cengage Learning, 2002.
2) Ravi Sethi, *Programming Languages: Concepts & Constructs*, 2nd Edition., Pearson Education, 1996.
3) David A. Watt, *Programming Language Design Concepts*, Wiley Dreamtech, 2004.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction: Reasons for studying Concepts of programming languages, Programming Domains, Language Evaluation Criteria, Influence on Language Design, Language Design Trade- offs, Implementation Methods, Names, Variables, Concept of Binding, Scope and Lifetime, Referencing Environments	**7**
II	Primitive Data Types, Character String Types, User-Defined Ordinal Types, Array Types, Record Types, List Types, Pointer and Reference Types, Implementation of pointer and reference types, Type Checking, Strong Typing, Type Equivalence, Expressions and Assignment Statements, Arithmetic Expressions, Overloaded Operators, Type Conversions, Relational and Boolean Expressions, Short-Circuit Evaluation, Assignment Statements, Mixed-mode Assignment	**10**
III	Selection Statements, Iterative Statements, Unconditional Branching, Guarded Commands, Subprograms: Design Issues of Subprograms, Local Referencing Environments, Parameter Passing Methods, Subprograms as Parameters, Overloaded Subprograms, Closures, Co-routines	**10**
IV	Inheritance, Dynamic Binding, Design Issues for Object Oriented Languages, Support for Object Oriented Programming in C++, Implementation of Object-Oriented Constructs, Exception Handling – Basic Concepts, Exception Handling - Design Issues	**9**
V	Subprogram Level Concurrency, Semaphores, Monitors, Message Passing, Introduction to LISP and Scheme, Comparison of Functional and Imperative Languages, Basic elements of Prolog, Applications of Logic Programming	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U42C	CRYPTOGRAPHY	PEC	3	0	0	3	2022

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW:

This course introduces the fundamentals of classical and modern cryptography, covering symmetric and asymmetric encryption, hashing, authentication, and key management. It emphasizes secure communication protocols, real-world cryptographic systems, and emerging trends, preparing students for secure system design and cryptographic application in cybersecurity, networking, and blockchain technologies.

iii) COURSE OUTCOMES

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

CO1	Explain the principles of cryptographic security, classical ciphers, and the need for data protection.	Understand
CO2	Demonstrate the structure and operation of modern symmetric key algorithms such as AES and IDEA.	Understand
CO3	Explain the functioning of public key cryptographic methods like RSA, ECC, and their key management techniques.	Understand
CO4	Illustrate the role of hashing, message authentication codes, and digital signatures in ensuring integrity and authenticity.	Understand
CO5	Summarize real-world applications of cryptography in secure communication, blockchain, and emerging technologies.	Understand

iv) SYLLABUS

Need for security. Principles of security. Types of attacks. Classical encryption techniques. Stream and block ciphers. Public key vs symmetric key systems. DES, AES, IDEA. Block cipher modes. RSA, ElGamal, ECC. Diffie-Hellman key exchange. Key generation, distribution, and management. Cryptographic hash functions. SHA-256, SHA-512, MD5. MAC, HMAC, CMAC. Digital signatures. X.509 authentication. Public Key Infrastructure (PKI). Applications in secure communication, IoT, and blockchain.

v) (a) TEXT BOOKS

1) William Stallings, *Cryptography and Network Security Principles and Practice*, Pearson Edu, 6th Edition, 2013.
2) Bruice Schneier, *Applied Cryptography Protocols, Algorithms and source code in C*, 2nd Edition, Wiley, 1996.

(b) REFERENCES

1) Behrouz A. Forouzan, *Cryptography and Network Security*, McGraw Hill, 2nd Edition, 2007.
2) Johannes A. Buchmann, *Introduction to Cryptography*, Springer, 2nd Edition, 2004.
3) DouglasR. Stinson, *Cryptography Theory and Practice*, 3rd Edition, Chapman& Hall/CRC, 2006.

4) Bernard Menezes, *Network Security and Cryptography*, Cengage Learning, 2011.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Security and Classical Cryptography** Need for information security. Security goals and principles. Types of attacks: passive and active. OSI Security Architecture. Classical encryption techniques: Substitution and transposition techniques. Introduction to Stream ciphers and Block ciphers. Symmetric vs. Asymmetric key cryptosystems. Overview of secure communication channels.	**8**
II	**Symmetric Key Cryptography** Symmetric key cryptography concepts and requirements. Block cipher principles and modes of operation. Advanced Encryption Standard (AES) – structure and operation. International Data Encryption Algorithm (IDEA). Stream ciphers: RC4 and modern usage. Overview of vulnerabilities: Differential and linear cryptanalysis (concept only). Real-world applications of symmetric cryptography (e.g., Wi-Fi encryption, disk encryption).	**9**
III	**Public Key Cryptography and Key Management** Principles of public key cryptosystems. RSA algorithm: working and security considerations. Diffie-Hellman key exchange. ElGamal cryptographic system. Elliptic Curve Cryptography (ECC): motivation and applications. Modern trends: Introduction to Post-Quantum Cryptography (NTRU, Lattice-based schemes – overview only). Key generation, distribution, updating, and compromise handling. Public Key Infrastructure (PKI), Certificates, and X.509.	**10**
IV	**Hashing, Message Authentication and Digital Signatures** Authentication requirements and functions. Message Authentication Code (MAC) and Hash functions. Secure Hash Algorithms: SHA-2 and SHA-3 families. HMAC and CMAC. Digital signatures: RSA and ECDSA. Applications: Blockchain Merkle Trees, Digital certificate verification. Deprecation notes: MD5 and SHA-1 (explained as legacy).	**9**
V	**Applications and Modern Cryptography** Cryptography in secure communication: SSL/TLS, Email security (PGP/GPG), VPNs. Password hashing techniques: bcrypt, scrypt, Argon2. Cryptography in Blockchain and IoT. Introduction to Zero-Knowledge Proofs (concept only). Overview of Homomorphic Encryption (concept only). Cryptographic tools and libraries: OpenSSL, GPG, Python cryptography libraries. Case studies and current research trends.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U42D	MECHATRONICS	PEC	3	0	0	3	2022

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW: his course introduces the fundamentals of Mechatronics, focusing on the integration of mechanical, electrical, electronic, and control systems. Students will explore Computer Numerical Control (CNC) machine components, system modeling in various physical domains, and control systems including PLCs. The course also covers Mechatronics in robotics, including drives, sensors, and vision systems with basic image processing techniques.

iii) COURSE OUTCOMES

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

CO1	Classify and explain various types of sensors and actuators based on their characteristics and applications.	Understand
CO2	Illustrate the fabrication methods of MEMS and explain the working principles of MEMS-based pressure sensors, accelerometers, and gyroscopes.	Understand
CO3	Explain the design, functioning, and measurement systems of CNC machine components and the basic principles of system modeling for mechanical, electrical, fluid, and thermal systems.	Understand
CO4	Apply control systems and PLC programming to develop ladder programs for Mechatronics systems.	Apply
CO5	Explain the robotic sensors and vision system	Understand

iv) SYLLABUS

Introduction to Mechatronics: Structure of Mechatronics system-Sensors-Actuators-Micro Electro Mechanical Systems (MEMS)-Development of simple hydraulic and pneumatic circuits using standard Symbols-Mechatronics in Computer Numerical Control (CNC) machines-Typical elements of open and closed loop control systems. Adaptive controllers for machine tools. Programmable Logic Controllers (PLC)-Case studies of Mechatronics Systems-Mechatronics in Robotics-Electrical Drives-Robotic vision system.

v) (a) TEXT BOOKS

1) Bolton W., Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Person Education Limited, New Delhi, 2007
2) Ramachandran K. P., G. K. Vijayaraghavan, M. S. Balasundaram, Mechatronics: Integrated Mechanical Electronic Systems, Wiley India Pvt. Ltd., New Delhi, 2008.
3) Saeed B. Niku, Introduction to Robotics: Analysis, Systems, Applications, Person Education, Inc., New Delhi, 2006.
4) Devdas Shetty, Richard A. Kolk, “Mechatronics System Design”, 2nd Edition, Cengage Learning 2012.

(b) REFERENCES

1) David G. Aldatore, Michael B. Histand, Introduction to Mechatronics and Measurement Systems, McGraw-Hill Inc., USA, 2003.
2) Gordon M. Mair, Industrial Robotics, Prentice Hall International, UK, 1998.
3) HMT, Mechatronics, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.
4) Vijay K. Varadan, K. J. Vinoy, S. Gopalakrishnan, Smart Material Systems and MEMS: Design and Development Methodologies, John Wiley & Sons Ltd., England, 2006.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Mechatronics: Structure of Mechatronics system. Sensors - Characteristics -Temperature, flow, pressure sensors. Displacement, position and proximity sensing by magnetic, optical, ultrasonic, inductive, capacitive and eddy current methods. Encoders: incremental and absolute, gray coded encoder. Resolvers and synchros. Piezoelectric sensors. Acoustic Emission sensors. Principle and types of vibration sensors. Actuators: Mechanical actuators, Electrical actuators, Hydraulic and Pneumatic actuators	9
II	Directional control valves, pressure control valves, process control valves. Rotary actuators. Development of simple hydraulic and pneumatic circuits using standard Symbols. Micro Electro Mechanical Systems (MEMS): Fabrication: Deposition, Lithography, Principle, fabrication and working of MEMS based pressure sensor, accelerometer and gyroscope.	9
III	Mechatronics in Computer Numerical Control (CNC) machines: Design of modern CNC machines - Mechatronics elements - Machine structure: guide ways, drives. Bearings: anti-friction bearings, hydrostatic bearing and hydrodynamic bearing. Re-circulating ball screws, pre-loading methods. Re-circulating roller screws. Measuring system for NC machines - direct and indirect measuring system. System modeling - Mathematical models and basic building blocks of general mechanical, electrical, fluid and thermal systems.	9
IV	Typical elements of open and closed loop control systems. Adaptive controllers for machine tools. Programmable Logic Controllers (PLC) –Basic structure, input/ output processing. Programming: Timers, Internal Relays, Counters and Shift registers. Development of simple ladder programs for specific purposes. Case studies of Mechatronics systems: Automatic camera, bar code reader, pick and place robot, automatic car park barrier system, automobile engine management system.	9
V	Mechatronics in Robotics-Electrical drives: DC, AC, brushless, servo and stepper motors. Harmonic drive. Force and tactile sensors. Range finders: ultrasonic and light-based range finders. Robotic vision system	

	- Image acquisition: Vidicon, charge coupled device (CCD) and charge injection device (CID) cameras. Image processing techniques: histogram processing: sliding, stretching, equalization and thresholding.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U42E	COMPUTER AIDED DESIGN OF ELECTRICAL MACHINES	PEC	3	0	0	3	2022

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW: This course aims to provide students with a comprehensive understanding of the design of static and rotating electrical machines. Additionally, the course fosters cognitive learning, enhances problem-solving abilities, and introduces students to the fundamental principles of computer-aided design (CAD).

iii) COURSE OUTCOMES

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

CO1	Apply the principles of thermal analysis to compute the variation of temperature rise in an electrical machine during heating and cooling.	Apply
CO2	Solve for the gap contraction factors and air gap mmf of electrical machines, based on the given data	Apply
CO3	Solve for the main dimensions of single phase and three phase transformers, based on the given data.	Apply
CO4	Develop the main dimensions of rotating electrical machines, based on the given data.	Apply
CO5	Explain the basic principles of computer aided electrical machine design.	Understand

iv) SYLLABUS

Principles of Electrical Machine Design – Temperature rise-time curve and MATLAB implementation, Magnetic circuit calculations – air gap reluctance, slot and duct effects, gap contraction factors, air gap mmf, saliency effect, Transformer Design – Output equations for single-phase and three-phase, emf per turn, optimal design considering cost and loss, scaling laws, core, winding, window and yoke design with MATLAB.

DC Machine Design – Output equation, specific electric and magnetic loadings, selection of speed and number of poles, design of main dimensions, armature, field system and poles with MATLAB.

Synchronous Generator Design – Output equation, dimensions of salient pole and turbo alternators, stator design, numerical problems with MATLAB, Induction Motor Design – Output equation, specific loadings, stator and rotor design of squirrel cage and slip ring motors with MATLAB.

Introduction to Computer-Aided Design – analysis and synthesis methods, hybrid techniques, basics of Finite Element Method (FEM), advantages of computer-aided design.

v) (a) TEXT BOOKS

1) Sawhney A.K., *A Course in Electrical Machine Design*, Dhanpat Rai & Co. (P) Limited, New Delhi, 2016.

2) William T. Ryan, *Design of Electrical Machinery*, Creative Media Partners, LLC, 4th Edition, 2015.
3) Upadhay K.G., *Design of Electrical Machines*, New Age International, 2011.
4) Agarwal R.K., *Principles of Electrical Machine Design*, S. K. Kataria & Sons, 5th Edition, 2014.
5) Say M.G., *The Performance and Design of AC Machines*, CBS Publishers, New Delhi, 3rd Edition, 2002.
6) Albert E Clayton & Hancock N.N., *Performance and Design of DC Machines*, Oxford and IBH Publishing Co. & Pvt. Ltd, New Delhi, 3rd Edition, 1971.
7) K. M. Vishnu, *Computer Aided Design of Electrical Machines*, B.S. Publications, 2008.
8) M. Ramamoorty, *Computer-Aided Design of Electrical Equipment*, John Wiley & Sons, 2008.

(b) REFERENCES

1) Rajani V., Nagarajan V.S., *Electrical Machine Design*, Pearson Publications, 3rd Edition, 2018.
2) Thomas A. Lipo, *Introduction to AC machine design*, Wiley-IEEE Press, 2017.
3) Deshpande M.V., *Design and Testing of Electrical Machines*, PHI Learning Pvt. Ltd., 2010.
4) Juha Pyrhonen, Valeria Hrabovcova, Tapani Jokinen, *Design of Rotating Electrical Machines*, John Wiley and Sons Inc., 2nd Edition, 2013.
5) Ramamoorthy M, *Computer Aided Design of Electrical Equipment*, East-West Press, 2nd Edition, January 2008.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Principles of electrical machine design -** temperature rise-time curve – numerical problems – MATLAB Implementation. **Magnetic circuit calculations** – Reluctance of air gap in machines – effect of slots and ventilating ducts – gap contraction factors – calculation of air gap mmf – effect of saliency – numerical problems - MATLAB Implementation.	**8**
II	**Design of transformers** - output equation of single phase and three phase transformers – emf/turn – optimum designs- design for minimum cost, minimum losses - core design – design of windings, window dimensions and yoke – overall dimensions – numerical problems – MATLAB Implementation.	**9**
III	**Design of Rotating Electrical Machines** – Main Dimensions, Total Loadings, Specific Loadings. **Design of DC Machines** - output equation – choice of specific loadings - choice of speed and no of poles - calculation of main dimensions – design of length of air gap - numerical problems – Armature Design – Choice of armature winding – number of armature coils – slot dimensions – guiding factors for the choice of number of	**10**

	armature slots and design of winding – numerical problems – Design of field system – pole design, design of shunt field winding – numerical problems - MATLAB Implementation.	
IV	**Design of synchronous generators** - output equation - main dimensions of salient pole alternators – numerical problems - choice of specific loadings - Stator Design – number of armature slots, stator winding turns/phase and conductor cross section - numerical problems - MATLAB Implementation.	**8**
V	**Design of three phase induction motors** – output equation - main dimensions - numerical problems - choice of specific loadings - stator design – stator winding turns/phase, conductor cross section, number of slots, area of slots – numerical problems – choice of length of air gap. Rotor Design – design of squirrel cage induction motor - number of rotor slots – design of rotor bars and end rings - design of slip ring rotor winding - number of rotor slots – number of turns/phase and conductor cross section - numerical problems - MATLAB Implementation. **Introduction to computer aided design** - Analysis and synthesis methods - hybrid techniques - Introduction to Finite element method, Advantages.	**10**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U42F	SMART GRID TECHNOLOGIES	PEC	3	0	0	3	2022

i) PRE-REQUISITE: Nil.

ii) COURSE OVERVIEW: This course introduces various advancements in the area of smart grid. It also introduces distributed energy resources and micro-grid. In addition, cloud computing, cyber security and power quality issues in smart grids are also introduced.

iii) COURSE OUTCOMES

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

CO1	Explain the basic concept of distributed energy resources, micro-grid and smart grid.	Understand
CO2	Choose appropriate Information and Communication Technology (ICT) in a smart grid.	Apply
CO3	Explain infrastructure and technologies for the consumer domain of smart grid.	Understand
CO4	Explain infrastructure and technologies for smart substation and distribution automation.	Understand
CO5	Develop cloud computing infrastructure for smart grid considering cyber security.	Apply
CO6	Identify power quality issues in smart grid context.	Apply

iv) SYLLABUS

Introduction to smart grid: Evolution, definition, need, function, opportunities, barriers, components and architecture.

Information and Communication Technology in Smart Grid: Wired and wireless communication, Communication Protocols in Smart grid, Introduction to IEC 61850 standard and benefits.

Introduction to smart meters, Electricity tariff, Real Time Pricing, Plug in Hybrid Electric Vehicles, Intelligent Electronic Devices and their application for monitoring & protection.

Smart substations, Substation automation, Feeder automation, Fault detection, Isolation, and Service Restoration. Introduction to Smart distributed energy resources and their grid integration, Smart inverters, Concepts of micro grid. Energy Management.

Cloud Computing in Smart Grid: Private, Public and hybrid cloud. Types of cloud computing services. Cloud architecture for smart grid, Cyber Security: Challenges and solution in smart grid.

Power Quality Management in Smart Grid: Power quality and Electromagnetic compatibility.

v) (a) TEXT BOOKS

1) Stuart Borlase *Smart Grid Infrastructure Technology and Solutions*, CRC Press; 2nd Edition, 2017.
2) James Momoh, *Smart Grid: Fundamentals of Design and Analysis*, Wiley, 2012.
3) S. Chowdhury, *Microgrids and Active Distribution Networks*. Institution of Engineering and Technology, 2009.
4) Chris Mi, M. Abul Masrur, David Wenzhong Gao, *Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives*, 2011, Wiley publication.

(b) REFERENCES

4) Danda B. Rawat; Chandra Bajracharya, *Cyber security for smart grid systems: Status, challenges and perspectives*, IEEE Southeast Con 2015, DOI: 10.1109/SECON.2015.7132891.
5) Pillitteri, V. and Brewer, T. (2014), *Guidelines for Smart Grid Cyber security*, NIST Interagency/Internal Report (NISTIR), National Institute of Standards and Technology, Gaithersburg, MD, [online], https://doi.org/10.6028/NIST.IR.7628r1.
6) Barker, Preston, Price, Rudy F., *Cyber security for the Electric Smart Grid: Elements and Considerations*, Nova Science Publishers Inc, 2012.
7) Eric D. Knapp, Raj Samani, *Applied Cyber Security and the Smart Grid: Implementing Security Controls into the Modern Power Infrastructure*, Syngress; 1st Edition, 2013.
8) Richard J. Campbell, *The Smart Grid and Cyber security: Regulatory Policy and Issues*, Congressional Research Service, 2011.
9) Dariusz Kloza, Vagelis Papakonstantinou, Sanjay Goel, Yuan Hong, *Smart grid security*, Springer, 2015.
10) Roger C. Dugan, *Electrical Power Systems Quality*, McGraw-Hill Publication, 3rd Edition, 2012.
11) G.T. Heydt, *Electric Power Quality*, Stars in a Circle Publications, 2nd Edition, 2000.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Smart Grid**: Evolution of electric grid, definitions needed for smart grid, smart grid drivers, and functions of smart grid, opportunities and barriers of smart grid, difference between conventional grid and smart grid, concept of resilient and self- healing grid. Components and architecture, inter-operability, impacts of Smart Grid on system. Present development and international policies in smart grid, Smart grid standards.	**7**
II	**Information and Communication Technology in Smart Grid**: Wired and wireless communication -radio mesh, ZIGBEE, 3G, 4G and 5G, digital PLC, DSL, Wi-Max, LAN, NAN, HAN, Wi-Fi, Bluetooth. Bluetooth Low Energy (BLE), Light-Fi, substation event - GOOSE, IEC 61850 substation model.	**8**

	Communication protocols in smart grid, introduction to IEC 61850 standard and benefits, IEC Generic Object-Oriented Substation Event - GOOSE. IEC 61850, Substation model.	
III	**Smart Grid Technologies Part I:** Introduction to smart meters, electricity tariff, real time pricing-Automatic Meter Reading (AMR) System, services and functions, components of AMR systems, Advanced Metering Infrastructure (AMI). Plug in Hybrid Electric Vehicles (PHEV), Vehicle to Grid, Grid to Vehicle. Smart sensors, smart energy efficient end use devices, home & building automation, Intelligent Electronic Devices (IED) and their application for monitoring & protection, DFRA, DPRA, CBMA. Phasor Measurement Unit (PMU), standard for PMU. Time synchronization techniques, Wide Area Monitoring, control and protection systems - architecture, components of WAMS, and applications: voltage stability assessment, frequency stability assessment, power oscillation assessment, communication needs of WAMS, remedial action scheme.	**11**
IV	**Smart Grid Technologies Part II:** Smart substations, substation automation, feeder automation, fault detection, isolation, and service restoration, Geographic Information System (GIS), Outage Management System (OMS). Introduction to smart distributed energy resources and their grid integration, smart inverters. Concepts of micro grid, need & application of micro grid – Energy Management-Role of technology in demand response- Demand Side Management, Demand Side Ancillary Services, Dynamic Line rating.	**10**
V	**Cloud Computing in Smart Grid**: Public and hybrid cloud, cloud architecture of smart grid, types of cloud computing services- IaaS, SaaS, PaaS, DaaS. **Cyber Security -** Cyber security challenges and solutions in smart grid**,** cyber security risk assessment, and security index computation. **Power Quality Management in Smart Grid** - Fundamentals, power quality & EMC in Smart Grid.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U42G	DATA ANALYTICS FOR ELECTRICAL ENGINEERS	PEC	3	0	0	3	2022

i) PRE-REQUISITE: EL2U31E Programming in Python

ii) COURSE OVERVIEW: This course provides foundational and advanced data analytics concepts with a specific focus on applications in Electrical and Computer Engineering. It covers statistical analysis, machine learning algorithms, and real-world applications such as signal processing, smart grid analytics, and embedded system monitoring.

iii) COURSE OUTCOMES

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

CO1	Explain data types, acquisition and cleaning methods, and basic Python-based techniques for exploratory data analysis.	Understand
CO2	Apply probability and statistical inference methods to analyze data and model engineering systems.	Apply
CO3	Make use of supervised learning algorithms for classification and regression tasks in engineering applications.	Understand
CO4	Utilize clustering methods and dimensionality reduction techniques to process complex datasets.	Apply
CO5	Apply data analytics techniques to optimize smart grids, IoT, signal processing, and predictive maintenance.	Apply

iv) SYLLABUS

Introduction to Data Analytics: Overview and role of data analytics, Descriptive statistics and data visualization, Introduction to Python libraries: NumPy, Pandas, Matplotlib.

Probability and Statistical Inference: Probability theory, random variables, distributions, Hypothesis testing, confidence intervals, Correlation and regression analysis.

Supervised Learning: Linear and logistic regression, Decision trees, random forests, Support vector machines (SVMs).

Unsupervised Learning & Dimensionality Reduction: K-means and hierarchical clustering, Principal Component Analysis (PCA), t-SNE, Feature selection methods.

Applications of Data Analytics: Signal and image data processing, Smart grid and IoT analytics, Embedded system data monitoring and forecasting.

v) (a) TEXT BOOKS

1) Montgomery, D. C., & Runger, G. C., *Applied Statistics and Probability for Engineers*, Wiley, 2014.
2) Géron, A., *Hands-On Machine Learning with Scikit-Learn*, Keras, and TensorFlow, O'Reilly, 2019.

(b) REFERENCES

1) Kuhn, M., & Johnson, K., *Applied Predictive Modelling*, Springer, 2013.
2) James, G., et al., *An Introduction to Statistical Learning*, Springer, 2021.

3) Bishop, C. M., *Pattern Recognition and Machine Learning*, Springer, 2006.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Data Analytics Role of data analytics in Electrical and Computer Engineering, Types of data: structured, unstructured, time-series, categorical, Data collection methods and sensors in systems. Data cleaning: handling missing data, outliers, noise reduction. Exploratory Data Analysis (EDA): Descriptive statistics (mean, median, variance, standard deviation), Data visualization techniques: histograms, boxplots, scatter plots. Introduction to Python for data analysis: NumPy, Pandas, Matplotlib, and Seaborn. Case Study: Data profiling in smart energy meters	9
II	Probability and Statistical Inference Probability concepts: conditional probability, Bayes' theorem Random variables: discrete and continuous, distributions (Normal, Poisson, Binomial), Central Limit Theorem and Law of Large Numbers, Estimation techniques and confidence intervals, Hypothesis testing: z-test, t-test, chi-square test. Linear and multiple regression: Assumptions and diagnostic checks, Applications in sensor calibration and system modelling, Correlation vs causation. Case Study: Anomaly detection in power quality data.	9
III	Supervised Learning Overview of supervised learning and model evaluation metrics. Linear regression with regularization (Ridge, Lasso) Logistic regression and classification metrics (precision, recall, F1-score), Decision trees and ensemble methods: Bagging, Random Forests, Gradient Boosted Trees. Support Vector Machines (SVM): linear and kernel-based, k-Nearest Neighbors (k-NN) algorithm, Cross-validation and bias-variance trade-off. Case Study: Fault classification in electrical machines.	9
IV	Unsupervised Learning and Dimensionality Reduction Clustering techniques: K-Means, Hierarchical clustering, DBSCAN, Cluster evaluation metrics. Dimensionality reduction: Principal Component Analysis (PCA), t-Distributed Stochastic Neighbour Embedding (t-SNE), Feature selection techniques, Data transformation and scaling methods (standardization, normalization). Case Study: Clustering electricity consumption patterns for demand-side management.	9
V	Applications of Data Analytics Smart Grids: Load forecasting, renewable energy prediction, Real-time monitoring using streaming analytics.	9

	Signal Processing: Time series analysis, noise filtering, FFT Event detection using statistical methods. Internet of Things (IoT): Sensor fusion, anomaly detection in embedded systems, Data analytics pipelines for IoT devices. Predictive Maintenance: Machine condition monitoring, Remaining useful life (RUL) prediction using analytics.	
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U42H	HVDC AND FACTS	PEC	3	0	0	3	2022

i) **PRE-REQUISITE:** EL2U30D: Power Electronics and Drives, EL2U40B: Power System Engineering.

ii) **COURSE OVERVIEW**: The course deals with the importance of HVDC transmission, analysis of HVDC Converters, Harmonics and Filters, Reactive power control and Power factor improvements of the system. It also deals with basic FACTS concepts, static shunt and series compensation and combined compensation techniques.

iii) **COURSE OUTCOMES**

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

CO1	Compare AC and DC systems, Explain the types of HVDC Links, various parameters in HVDC and FACTS devices.	Understand
CO2	Analyze the Graetz circuit with various conditions.	Analyze
CO3	Explain various control schemes, harmonics and design the Filters in HVDC.	Understand
CO4	Summarize the Operation of various Shunt devices and their control.	Understand
CO5	Explain the Operation of various Series devices and their control.	Understand

iv) **SYLLABUS**

Basic HVDC Concepts - Comparison of AC-DC transmission systems, application of DC transmission, types of DC links, Benefits from FACTS controllers.

Analysis of HVDC Converters - Analysis of Graetz circuit Analysis of HVDC converters, 12 Pulse converters-relations between AC and DC quantities.

HVDC system control, harmonics - Basic control-desired features of control-actual control Characteristics - Generation of harmonics (Characteristics and Non-characteristics harmonics), Design of DC and AC filters.

Static Shunt Compensation - Objectives of Shunt Compensation, Power Oscillation Damping, Methods of controllable VAR generation – Variable Impedance type only.

STATIC SERIES COMPENSATORS: Concept of series capacitive compensation, Improvement of Transient Stability, Power Oscillation Damping, Sub Synchronous Oscillation Damping-control schemes for GCSC, TSSC and TCSC.

v) (a) **TEXT BOOKS**

1) K. R.Padiyar, *HVDC Transmission Systems*, 2nd edition (in Two Colour), New Age International publishers, 2012.
2) N. G. Hingoraniand L.Gyugui, *Understanding FACTS Concepts and Technology of Flexible AC Transmission Systems*, B.S. Publications, Indian Reprint 2000.

(b) REFERENCES

1) E. Uhlmann, *Power Transmission by Direct Current*, Springer 1st edition, 2012.
2) Vijay K. Sood, *HVDC and FACTS Controller: Application of Static Converters in power systems*, IEEE Power Electronics and Power Systems series, Kluwer Academic publishers, Boston, First edition January 2004.
3) E.W. Kimbark, *Direct Current Transmission*, Wiley Inter Science, New York, 1971.
4) R. Mohan Mathur, Rajiv K Varma, *Thyristor based FACTS Controller for Electrical Power Systems*, John Wiley Sons, 2011.
5) X. P. Zhang, C. Rehtanz, B.Pal, *Flexible AC Transmission System Modeling and Control*, Springer, 2006.
6) Padiyar K.R., *FACTS controllers for Transmission and Distribution Systems* New Age International Publishers, 1st Edition, 2007.
7) Enrique Acha, Claudio R. Fuerte-Esqivel, Hugo Ambriz-Perez, Cesar Angeles-Camacho *FACTS – Modeling and simulation in Power Networks* John Wiley & Sons, 1st Edition, 2002.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**BASIC HVDC CONCEPTS**: Introduction, Comparison of AC and DC Transmission (Economics of power transmission, Technical performance and Reliability), Application of DC transmission, Description of DC transmission system (Types of DC links and Converter Station), Planning for HVDC transmission, Modern trends in HVDC technology. **FACTS CONCEPTS** Transmission interconnections powerflow in an AC system, loading capability limits, Dynamic stability considerations, importance of controllable parameters, basic types of FACTS controllers, Benefits from FACTS controllers.	**9**
II	**ANALYSIS OF HVDC CONVERTERS** Introduction, Analysis of Graetz circuit –with grid control but no overlap-with grid control and overlap less than 600 - relationship between AC and DC quantities-equivalent circuit of rectifier, Inversion- equation of average direct current and voltage interms of β and γ– equivalent circuit of inverter, 12 Pulse converters-relations between AC and DC quantities.	**9**
III	**HVDC SYSTEM CONTROL, HARMONICS AND FILTERS**: Basic means of control-desired features of control-actual control characteristics-constant minimum ignition angle control-constant current control-constant extinction angle control-tap changer control-power control and current limits, System control hierarchy, firing angle control- IPC-EPC. Introduction, Generation of harmonics (Characteristics and Non-characteristics harmonics), Design of DC and AC filters (design and types of filters)	**9**

IV	**STATIC SHUNT COMPENSATION: Objectives of Shunt** Compensation, midpoint voltage regulation voltage Instability prevention, Improvement of Transient Stability, Power Oscillation Damping, Methods of controllable VAR generation – Variable Impedance type only.	**9**
V	**STATIC SERIES COMPENSATORS:** Concept of series capacitive compensation, Improvement of Transient Stability, Power Oscillation Damping, Sub Synchronous Oscillation Damping. Functional requirements of GTO Thyristor Controlled Series Capacitor (GCSC), control schemes of Thyristor Switched Series Capacitor (TSSC), and Thyristor Controlled Series Capacitor (TCSC) control schemes for GCSC, TSSC and TCSC.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

PROGRAMME ELECTIVE V

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U43A	ROBOTICS AND ARTIFICIAL INTELLIGENCE	PEC	3	0	0	3	2022

i) PRE-REQUISITE: EL2U41D: Fundamentals of Robotics

ii) COURSE OVERVIEW: This course provides an introduction to the key concepts in robotics and artificial intelligence, covering topics such as robot kinematics, perception, control, AI, machine learning, and their applications in autonomous systems.

iii) COURSE OUTCOMES

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

CO1	Explain the concepts of intelligent sensing, sensor fusion, and the role of distributed control in autonomous systems.	Understand
CO2	Make use of vision and perception for real-time robotic control and autonomy.	Apply
CO3	Explain how AI and ML enhance robot adaptability and autonomy.	Understand
CO4	Infer intelligent control, reinforcement learning, and safe interaction with humans.	Understand
CO5	Apply learned concepts to cutting-edge technologies, understand societal impacts and future directions.	Apply

iv) SYLLABUS

Advanced Robot Architectures and Intelligent Sensors: Advanced Robot Architectures, Real-time operating systems for robotics. Intelligent Sensor Integration. Sensor Network and Communication.

Perception and Computer Vision in Robotics: Robotic Perception, SLAM (Simultaneous Localization and Mapping). Computer Vision for Robotics. Visual Servoing. Applications and control strategies.

Artificial Intelligence and Machine Learning in Robotics: AI in Robotics, Machine Learning for Robots. Deep Learning in Robotics. Introduction to policy learning and behavior cloning.

Robot Learning, Control, and Human-Robot Interaction (HRI): Reinforcement Learning in Robotics. Adaptive and Intelligent Control. Human-Robot Interaction (HRI).

Applications and Trends in Robotics and AI: Autonomous Systems. Robotics in Smart Industries. Ethical and Societal Aspects. Research Trends & Case Studies. Robotic competitions: DARPA, RoboCup.

v) (a) TEXT BOOKS

1) Lentin Joseph, *Robot Operating System (ROS) for Absolute Beginners: Robotics Programming Made Easy*, Apress, 2018.

2) Sebastian Thrun, Wolfram Burgard, and Dieter Fox, *Probabilistic Robotics*, MIT Press, 2005.
3) Richard Szeliski, *Computer Vision: Algorithms and Applications*, 2nd Edition, Springer, 2022.
4) Francis X. Govers, *Artificial Intelligence for Robotics: Build intelligent robots that perform human tasks using AI techniques*, Packt Publishing, 2018.
5) Mohammad S. Obaidat, Nasir Ghani, *Autonomous Robots and Systems: A Comprehensive Introduction*, Springer, 2023.
6) A.K. Gupta and S.K. Arora, *Robotics and Industrial Automation: A Handbook*, 3rd Edition, Laxmi Publications, 2013.

(b) REFERENCES

1) Kevin M. Lynch and Frank C. Park, *Modern Robotics: Mechanics, Planning, and Control*, Cambridge University Press, 2017.
2) Kazem Sohraby, Daniel Minoli, and Taieb Znati, *Wireless Sensor Networks: Technology, Protocols, and Application,* Wiley-Interscience, 2007.
3) Peter Corke, *Robotics, Vision and Control: Fundamental Algorithms in MATLAB*, 2nd Edition, Springer, 2017.
4) Timothy D. Barfoot, *Simultaneous Localization and Mapping: Exactly Sparse Information Filters*, Morgan & Claypool Publishers, 2011.
5) Joseph Howse et al., *Deep Learning for Robot Vision*, Packt Publishing, 2019.
6) Stuart Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach*, 4th Edition, Pearson, 2020.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Advanced Robot Architectures and Intelligent Sensors:** Advanced Robot Architectures - Distributed and centralized control architectures, Real-time operating systems for robotics, Middleware in robotics: ROS (Robot Operating System) overview. Intelligent Sensor Integration - Multisensor fusion techniques, Smart sensors and self-calibration, Vision sensors with embedded AI, Event-based sensors (neuromorphic). Sensor Network and Communication - IoT in robotics, Wireless sensor networks (WSNs), Communication protocols (CAN, RS485, ROS topics, MQTT).	9
II	**Perception and Computer Vision in Robotics:** Robotic Perception Basics - Concept of environment mapping, SLAM (Simultaneous Localization and Mapping): Overview and techniques (2D & 3D), Occupancy grids, landmark-based mapping. Computer Vision for Robotics - Feature extraction and matching (SIFT, SURF, ORB), Object detection and classification (Haar, HOG, YOLO, SSD), Depth estimation and stereo vision. Visual Servoing - Image-based vs Position-based visual servoing, Applications and control strategies.	9

III	**Artificial Intelligence and Machine Learning in Robotics:** AI in Robotics - Introduction to AI: Agents, environments, decision making, Path planning using AI (A*, Dijkstra, RRT), Expert systems and fuzzy logic control. Machine Learning for Robots - Supervised, unsupervised, and reinforcement learning, Robot learning from demonstration, Model-free vs model-based learning. Deep Learning in Robotics - CNNs for vision tasks, Recurrent networks for sequence prediction, Introduction to policy learning and behavior cloning.	**9**
IV	**Robot Learning, Control, and Human-Robot Interaction (HRI):** Reinforcement Learning in Robotics - MDPs and policy optimization, Q-learning, Deep Q Networks (DQN). Applications in motion control and decision-making. Adaptive and Intelligent Control - Adaptive PID, fuzzy logic control, Model Predictive Control (MPC), Learning-based control (LQR, neural controllers). Human-Robot Interaction (HRI) - Types of HRI: teleoperation, collaborative, social. Emotion and gesture recognition. Safety in HRI, standards, and design principles.	**9**
V	**Applications and Trends in Robotics and AI:** Autonomous Systems - Mobile robot navigation: mapping, localization, obstacle avoidance. Self-driving cars: sensors, perception stacks. Drones and aerial autonomy. Robotics in Smart Industries - Industry 4.0 and collaborative robots (cobots), Predictive maintenance and digital twins. Ethical and Societal Aspects - Ethics of AI in robotics, Explainable AI (XAI) in robotic systems. Legal and societal implications. Research Trends & Case Studies - Boston Dynamics, OpenAI Robotics, Tesla FSD - Robotic competitions: DARPA, RoboCup.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Cate-gory	L	T	P	Credit	Year of Introduction
EE1U45A	ELECTRIC AND HYBRID VEHICLES	PEC	3	0	0	3	2022

i) PRE-REQUISITE: EL2U30C: Electrical Machines, EL2U30D: Power Electronics and Drives.

ii) COURSE OVERVIEW: The main goal of this course is to expose the students to the fundamentals and trends of electric, hybrid, and autonomous vehicles, including energy storage, electric machines, charging systems, and communication protocols.

iii) COURSE OUTCOMES

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

CO1	Apply hybrid electric vehicle principle to determine the vehicle performance.	Apply
CO2	Illustrate the basic concepts and compare various configurations of Electric and Hybrid Electric drive trains	Understand
CO3	Explain the propulsion unit for electric and hybrid vehicles	Understand
CO4	Outline proper energy storage systems for vehicle applications	Understand
CO5	Infer various communication protocols and technologies used in vehicle networks	Understand

iv) SYLLABUS

Conventional Vehicles, Basics of vehicle performance, Basic Architecture of hybrid traction, Electric Drive train, Power flow control.
Electric Propulsion unit, Configuration and control of DC motor drives, Induction Motor drives, PM and SRM motor drives.
Energy Storage Requirements in Hybrid and Electric Vehicles, Battery, fuel cell, flywheel and supercapacitor-based energy storage.
Communication Systems, Energy Management Strategies, EV charging technologies and policies.

v) (a) TEXT BOOKS

1) Iqbal Husain: *Electric and Hybrid vehicles: Design Fundamentals,* CRC press, 3rd Edition 2003.
2) Ehsani M., *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, CRC Press, 2005.
3) Gianfranco Pistoia, *Electric and Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure and the Market,* Elsevier, 2010.
4) Chan C. C. and Chau K. T., *Modern Electric Vehicle Technology,* OXFORD University Press, 2001.

(b) REFERENCES

1) James Larminie, John Lowry, *Electric Vehicle Technology Explained*, 2nd Edition Wiley 2003.
2) Fuhs A. E., *Hybrid Vehicles and the Future of Personal Transportation,* CRC Press, 2009.
3) Chris Mi , Abul Masrur M., *Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives,* 2nd Edition, John Wiley & Sons Ltd,2017.
4) Sheldon S. Williamson, *Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles*, Springer, 2013.

(c) ONLINE RESOURCES

1) NPTEL courses/Materials (IITG, IITM, IITD) – Electric and Hybrid vehicles
   https://nptel.ac.in/courses/108/103/108103009/ (IIT Guwahati)
   https://nptel.ac.in/courses/108/102/108102121/ (IIT Delhi)
   https://nptel.ac.in/courses/108/106/108106170/ (IIT Madras)
2) FOC Control - video lecture by Texas Instruments
   https://training.ti.com/kr/field-oriented-control-permanent-magnet-motors
3) Sensored and sensorless FOC control of PMSM motors – Application notes (TI, MATLAB)
   https://www.ti.com/lit/an/sprabz0/sprabz0.pdf?ts=1620018267996&ref_url=https%253A%252F%252Fwww.google.com%252F
   https://in.mathworks.com/help/physmod/sps/ref/pmsmfieldorientedcontrol.html
4) Electric Vehicle Conductive AC Charging System
   https://dhi.nic.in/writereaddata/UploadFile/REPORT%20OF%20COMMITTEE636469551875975520.pdf Electric Vehicle Conductive AC Charging System

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Hybrid Electric Vehicles**: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. **Conventional Vehicles**: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance. **Autonomous Vehicles:** Levels of automation, significance & effects of automation in vehicles	**9**
II	**Hybrid Electric Drive-trains**: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies. **Electric Drive-trains:** Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies.	**9**

III	**Electric Propulsion unit:** Introduction to electric components used in hybrid and electric vehicles **DC Drives**: Review of Separately excited DC Motor control – Speed and torque equations -Closed loop control of speed and torque. **Induction motor Drives**: Voltage and frequency control-Field Oriented Control (FOC) (Block diagram only)	**10**
IV	**Energy Storage**: Introduction to energy storage requirements in Hybrid and Electric Vehicles- Battery based energy storage systems, Battery Management System, Fuel Cell based energy storage systems-Hybridization of different energy storage devices **Overview of Electric Vehicle Battery Chargers** - On-board chargers, Electric Vehicle Supply Equipment (EVSE) - Grid to EVSE to On-board chargers to battery pack power flow block schematic diagrams. Types of charging stations - AC Level 1 & 2, DC - Level 3 –V2G concept.	**11**
V	**Vehicle Communication protocols**: Need & requirements - Functions of Control Pilot (CP) and Proximity Pilot (PP) pins, Communication Protocols - CAN, LIN, FLEXRAY- CAN Architecture-Power line communication (PLC) in EV.	**6**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U43C	DEEP LEARNING	PEC	3	0	0	3	2022

i) PRE-REQUISITE: EL2U41B: Machine Learning

ii) COURSE OVERVIEW: This course aims to introduce the learner to an overview of the concepts and algorithms involved in deep learning. Basic concepts and application areas of machine learning, deep networks, convolutional neural network and recurrent neural network are covered in this course. This is a foundational program that will help students understand the capabilities, challenges, and consequences of deep learning and prepare them to participate in the development of leading-edge AI technology. They will be able to gain the knowledge needed to take a definitive step in the world of AI.

iii) COURSE OUTCOMES

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

CO1	Explain the fundamentals of Deep Learning, including neural networks, activation functions, and optimization techniques	Understand
CO2	Apply Convolutional Neural Networks for Computer Vision applications	Apply
CO3	Make use of Recurrent Neural Networks and Long Short-Term Memory networks for Natural Language Processing applications	Apply
CO4	Apply various Deep Learning techniques to improve model performance	Apply
CO5	Make use of Deep Learning models integrating Computer Vision and NLP in real-world scenarios	Apply

iv) SYLLABUS

Introduction to Deep Learning and Artificial Intelligence, Mathematical foundations for Deep Learning, Introduction to Artificial Neural Networks, Basics of Computer Vision - Convolution Neural Network, Natural Language Processing basics - Recurrent Neural Networks, Long short term memory techniques, Model transformation techniques and transfer learning, Applications of deep learning and AI.

v) (a) TEXT BOOKS

1) Ian Goodfellow, Yoshua Bengio, Aaron Courville, *Deep Learning*, MIT Press, 2015.
2) Aston Zhang, Zachary C. Lipton, Mu Li, and Alexander J. Smola, *Dive into Deep Learning*, August 2019.
3) Aggarwal, Charu C., *Neural Networks and Deep Learning*, Springer International Publishing AG, part of Springer Nature 2018.

(b) REFERENCES

1) Russell Reed, Robert J Marksll, Neural Smithing, *Supervised Learning in Feedforward Artificial Neural Networks*, Bradford Book, 2014.
2) Mohit Sewak, Md. Rezaul Karim, Pradeep Pujari, *Practical Convolutional Neural Networks*, Packt Publishing, 2018.

3) Sudharsan Ravichandran, *Hands-On Deep Learning Algorithms with Python*, Packt Publishing, 2019
4) Francois Chollet, *Deep Learning with Python*, Manning Publications Co., 2018.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Deep Learning: Fundamentals of Deep Learning and AI: Definition of AI, Machine Learning, and Deep Learning, Evolution of Neural Networks and DL applications in Computer Vision & NLP, Difference between Machine Learning and Deep Learning. Mathematical Foundations for Deep Learning: Linear Algebra: Vectors, Matrices, Eigenvalues, Eigenvectors, Probability & Statistics: Basics, Bayes' theorem, Probability Distributions, Optimization: Gradient Descent, Stochastic Gradient Descent (SGD), Cost functions. Introduction to Artificial Neural Networks (ANN): Perceptron Model: Neurons, Weights, and Bias, Activation Functions: Sigmoid, ReLU, Softmax, Forward and Backpropagation: Chain rule, Loss functions (MSE, Cross-Entropy).	9
II	Basics of Computer Vision & Image Processing: Understanding Images: Pixels, RGB, Grayscale, Image Representation, Image Filtering: Edge Detection, Gaussian Blur, Convolution basics, Feature Extraction and its importance in Deep Learning. Concept of Convolutions and Feature Maps, Padding, Stride, and Pooling (Max, Average), Fully Connected Layers in CNNs. CNN Architectures. Famous CNN Architectures: LeNet, AlexNet, VGG, ResNet (Overview). Hands-on: Implementing a CNN using Keras for Image Classification (sample datasets)	9
III	Introduction to NLP and Word Embeddings: NLP Basics: Tokenization, Lemmatization, Stopwords Removal, One-hot Encoding vs. Word Embeddings, Recurrent Neural Networks & LSTMs: Working of RNNs: Sequential Data Processing, Hidden States, Issues with RNNs: Vanishing Gradient Problem, LSTM & GRU: Gating Mechanisms, Hands-on NLP Applications: Text Classification using LSTM, Sentiment Analysis using IMDb dataset in Keras, Named Entity Recognition (NER)	9
IV	Hyperparameter Tuning & Optimization: Regularization: L1, L2, Dropout, Batch Normalization: Why and How, Learning Rate Scheduling and Optimizers (SGD, Adam, RMSprop). Transfer Learning & Pre-trained Models: Concept of Transfer Learning, Using Pre-trained CNN Models (VGG16, ResNet, MobileNet) for Image Classification, Fine-Tuning Layers for Specific Tasks. Hands-on Implementation of Transfer Learning: Implementing a Pre-trained Model in TensorFlow, Comparing Training Speed and	9

	Performance Improvements.	
V	Introduction to Generative Adversarial Networks (GANs) (Basic Concept), Autoencoders for Image Denoising, Applications of Deep Learning, DL in Healthcare (Medical Image Analysis), DL in Finance (Fraud Detection), DL in Robotics (Autonomous Systems), Implementing a Deep Learning Model (CNN or LSTM) for a real-world problem, Training, Testing, and Deployment.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U43D	NONLINEAR SYSTEMS	PEC	3	0	0	3	2022

i) PRE-REQUISITE: EL2U40A Control Systems

ii) COURSE OVERVIEW: The course aims in understanding the basic phenomena of limit cycles, determine their existence and non-existence in systems using various theorems. This course also aims to investigate the behavior of nonlinear systems, analyze their stability using the Lyapunov direct/indirect methods, frequency-domain methods and design various control schemes.

iii) COURSE OUTCOMES

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

CO1	Analyse the qualitative behaviour of nonlinear systems about their equilibrium points.	Analyse
CO2	Demonstrate the existence and uniqueness of solutions of nonlinear differential equations, the existence of periodic orbits/limit cycles for nonlinear systems.	Understand
CO3	Analyse the stability of nonlinear systems using various methods.	Analyse
CO4	Analyse the absolute stability of feedback systems with nonlinearities using Circle Criterion and Popov Criterion.	Analyse
CO5	Develop feedback linearization and stabilization for nonlinear systems.	Apply

iv) SYLLABUS

Non-linear system characteristics and mathematical modelling of a non-linear system, Stability of a nonlinear system based on equilibrium points, Bifurcation, Phase plane analysis of nonlinear systems.

Periodic solution of nonlinear systems and existence of limit cycle, Invariant set theorem, Bendixson's theorem and Poincare-Bendixson criteria, Existence and uniqueness of solutions to nonlinear differential equations, Lipschitz condition.

Lyapunov stability theorems, the direct method of Lyapunov, Construction of Lyapunov functions.

Passivity and loop transformations, KYP Lemma, Absolute stability, Circle Criterion, Popov Criterion.

Feedback linearization, Stabilization.

v) (a) TEXT BOOKS

1) Khalil H. K., *Nonlinear Systems*, 3rd Edition, Pearson, 2002
2) Gibson J. E., *Nonlinear Automatic Control*, Mc Graw Hill, 1963
3) Slotine J. E. and Weiping Li, *Applied Nonlinear Control*, Prentice-Hall, 1991.

(b) REFERENCES

1) Alberto Isidori, *Nonlinear Control Systems: An Introduction*, Springer-Verlag, 1985.

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

vi) COURSE PLAN

Module	Contents	No. of hours
I	Non-linear system characteristics and mathematical modelling of a non-linear system, Classification of equilibrium points, Stability of a nonlinear system based on equilibrium points, Bifurcation (construction not included), Phase plane analysis of nonlinear systems.	**8**
II	Periodic solution of nonlinear systems and existence of limit cycle, Open sets, closed sets, connected sets, Invariant set theorem, Bendixson's theorem and Poincare-Bendixson criteria, Existence and uniqueness of solutions to nonlinear differential equations (Proofs not required), Lipschitz condition.	**9**
III	Lyapunov stability theorems (Proofs not required)- local stability - local linearization and stability in the small- region of attraction, the direct method of Lyapunov, Construction of Lyapunov functions - Variable gradient and Krasovskii's methods, La Salles's invariance principle.	**9**
IV	Passivity and loop transformations, KYP Lemma (Proof not required), Absolute stability, Circle Criterion, Popov Criterion.	**10**
V	Feedback linearization, Input state linearization method, Input-output linearization method, Stabilization - regulation via integral control-gain scheduling.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U43E	SOLAR PV SYSTEMS	PEC	2	1	0	3	2022

i) PRE-REQUISITE: Nil.

ii) COURSE OVERVIEW: This course offers an in-depth introduction to the principles, components, and design of Solar Photovoltaic (PV) systems. It covers the fundamental concepts of solar energy, including solar radiation measurements and solar spectrum analysis, and gradually builds up to system design and grid integration. The course also introduces simulation tools for PV system design, life cycle cost analysis, and economic viability assessment.

iii) COURSE OUTCOMES

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

CO1	Explain the basics of solar energy conversion systems.	Understand
CO2	Explain the concepts and applications of solar thermal systems.	Understand
CO3	Outline the key parameters of PV modules and explain the various Maximum Power Point Tracking methods.	Understand
CO4	Model the components of solar photovoltaic systems and outline the advanced PV technologies.	Apply
CO5	Demonstrate the overcurrent protection methods and economics of PV Systems.	Understand

iv) SYLLABUS

Source of Solar Energy- Solar Constant - Solar Radiation on a Horizontal Surface - Solar Radiation on an Inclined Surface - Monthly Average Daily Solar Radiation on Inclined Surfaces. Solar Thermal System - Solar thermal collectors, Solar concentrators - Solar cooker, Solar Furnace, Solar Greenhouse, Solar Water Heater. Solar PV Systems - Solar Cell (Photovoltaic) Materials - Photovoltaic (PV) Module and PV Array, Packing Factor of the PV Module - Effect of shadowing - MPPT Techniques. Solar PV Systems- Design of Standalone System, Grid Interactive PV System, Bifacial solar modules and floating solar farms, Building-Integrated Photovoltaics (BIPV), Solar PV in electric vehicles and charging stations, Agri-voltaics and solar desalination. Protection Against Islanding and Reverse Power Flow –EMI Filters, Overcurrent protection of solar PV power system, Life cycle costing, Growth models. Introduction to simulation software for solar PV system design.

v) (a) TEXT BOOKS

1) Chetan Singh Solanki, *Renewable energy technologies: a practical guide for beginners*, 3rd Edition, PHI.
2) Chetan Singh Solanki, *Solar Photovoltaics: Fundamentals, Technologies and Applications*, 3rd Edition, PHI.
3) D.P. Kothari, M Jamil, *Grid Integration of Solar Photovoltaic Systems*, CRC Press, 2018.
4) G.N. Tiwari: *Solar Energy: Fundamentals, Design, Modelling and Applications*, Narosa Publishers, 2002.

5) A.A.M. Saigh (Ed), *Solar Energy Engineering*, Academic Press, 1977.

(b) REFERENCES

1) Masters, Gilbert M., *Renewable and Efficient Electric Power Systems*, John Wiley & Sons, Inc., Hoboken, New Jersey, 2004.
2) A. Duffie and W.A. Beckman, *Solar Energy Thermal Processes*, J. Wiley, 1994.
3) Thomas E. Kissell, David M. Buchla, Thomas L. Floyd, *Renewable Energy Systems*, Pearson, 2017.
4) G. N. Tiwari, Arvind Tiwari, Shyam, *Handbook of Solar Energy: Theory, Analysis and Applications*, Springer, 2016.
5) F. Kreith and J.F. Kreider, *Principles of Solar Engineering*, McGraw Hill, 1978.
6) Khan B. H., *Non-Conventional Energy Resources*, Tata McGraw Hill, 2009.
7) D.P. Kothari, K.C. Singal, Rakesh Ranjan, *Renewable Energy Sources and Emerging Technologies*, Prentice Hall of India, New Delhi, 2009.
8) Rao S. and B. B. Parulekar, *Energy Technology*, Khanna Publishers, 1999.
9) Sab S. L., *Renewable and Novel Energy Sources*, MI. Publications, 1995.
10) Sawhney G. S., *Non-Conventional Energy Resources*, PHI Learning, 2012.
11) Abbasi S. A. and N. Abbasi, *Renewable Energy Sources and their Environmental Impact*, Prentice Hall of India, 2001.
12) Boyle G. (ed.), *Renewable Energy: Power for Sustainable Future*, Oxford University Press, 1996.
13) Johansson T. B., H. Kelly, A. K. N. Reddy and R. H. Williams, *Renewable Energy Sources for Fuel and Electricity*, Earth scan Publications, London, 1993.
14) Tara Chandra Kandpal, Hari Prakash Garg, *Financial evaluation of Renewable Energy Technologies*, Mac Millam India Limited, 2003.
15) *IEEE Application Guide for IEEE Std 1547(TM), IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems*, in IEEE Std 1547.2-2008, pp.1-217, 15 April 2009, doi: 10.1109/IEEESTD.2008.4816078.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction - Sun and Earth, Solar Spectrum, Solar Geometry, Solar radiation on horizontal and inclined planes, Instruments for measurement of solar radiation, Extra-terrestrial Region - Terrestrial Region, Solar radiation at a given location - Daily Radiation Pattern, Annual Variation in Solar Radiation, Optimal Tilt for Solar Equipment, Monthly Averaged Global Radiation at Optimal Tilt.	**9**
II	Solar Thermal system - Principle of Conversion of Solar Radiation into Heat, – Solar thermal collectors – Flat plate collectors and its types – Heat transfer processes – Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector) – performance evaluation. Applications - Solar Cooking Systems- Principle of cooking - cooking by boiling - Speed of cooking- Energy required for cooking, Types of Solar cooker - Box type solar cooker - Dish type solar cooker- Heat Transfer type solar cooker, Solar Furnace, Solar Greenhouse, Solar Water Heater (flat plate).	**9**

III	Solar PV Systems-Introduction - Fundamentals of Semiconductor and Solar Cells - Photovoltaic Effect - Solar Cell (Photovoltaic) Materials - Basic Parameters of the Solar Cell -Generation of Solar Cell (Photovoltaic) Materials-.Photovoltaic (PV) Module and PV Array – Single - Crystal Solar Cell Module, Thin-Film PV Modules, III – V Single Junction and Multifunction PV Modules - Emerging and New PV Systems - Packing Factor of the PV Module - Efficiency of the PV Module - Energy Balance Equations for PV Modules -Series and Parallel Combination of PV Modules.- Effect of shadowing-MPPT Techniques - P&O, incremental conductance method.	**9**
IV	Solar PV Systems – Photovoltaic systems, Types, General design considerations, System sizing, Battery sizing, Inverter sizing, Design examples, Balance of PV systems. Cost estimation of a PV system, Solar PV Lantern -Design and Costing, Grid Interactive PV System-Advanced PV Applications: Bifacial solar modules and floating solar farms, Building-Integrated Photovoltaics (BIPV), Solar PV in electric vehicles and charging stations, Agri-voltaics and solar desalination.	**9**
V	Protection Against Islanding and Reverse Power Flow – EMI Filters. Overcurrent protection of solar PV power system, Selective fuse links for PV String protection, PV fuse selection flow chart, Fuse rating for PV Applications. Life cycle costing, Growth models, Annual payment and present worth factor, payback period, LCC with examples. Introduction to simulation software for solar PV system design.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U43F	CLOUD COMPUTING	PEC	3	0	0	3	2023

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW: This course provides a comprehensive understanding of cloud computing concepts, virtualization technologies, cloud architecture, and major cloud platforms like AWS, Microsoft Azure, and Google Cloud. It covers the fundamental characteristics, service, and deployment models of cloud computing, along with hands-on experience in deploying and managing applications on popular cloud platforms. The course also focuses on virtualization techniques, cloud services, and security aspects, including compliance, identity management, and monitoring tools, preparing students to effectively work with modern cloud technologies.

iii) COURSE OUTCOMES

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

CO1	Explain the fundamental concepts of cloud computing, including its characteristics, service models, deployment models, and evolution.	Understand
CO2	Demonstrate the principles of virtualization technologies, including hypervisors, virtual machines, containers, and various virtualization techniques.	Understand
CO3	Analyze cloud architecture and evaluate key cloud services, such as storage, compute, and database solutions across major platforms.	Understand
CO4	Deploy and manage cloud-based applications, using hands-on experience with AWS, Microsoft Azure, and Google Cloud platforms.	Understand
CO5	Evaluate cloud security risks and implement monitoring tools, ensuring data privacy, compliance, and effective resource management.	Understand

iv) SYLLABUS

Cloud computing characteristics, service models (IaaS, PaaS, SaaS), deployment models (public, private, hybrid, community), virtualization technologies (hypervisors, virtual machines, containers), virtualization techniques (hardware, storage, network), cloud architecture, cloud services (storage, compute, database), AWS, Microsoft Azure, Google Cloud, cloud security risks, data privacy, compliance, IAM, encryption, cloud monitoring tools (CloudWatch, Azure Monitor, Stackdriver).

v) (a) TEXT BOOKS

1) Thomas, E., Zaigham M., Ricardo P., *Cloud Computing Concepts, Technology & Architecture*, Prentice Hall, 2013.
2) Buyya, R., Broberg, J., & Goscinski, A. M., *Cloud Computing: Principles and Paradigms*, Wiley, 2013.
3) Miller, M. *Cloud Computing: Web-Based Applications That Change the Way You Work and Collaborate* Online. Que Publishing, 2008.

(b) REFERENCE

1) Marinescu, D. C., *Cloud computing: theory and practice*, Morgan Kaufmann, 2017.

2) Buyya, R., Broberg, J., & Goscinski, A. M., *Cloud computing: Principles and paradigms* John Wiley & Sons, 2011.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Module 1: Introduction to Cloud Computing and IoT** Definition and characteristics: On-demand self-service, broad network access, resource pooling, rapid elasticity, measured service, evolution of cloud computing: Grid computing, utility computing, virtualization, service models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), deployment models: Public cloud, private cloud, hybrid cloud, community cloud.	**9**
II	**Module 2: Cloud Infrastructure for IoT** Introduction to virtualization: Concept of hypervisors (Type 1 and Type 2), virtual machines (VMs) and containers, virtualization techniques: Hardware virtualization, storage virtualization, network virtualization, popular virtualization tools: VMware, VirtualBox, Docker containers.	**9**
III	**Module 3: Cloud-based IoT Data Management** Cloud architecture: Layered architecture of cloud, client-server architecture, cloud storage and networking basics, cloud services and applications: Storage services (Amazon S3, Azure Blob Storage, Google Cloud Storage), compute services (EC2, Azure VMs, Google Compute Engine), database services (RDS, Cosmos DB, BigQuery), case studies: AWS, Microsoft Azure, Google Cloud.	**9**
IV	**Module 4: Cloud Security for IoT** Amazon Web Services (AWS): Overview of AWS services (EC2, S3, Lambda, RDS), hands-on: Creating and managing VMs on AWS, Microsoft Azure: Overview of Azure services (Virtual Machines, Blob Storage, Functions), hands-on: Deploying a web app on Azure, Google Cloud Platform (GCP): Overview of GCP services (Compute Engine, Cloud Functions, Cloud SQL), hands-on: Setting up a project on GCP.	**9**
V	**Module 5: Cloud-based IoT Application Development** Cloud security: Security risks in the cloud, data privacy and compliance (GDPR, HIPAA), identity and access management (IAM), firewalls and encryption in the cloud, cloud monitoring and management: Tools (CloudWatch (AWS), Azure Monitor, Stackdriver (GCP)).	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U43G	VEHICULAR NETWORKS AND COMMUNICATION	PEC	3	0	0	3	2022

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW: This course designed to explore the principles and practices related to communication systems and networking in vehicular environments. The course focuses on the underlying technologies, protocols, and real-time applications that are shaping the future of vehicular communication, with a strong emphasis on Intelligent Transportation Systems (ITS), V2V (Vehicle-to-Vehicle), V2I (Vehicle-to-Infrastructure).

iii) COURSE OUTCOMES

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

CO1	Explain the architecture, types, and applications of vehicular networks and identify the challenges associated with communication in high-mobility environments.	Understand
CO2	Summarize the communication technologies and standards used in vehicular networks, such as IEEE 802.11p, DSRC, LTE, and 5G NR.	Understand
CO3	Extend knowledge of networking protocols and security mechanisms in vehicular networks, and understand the implementation challenges for secure communication in intelligent transportation systems.	Understand
CO4	Apply the performance of vehicular networks using various metrics and simulation tools, identifying key factors affecting communication quality.	Apply
CO5	Interpret the emerging applications and future trends in vehicular networks, including the integration of autonomous vehicles, AI, and the role of 5G in transforming transportation systems.	Understand

iv) SYLLABUS

Introduction to Vehicular Networks: Overview of Vehicular Networks (VN) and types. Architecture and key applications in Intelligent Transportation Systems (ITS). Challenges: High mobility, communication range, and safety concerns.

Communication Technologies for Vehicular Networks: Key technologies, V2V role in safety, V2I in urban planning, and traffic management. Emerging 5G NR standards and communication protocols

Network Protocols and Security in Vehicular Communication: Key communication protocols, Routing protocols for V2V and V2I. Security issues. Case Study: Security threats and solutions in ITS.

Performance Analysis of Vehicular Networks: Performance metrics. Simulation tools: NS-3, OMNeT++. Real-time analysis: Urban and highway scenarios, interference management, and QoS in vehicular communication.

Applications and Future Trends: Advanced applications: Autonomous vehicles, traffic monitoring, emergency response. Real-time data sharing and decision-making. Role of AI and ML in vehicular networks. Future of 5G and beyond, integration with smart cities, and urban mobility solutions.

v) (a) TEXT BOOKS

1) C. E. Lee, *Introduction to Vehicular Networking and Communication*, Elsevier, 2019.
2) X. Lin, *Vehicular Communication Systems: Protocols, Standards, and Applications,* Wiley-IEEE Press, 2020.
3) H. Hartenstein, *Security and Privacy in Vehicular Networks*, Springer, 2019.
4) T. G. Dietterich, *Analysis of Vehicular Ad Hoc Networks: Tools, Methods, and Case Studies*, Wiley, 2018.
5) M. Alam, *Advanced Vehicular Communications: Technologies and Applications*, Springer, 2022.

(b) REFERENCES

1) R. H. Weber, The Internet of Things: Legal Perspectives, Springer, 2010.
2) *H. Hartenstein, Vehicular Ad Hoc Networks: Architectures, Protocols, and Applications,* Springer, 2016.
3) *F. B. Bastani, Network Protocols in Vehicular Ad Hoc Networks,* Elsevier, 2017.
4) *Z. Zeng, Vehicular Security and Privacy: Advances and Challenges,* Wiley, 2021.
5) *J. S. L. H. Venkatesh, Performance Analysis and Optimization of Vehicular Networks,* Springer, 2020.
6) *S. M. Balamurugan, Autonomous Vehicles and Future Trends,* Elsevier, 2021.
7) *P. H. J. P. Weijun, Smart Mobility and Connected Vehicles,* Wiley, 2023.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Vehicular Networks:** Overview of Vehicular Networks (VN). Types of Vehicular Networks: V2V, V2I, V2X Architecture of Vehicular Networks. Applications of Vehicular Networks in Intelligent Transportation Systems (ITS) Challenges in Vehicular Networking: High mobility, Communication range, and Safety issues.	9
II	**Communication Technologies for Vehicular Networks:** Basics of Communication Technologies: DSRC, Wi-Fi, 5G, and LTE. Role of V2V Communication in Vehicular Safety. Role of V2I Communication in Urban Planning and Traffic Management. Emerging communication standards: 5G NR (New Radio) for vehicular communication. Communication protocols: IEEE 802.11p, Cellular V2X (C-V2X)	9
III	**Network Protocols and Security in Vehicular Communication:** Communication Protocols in Vehicular Networks: Medium Access	9

	Control (MAC), Transport Layer Protocols, Routing Protocols for V2V and V2I communications. Security Issues in Vehicular Networks: Authentication and Authorization, Secure Communication and Data Privacy, Vulnerabilities and Attack Mitigation. Case Study: Security Threats and Solutions in ITS	
IV	**Performance Analysis of Vehicular Networks:** Metrics for Performance Evaluation: Throughput, Latency, Packet Delivery Ratio (PDR) Simulation Tools for Vehicular Networks: NS-3, OMNeT++ Real-time Performance Analysis in Urban and Highway Scenarios Interference Management and Quality of Service (QoS) in Vehicular Communication. Impact of Mobility on Network Performance.	**9**
V	**Applications and Future Trends:** Advanced Applications: Autonomous Vehicles, Traffic Monitoring, Emergency Response. Real-time Data Sharing and Decision Making in Vehicular Networks. Role of AI and Machine Learning in Vehicular Networks. 5G and Beyond: The Future of Vehicular Networks. Integration with Smart Cities and Urban Mobility Solutions	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U43H	POWER SYSTEM PROTECTION	PEC	3	0	0	3	2022

i) PRE-REQUISITE: EL2U40B Power System Engineering

ii) COURSE OVERVIEW: The goal of this course is to expose the students to the fundamental concepts of generation, transmission and distribution of electric power. The course also intends to deliver the basic concepts of power system protection including the different types of relays and circuit breakers

iii) COURSE OUTCOMES

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

CO1	Explain the need for protective schemes and classify different types of electrical faults and their effects on power systems.	Understand
CO2	Illustrate the operating principles and characteristics of electromechanical, static, and numerical relays used in protection systems.	Understand
CO3	Interpret the principles and settings of overcurrent protection schemes and compare different types of overcurrent relays.	Understand
CO4	Summarize the working and characteristics of distance protection relays and assess their performance under different fault conditions.	Understand
CO5	Illustrate the concepts and components of differential protection, pilot relaying schemes, and circuit breaker operation with reference to power system protection.	Understand

iv) SYLLABUS

Introduction to Power System Protection.
Relay Construction and Operating Principles: Introduction, Electromechanical Relays, Static Relays – Merits and Demerits of Static Relays, Numerical Relays, Comparison between Electromechanical Relays and Numerical Relays.
Overcurrent Protection, Distance Protection.
Pilot Relaying Schemes: Introduction, Wire Pilot Protection, Carrier Current Protection.
Differential Protection, Rotating Machines Protection
Transformer and Buszone Protection: Introduction, Transformer Protection, Buszone Protection, Frame Leakage Protection.
Circuit Breakers: Operating Principle and Types.

v) (a) TEXT BOOKS

1) Bhuvanesh Oza, Nirmal Kumar Nair, Rashesh Mehta, *Power System Protection and Switchgear*, Tata McGraw Hill, 1st edition, 2017.
2) Badri Ram, D. N. Vishwakarma, *Power System Protection and Switchgear*, Tata McGraw Hill, 2nd edition, 1994.
3) J. B. Gupta, *A course in Electrical Power*, Kataria and Sons, 2013 edition.

(b) REFERENCES

1) Bhavesh Bhalja, R. P. Maheshwari, Nilesh G. Chothani, *Protection and Switchgear*, Oxford Higher Education, 2011 edition.
2) Sunil S. Rao, *Switchgear and Protection*, Khanna Publishers, 2nd edition, 2012.
3) N. Veerappan S.R. Krishnamurthy, *Power System Switchgear and Protection*, S. Chand, 1st edition, 2009.
4) Y. G. Paithankar, S. R. Bhide, *Fundamentals of Power System Protection*, PHI, 1st Edition, 2009.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Power System Protection:** Need for protective schemes, Nature and Cause of Faults, Types of Fault, Effects of Faults, Fault Statistics, Zones of Protection, Primary and Backup Protection, Essential Qualities of Protection, Performance of Protective Relaying, Classification of Protective Relays, Automatic Reclosing, Current Transformers and Voltage Transformers for Protection.	8
II	**Relay Construction and Operating Principles:** Introduction, Electromechanical Relays, Static Relays – Merits and Demerits of Static Relays, Numerical Relays, Comparison between Electromechanical Relays and Numerical Relays. **Overcurrent Protection:** Introduction, Time–current Characteristics, Current Setting, Time Setting, Overcurrent Protective Schemes, Reverse Power or Directional Relay, Protection of Parallel Feeders, Protection of Ring Mains, Earth Fault and Phase Fault Protection, Combined Earth Fault and Phase Fault Protective Scheme, Phase Fault Protective Scheme, Directional Earth Fault Relay, Static Overcurrent Relays, Numerical Overcurrent Relays.	9
III	**Distance Protection:** Introduction, Impedance Relay, Reactance Relay, Mho Relay, Angle Impedance Relay, Effect of Arc Resistance on the Performance of Distance Relays, Reach of Distance Relays. Effect of Power Surges (Power Swings) on Performance of Distance Relays, Effect of Line Length and Source Impedance on Performance of Distance Relays.	8
IV	**Pilot Relaying Schemes:** Introduction, Wire Pilot Protection, Carrier Current Protection. **Differential Protection:** Introduction, Differential Relays, Simple Differential Protection, Percentage or Biased Differential Relay, Differential Protection of 3 Phase Circuits, Balanced (Opposed) Voltage Differential Protection. **Rotating Machines Protection:** Introduction, Protection of Generators. **Transformer and Buszone Protection:** Introduction, Transformer Protection, Buszone Protection, Frame Leakage Protection.	10

V	**Circuit Breakers:** Introduction, Fault Clearing Time of a Circuit Breaker, Arc Voltage, Arc Interruption, Restriking Voltage and Recovery Voltage, Current Chopping, Interruption of Capacitive Current, Classification of Circuit Breakers, Air – Break Circuit Breakers, Oil Circuit Breakers, Air – Blast Circuit Breakers, SF6 Circuit Breakers, Vacuum Circuit Breakers, High Voltage Direct Current Circuit Breakers, Rating of Circuit Breakers, Testing of Circuit Breakers.	**10**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

PROGRAMME ELECTIVE VI

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U44A	DIGITAL CONTROL SYSTEMS	PEC	2	1	0	3	2022

i) **PRE-REQUISITE:** EE1U20A: Circuits and Networks, EE1U30C: Signals and Systems, EE1U30E: Linear Control Systems.

ii) **COURSE OVERVIEW**: This course aims to provide a strong foundation in discrete domain modelling, analysis and design of digital controllers to meet performance requirements.

iii) **COURSE OUTCOMES**

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

CO1	Explain the various control blocks and components of digital control systems.	Understand
CO2	Use z-domain techniques to analyse sampled data systems	Apply
CO3	Design a digital controller/ compensator in the frequency domain.	Apply
CO4	Design a digital controller/ compensator in the time domain.	Apply
CO5	Develop controllers for linear discrete time systems using state variable concepts.	Analyse

iv) **SYLLABUS**

Basic digital control system - Mathematical modelling - sampling and reconstruction - Zero order and First order hold circuits - realisation of digital filters. Relation between transfer function and pulse transfer function - Mapping between s-domain and z-domain.

Pulse transfer function of different configurations of systems - Modified z-transform -Time Response of discrete time system.

Design of controller/Compensator in frequency domain - Bilinear transformation and sketching of frequency response. Introduction to design and simulation using MATLAB.

Design of controller/Compensator based on time response, Design of controllers and compensators by the method of Ragazzini - Introduction to Dead beat response and deadbeat controller design.

Modern control approach to digital control - Introduction to state space - Computation of solution of state equation and state transition matrix. Controllability, observability and stability of discrete time systems. Digital controller and observer design.

v) (a) **TEXT BOOKS**

1) C. L. Philips, H. T. Nagle, “Digital Control Systems”, Prentice-Hall, Englewood Cliffs, New Jersey, 1995.
2) M. Gopal, “Digital Control and State Variable Methods”, Tata McGraw-Hill, 1997.

3) Ogata K., "Discrete-Time Control Systems", Pearson Education, 2nd Edition, 2005.

(b) REFERENCES

1) Benjamin C. Kuo, "Digital Control Systems", 2nd Edition, Saunders College Publishing, Philadelphia, 1992.
2) Constantine H. Houpis and Gary B. Lamont, "Digital Control Systems Theory", Hardware Software, McGraw Hill Book Company, 1985.
3) Isermann R., "Digital Control Systems: Fundamentals, Deterministic Control", V. I, 2nd Edition, Springer Verlag, 1989.
4) Liegh J. R., "Applied Digital Control Theory, Design and Implementation,", Dover Publishers, 2nd Ed. ISBN13-.**978-0486450513**
5) Åström, Karl J., and Björn Wittenmark, "Computer-controlled systems: Theory and design", Courier Corporation, 2013.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Basic digital control system- Mathematical modeling - sampling and reconstruction - Zero order and First order hold circuits - realisation of digital filters. Relation between transfer function and pulse transfer function - Mapping between s-domain and z-domain.	**9**
II	Pulse transfer function of different configurations of systems- Modified z-transform-Time Response of discrete time system. Order and Type of a system Steady state error and Static error constants.	**8**
III	Bilinear transformation and sketching of frequency response - Digital P/PI/PID controller design based on frequency response - Digital compensator based on frequency response. Introduction to design and simulation using MATLAB (for demo/ assignment only and not to be included for examination).	**10**
IV	Design of lag, lead and lag-lead compensator using root locus - Design of controllers and compensators by the method of Ragazzini- Dead beat response controller introduction.	**8**
V	Introduction to state space - state space modeling of discrete time SISO system - Computation of solution of state equation and state transition matrix. Controllability, observability and stabilizability of discrete time systems- Loss of controllability and observability due to sampling. Digital controller and observer design - state feedback – pole placement - full order observer - reduced order observer.	**10**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 arks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U44B	BLOCKCHAIN TECHNOLOGIES	PEC	3	0	0	3	2022

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW:

This course introduces blockchain fundamentals, cryptographic principles, consensus mechanisms, Bitcoin, Ethereum, and smart contracts. Students explore real-world applications in energy, IoT, and finance. With a focus on decentralization, security, and development tools, it prepares Electrical and Computer Engineering students for industry roles in blockchain-based systems and emerging technologies.

iii) COURSE OUTCOMES

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

CO1	Explain the fundamental concepts of cryptocurrency and the way cryptographic techniques ensure secure transactions.	Understand
CO2	Demonstrate the structure and workflow of public blockchains such as Bitcoin.	Understand
CO3	Explain the concept and working of smart contracts using Solidity.	Understand
CO4	Describe the features and architecture of enterprise blockchains like Hyperledger Fabric.	Understand
CO5	Explain real-world use cases of blockchain in energy systems.	Understand

iv) SYLLABUS

Introduction to Cryptography. Symmetric and Asymmetric Encryption. Digital Signatures and Hashing Algorithms. Blockchain Architecture and Components. Types of Blockchain: Public, Private, Consortium. Distributed Ledger Technology and Decentralization. Consensus Mechanisms: PoW, PoS, PBFT, Raft. Bitcoin: Transactions, Wallets, Mining. Ethereum: Architecture, Smart Contracts, Gas. Solidity Programming: Variables, Functions, Inheritance. Smart Contract Deployment and Use Cases. Blockchain in Energy Systems, Supply Chain, and Governance. Integration with IoT, Cloud, and AI. Overview of Hyperledger and Enterprise Blockchain Platforms.

v) (a) TEXT BOOKS

1) Imran Bashir, *Mastering Blockchain: A deep dive into distributed ledgers, consensus protocols, smart contracts, DApps, cryptocurrencies, Ethereum, and more*, Packt Publishing, Third edition, 2020.

(b) REFERENCES

1) Ritesh Modi, *Solidity Programming Essentials: A beginner's guide to build smart contracts for Ethereum and blockchain*, Packt Publishing, First edition, 2018.
2) Kumar Saurabh, Ashutosh Saxena, *Blockchain Technology: Concepts and Applications*,

First Edition, Wiley Publications, First edition, 2020.
3) Chandramouli Subramanian, Asha A George, et al, *Blockchain Technology*, Universities Press (India) Pvt. Ltd, First edition, August 2020.
4) Lorne Lantz, Daniel Cawrey, *Mastering Blockchain: Unlocking the Power of Cryptocurrencies, Smart Contracts, and Decentralized Applications*, O'Reilly Media, First edition, 2020.
5) Andreas M. Antonopoulos, Gavin Wood, *Mastering Ethereum: Building Smart Contracts and DApps*, O'Reilly Media, First edition, 2018.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Module 1: Foundations of Cryptography and Blockchain Introduction to cryptography. Symmetric and asymmetric cryptography. Digital signatures and RSA. Hashing and Merkle trees. Blockchain definition and architecture. Key features: immutability, decentralization, transparency. Distributed ledger vs. traditional database. Components and types of blockchain – public, private, consortium. Blockchain benefits and limitations.	**9**
II	Module 2: Consensus Mechanisms and Bitcoin Ecosystem Consensus mechanisms: PoW, PoS, PBFT, Paxos, Raft. Bitcoin architecture and working. Public and private keys, addresses. Transactions, coinbase, validation process. Bitcoin mining – tasks, algorithms, hash rate. Wallets and transaction lifecycle. Limitations and security threats in Bitcoin.	**9**
III	Module 3: Ethereum and Smart Contracts Ethereum ecosystem and architecture. Ether and Gas. Ethereum Virtual Machine (EVM). Smart contracts – definition, templates, oracles. Solidity basics – variables, functions, control structures. Events, error handling, inheritance. Case studies: voting system, auction smart contracts. Debugging and optimization.	**9**
IV	Module 4: Enterprise Blockchain – Hyperledger and MultiChain Hyperledger Fabric – architecture, peers, chaincode, channels. Smart contract deployment using Composer. MultiChain platform – features, permission models, command-line usage. Blockchain-as-a-Service (BaaS). Permissioned vs permissionless blockchains. Comparison of public and enterprise frameworks.	**9**
V	Module 5: Applications of Blockchain Use cases in smart grid, energy trading, power system automation. Blockchain in healthcare, supply chain, identity verification (Aadhaar), capital markets. Blockchain with IoT. Blockchain integration with AI and cloud. Security, scalability, and regulatory challenges. Emerging trends and career paths.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U44C	DATA MINING	PEC	3	0	0	3	2022

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW: This course helps to understand the concepts of data mining and data warehousing. It covers the key processes of data mining, data preprocessing techniques, fundamentals and advanced concepts of classification, clustering, association rule mining, web mining and text mining. It enables the learners to develop new data mining algorithms and apply the existing algorithms in real-world scenarios.

iii) COURSE OUTCOMES

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

CO1	Explain the basic concepts, architecture, and functionalities of data warehousing and data mining.	Understand
CO2	Explain various preprocessing techniques to convert raw data into suitable format for practical data mining tasks.	Understand
CO3	Apply classification and clustering algorithms to organize and group data effectively.	Apply
CO4	Apply association rule mining algorithms to extract patterns from transactional data.	Apply
CO5	Explain advanced data mining concepts and their applications in emerging domains.	Understand

iv) SYLLABUS

Introduction to data mining and data warehousing-Data warehouse-Differences between Operational Database Systems and Data Warehouses, Multidimensional data model- Data Preprocessing-Need of data preprocessing, Data Cleaning- Missing values-Classification-Introduction, Decision tree construction principle, Splitting indices-Introduction to clustering-Clustering Paradigms, Partitioning Algorithm-Association Rule Analysis-Association Rules-Introduction, Methods to discover Association rules, Apriori(Level-wise algorithm),Advanced Data Mining Techniques-Web Mining - Web Content Mining, Web Structure Mining- Page Rank, Clever, Web Usage Mining.

v) (a) TEXT BOOKS

1) Dunham M H, *Data Mining: Introductory and Advanced Topics*, Pearson Education, New Delhi, 2003.
2) Arun K Pujari, *Data Mining Techniques*, Universities Press Private Limited, 2008.
3) Jaiwei Han and Micheline Kamber, *Data Mining Concepts and Techniques*, Elsevier, 2006.

(b) REFERENCES

1) M Sudeep Elayidom, *Data Mining and Warehousing*, 1st Edition, 2015, Cengage Learning India Pvt. Ltd.
2) MehmedKantardzic, *Data Mining Concepts, Methods and Algorithms*, John Wiley and Sons, USA, 2003.

3) Pang-Ning Tan and Michael Steinbach, *Introduction to Data Mining*, Addison Wesley, 2006.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Data Mining and Data Warehousing** Data Warehouse- Definition, Features, and Applications, Differences between Operational Database Systems and Data Warehouses, Multidimensional Data Model, Data Warehouse Schema: Star, Snowflake, and Fact Constellation. OLAP Operations: Roll-up, Drill-down, Slice, Dice, Pivot. Data Warehouse Architecture, Transition from Data Warehousing to Data Mining, Data Mining Concepts and Applications, Knowledge Discovery in Database (KDD) vs Data Mining, Architecture of a Typical Data Mining System, Data Mining Functionalities (Classification, Clustering, Association), Issues in Data Mining.	**10**
II	**Data Preprocessing Techniques -**Need of data preprocessing, Data Cleaning- Handling missing values and noisy data, Data Integration and Transformation, Data Reduction techniques -Data cube aggregation, Attribute subset selection, Dimensionality reduction, Numerosity reduction. Data Discretization and generation of concept hierarchies.	**8**
III	**Classification-** Introduction, Decision tree construction principle, Splitting indices -Information Gain, Gini index, Decision tree construction algorithms-ID3, Decision tree construction with presorting-SLIQ, Classification Accuracy-Precision, Recall. **Introduction to clustering**-Clustering Paradigms, Partitioning Algorithm- PAM, Hierarchical Clustering-DBSCAN, Categorical Clustering-ROCK	**9**
IV	**Association Rule Analysis**-Association Rules-Introduction, Methods to discover Association rules, Apriori (Level-wise algorithm), Partition Algorithm, Pincer Search Algorithm, Dynamic Itemset Counting Algorithm, FP-tree Growth Algorithm.	**8**
V	**Advanced Data Mining Techniques-**Web Mining - Web Content Mining, Web Structure Mining- Page Rank, Clever, Web Usage Mining- Preprocessing, Data structures, Pattern Discovery, Pattern Analysis. Text Mining-Text Data Analysis and information Retrieval, Basic measures for Text retrieval, Text Retrieval methods, Text Indexing Techniques, Query Processing Techniques.	**10**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U44D	SPECIAL ELECTRIC MACHINES	PEC	3	0	0	3	2022

i) PRE-REQUISITE: EL2U30C: Electrical Machines, EL2U40A: Control Systems.

ii) COURSE OVERVIEW: The goal of this course is to get an overview of special electric machines for control and industrial applications.

iii) COURSE OUTCOMES

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

CO1	Outline the principle of PMDC, BLDC motor and its drive circuits.	Understand
CO2	Classify the various types of stepper motors and its drive circuits.	Understand
CO3	Illustrate the principle of reluctance motors and the various power converter circuits used in switched reluctance motors.	Understand
CO4	Compare the various types of AC and DC servomotors.	Understand
CO5	Explain the principle of Universal motors and Linear Induction motors.	Understand

iv) SYLLABUS

Permanent Magnet DC Motors - Brushless DC motor – construction – principle of operation.
Stepper motors – Basic principle – Classification – Types of excitation – characteristics – applications.
Reluctance motors, Synchronous Reluctance Motor – principle of operation - torque equation – characteristics – applications; Switched reluctance motors – principle of operation – power converter circuits – applications.
AC Servomotors, DC servomotors - principle of operation – types – comparison- applications.
Single Phase Special Electrical Machines: Universal Motors – construction - principle of operation - applications.
Linear Electric Machines: Linear Induction Motors, Linear Levitation Machines.

v) (a) TEXT BOOKS

1) E. G. Janardanan, *Special Electrical Machines*, PHI Learning Private Limited, 2014.
2) T. J. E. Miller, *Brushless Permanent Magnet and Reluctance Motor Drives*, Clarendon Press, Oxford, 1989.

(b) REFERENCES

1) Irving L. Kosow, *Electrical Machinery and Transformers*, Pearson, 2nd Edition 2007.
2) Theodore Wildi, *Electric Machines, Drives and Power Systems*, Pearson Education, 5th Edition, 2013.

3) Veinott & Martin, *Fractional & Subfractional Horsepower Electric Motors*, McGraw Hill, 4th Edition, 1986.
4) Paul Acamley, *Stepping Motor – A Guide to Theory and Practice*, IEE London, 2002.
5) B. K. Bose, *Modern power electronics and AC drives*, Prentice Hall of India, N J, 2002.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Permanent Magnet DC Motors:** Construction-Principle of operation - Torque equation–Performance characteristics -Applications. **Brushless DC motors:** Classification- Construction-Principle of operation –Electronic commutator-BLDC square wave- BLDC sine wave - Comparison - Applications - Drive circuits.	9
II	**Stepper motors:** Basic Principle - Classification – Variable Reluctance - Permanent Magnet - Hybrid type – Comparison - Theory of operation – Types of excitation mode- Static and Dynamic characteristics - Drive circuits – Bipolar and Unipolar-Open loop and Closed loop control of Stepper motors –Applications.	9
III	**Synchronous Reluctance Motor (SyRM):** Construction of SyRM, Working-Phasor Diagram and Torque Equation-Torque-speed characteristics- Control of SyRM - Applications. **Switched Reluctance Motors** – Construction - Principle of operation Torque equation-Torque-speed characteristics-Power converter circuits - Rotor Position Sensors, Control of SRM-Applications.	10
IV	**AC Servomotors**- Construction - Principle of operation– features - Performance characteristics- Damping of AC servomotors – Drag cup servomotors -Applications. **DC Servomotors** – Principle - Field and armature-controlled DC servomotors– Comparison – Characteristics-Transfer function-Applications.	8
V	**Single-Phase Special Electric Machines:** Hysteresis Motor, Universal Motors –Construction-Principle of operation– Applications. **Linear Electric Machines:** Linear Induction Motor - Types of forces, Thrust equation, Thrust-speed characteristics, End effect and Transverse edge effect - Linear Levitation Machines - Applications.	9
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U44E	SOFTWARE TESTING	PEC	3	0	0	3	2022

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW:

This course offers an introduction to theoretical computer science with a focus on the principles and practices of software testing. It explores a range of techniques for designing test cases aimed at verifying different software artifacts, including requirements, design models, and source code. Learners will study test case design methods based on graph theory, programming language syntax, and symbolic execution, utilizing tools such as PEX. The course equips students with a structured approach to software testing, enabling them to apply systematic testing strategies throughout the application development process.

iii) COURSE OUTCOMES

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

CO1	Explain the fundamental concepts of software testing, including the need for testing, testing processes, key terminologies, types of testing, and testing methods	Understand
CO2	Outline unit testing concepts, including static and dynamic testing methods, and basics of mutation testing.	Understand
CO3	Explain graph coverage criteria in terms of control flow graph and data flow graph for a given program	Understand
CO4	Demonstrate the importance of black-box approaches in terms of domain and functional testing	Understand
CO5	Demonstrate grey box testing concepts, its advantages and disadvantages, and various testing techniques	Understand
CO6	Apply JUnit and MuClipse for mutation testing, graph-based testing, and black-box testing, and utilize PEX for symbolic execution through case studies.	Apply

iv) SYLLABUS

Popular software errors (Ariane 5, Therac-25, Intel Pentium Bug); importance of software testing, software quality, testing roles; testing process (Level 0–4 thinking); key terminologies: verification, validation, faults, errors, bugs, test cases, coverage criteria. Types of testing: unit, integration, system, acceptance, beta, functional, stress, performance, usability, regression. Testing methods: black box, white box, grey box. Unit testing concepts: static, dynamic, control flow, data flow, domain, functional testing. Mutation testing: mutants, mutation operators, mutation score; case studies with JUnit and MuClipse. Graph coverage: node, edge, path, prime path, round-trip coverage; data flow: du paths, du pairs; control flow graphs for code structures; design-level coverage: call graphs, inheritance, coupling du-pairs; graph-based testing case study using JUnit. Domain testing: input space partitioning, interface-based and functionality-based modeling, coverage criteria (ACoC, ECC, Pair-wise, T-wise, Base Choice), TriTyp example. Functional testing: steps, equivalence class partitioning, boundary value analysis, decision

tables, random testing; black box testing case study using JUnit. Grey box testing concepts, methodology, advantages, disadvantages; techniques: matrix testing, regression, orthogonal array (OAT), pattern testing. Introduction to PEX, parameterized unit testing, symbolic execution, symbolic execution tree, and PEX case study.

v) (a) TEXT BOOKS

1) Paul Ammann and Jeff Offutt, *Introduction to Software Testing*, Cambridge University Press, 2nd edition, 2016
2) Kshirasagar Naik and Priyadarshi Tripathy, *Software Testing and Quality Assurance: Theory and Practice*, Wiley, 1st edition, 2008
3) Srinivasan Desikan & Gopalaswamy Ramesh, *Software Testing: Principles and Practice*, Pearson Education, 1st edition, 2006
4) Dorothy Graham, Erik van Veenendaal, Isabel Evans, and Rex Black, *Foundations of Software Testing*, Cengage Learning, 4th edition, 2019

(b) REFERENCES

1) Boris Beizer, *Software Testing Techniques*, Van Nostrand Reinhold, 2nd edition, 1990
2) King, James C, *Symbolic Execution and Program Testing*, Association for Computing Machinery, July 1976.
3) Nancy G. Leveson, *Engineering - A Safer World: Systems Thinking Applied to Safety*, MIT Press, 1st edition, 2011
4) https://www.csc.ncsu.edu/academics/undergrad/honors/thesis/muclipsebinder.pdf Muclipse tutorial.
5) https://www.microsoft.com/en-us/research/wp-content/uploads/2016/08/deep_dive_into_pex_for_code_hunt.pdf

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Software Testing: Some Popular Errors – Ariane 5, Therac 25, Intel Pentium Bug. What is Software testing? Why should it be tested? Software Quality, Role of Testing. Testing Process - Level 0 thinking, Level 1 thinking, Level 2 thinking, Level 3 thinking, Level 4 thinking. Software Testing Terminologies - Verification, Validation and Testing, Faults, Error and Bug, Test cases, Coverage Criteria. Types of Testing- Unit testing, integration testing, System testing, Acceptance testing, Beta testing, Functional testing, Stress testing, Performance testing, Usability testing and Regression testing. Testing Methods - Black Box testing, White Box testing, Grey Box testing.	**9**
II	Concept of Unit testing. Static Unit testing. Dynamic Unit testing - Control Flow testing, Data Flow testing, Domain testing, Functional Program testing. Mutation testing - Mutation and Mutants, Mutation operators, Mutation score. Junit - Framework for Unit testing. Case Study - Mutation testing using Junit and Muclipse.	**9**
III	Overview of Graph Coverage Criteria. Structural Graph Coverage Criteria - Node/vertex coverage, Edge coverage, Edge pair coverage, Path coverage, Complete path coverage, Prime path coverage, Complete round trip coverage, Simple round trip coverage. Data Flow	**9**

	Criteria - du paths, du pairs. Subsumption Relationships among Graph Coverage Criteria. Graph Coverage for Source Code - Control flow graphs for code, CFG: If statement, CFG: If statement with return, CFG: Switch-case, CFG: Loops, CFG: Exceptions (try-catch). Example program – Statistics. Graph Coverage for Design Elements - Call graphs and classes, Class inheritance testing: Coverage criteria, Coverage criteria on inheritance graph, Data flow at the design level, Inter-procedural DU pairs, Coupling du-pairs example. Example - Quadratic Root. Case Study - Graph Based testing using JUnit Framework.	
IV	Domain Testing / Input Space Partitioning - Partitions of a set. Input domain modelling - Interface-based approach, Functionality-based approach. Identifying values. Multiple partitions of the input domain – All Combinations Coverage (ACoC), Each Choice Coverage (ECC), Pair-wise Coverage, T-wise Coverage, Base Choice Coverage, Multiple Base Choices Coverage. TriTyp example. Functional Testing – Functional Testing Concepts of Howden. Functional testing - Important Steps. Types of Functional testing - Equivalence Class Partitioning, Boundary Value Analysis, Decision Tables, Random Testing. Case Study - Black Box testing approaches using JUnit.	**9**
V	Introduction to Grey Box testing - Why Grey Box testing, Gray Box Methodology, Advantages and Disadvantages. Techniques of Grey Box Testing - Matrix Testing, Regression Testing, Orthogonal Array Testing or OAT, Pattern Testing. An Introduction to PEX - Parameterized Unit Testing, The Testing Problem. Symbolic Execution – Example, Symbolic execution tree. PEX application Case Study – PEX.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U44F	BIOINFORMATICS	PEC	3	0	0	3	2022

i) PRE-REQUISITE: Basic knowledge of programming and statistics.

ii) COURSE OVERVIEW:

This course is designed to introduce students to the core concepts of bioinformatics, bridging the gap between biology and computer science. The course emphasizes algorithms, biological databases, sequence analysis, data visualization, and machine learning applications in the context of modern biology and healthcare.

iii) COURSE OUTCOMES

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

CO1	Explain the foundational concepts of bioinformatics and molecular biology	Understand
CO2	Explain sequence alignment techniques and interpret phylogenetic relationships using computational tools.	Understand
CO3	Apply genomic and proteomic data to predict gene structures and protein conformations using bioinformatics tools and databases.	Apply
CO4	Develop Python scripts and automation tools to parse, analyze, and visualize biological sequence.	Apply
CO5	Explain the applications of bioinformatics in drug discovery, systems biology, healthcare, and IoT.	Understand

iv) SYLLABUS

Introduction to Bioinformatics & Biological Databases: Scope of bioinformatics in engineering, Basics of molecular biology -, Sequence formats - FASTA, GenBank, GFF, Database searching and retrieval techniques. Sequence Alignment and Phylogenetics, Phylogenetic tree construction and interpretation. Genomics, Proteomics and Structural Bioinformatics, Tools: ORF Finder, ExPASy, SWISS-MODEL, Structural databases and visualization tools, Programming and Data Analysis in Bioinformatics, Applications and Emerging Trends

v) (a) TEXT BOOKS

1) Arthur Lesk, *Introduction to Bioinformatics*, 4th edition, OUP Oxford, 2014.
2) S. Harisha, *Fundamentals of Bioinformatics*, I.K. International Publishing House Pvt. Limited, 2013.
3) Jin Xiong, *Essential Bioinformatics*, Cambridge University Press, 2006.

(b) REFERENCES

1) Gautam B. Singh, *Fundamentals of Bioinformatics and Computational Biology: Methods and Exercises in MATLAB*, Springer Nature Switzerland, 2025.
2) Miguel Rocha, Pedro G. Ferreira, *Bioinformatics Algorithms: Design and Implementation in Python*, Elsevier Science, 2018.

3) Richard Durbin, *Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids*, Cambridge University Press, 1998.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Bioinformatics & Biological Databases:** Scope of bioinformatics in engineering**,** Basics of molecular biology - DNA, RNA, proteins**,** Biological databases - NCBI, EMBL, DDBJ, UniProt, PD, Sequence formats - FASTA, GenBank, GFF**,** Database searching and retrieval techniques.	**8**
II	**Sequence Alignment and Phylogenetics:** Sequence alignment - local vs. global**,** Pairwise alignment - Needleman-Wunsch, Smith-Waterman**.** BLAST and FASTA tools. Multiple sequence alignment - ClustalW, MUSCLE. Phylogenetic tree construction and interpretation.	**10**
III	**Genomics, Proteomics and Structural Bioinformatics:** Genome annotation and gene prediction, Protein structure levels: primary to quaternary, Protein structure prediction (homology modeling, threading, ab initio), Tools: ORF Finder, ExPASy, SWISS-MODEL, Structural databases and visualization tools.	**9**
IV	**Programming and Data Analysis in Bioinformatics:** Introduction to Python for bioinformatics, File handling - Parsing FASTA, FASTQ, Sequence manipulation and pattern matching, Regular expressions and automation using shell scripting, Data visualization using Python (matplotlib, seaborn).	**9**
V	**Applications and Emerging Trends:** Drug discovery and molecular docking basics, Systems biology and network modeling, Machine learning applications in bioinformatics, Bioinformatics in healthcare and IoT-based biosensing, Ethical issues, data privacy and regulation in bioinformatics.	**9**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U44G	COMPUTER AIDED ELECTRICAL SYSTEM DESIGN	PEC	2	1	0	3	2022

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW:

This course introduces students to the principles and practices of electrical system design using computer-aided tools. Emphasis is placed on the design and analysis of low-voltage and medium-voltage electrical distribution systems in residential, commercial, and industrial installations through the use of modern software tools.

iii) COURSE OUTCOMES

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

CO1	Explain the standards and regulations used in the design of components for medium and high voltage installations.	Understand
CO2	Develop the lighting schemes for indoor and outdoor lightings.	Apply
CO3	Design low/medium voltage domestic electrical installations and select suitable components and protective devices.	Apply
CO4	Develop the single line diagram of 11kV indoor and outdoor transformer substations with light and power loads in an industry	Apply
CO5	Design the earthing system for a 11kV substation.	Apply
CO6	Make use of various software tools for design of electrical systems.	Apply

iv) SYLLABUS

General awareness of IS Codes, The Electricity Act 2003- National Electric Code– Scope. Graphical symbols -Introduction to Computer aided design tools - MS Excel - formulas, functions

Lighting design calculations - Design of illumination systems - Average lumen method- Design of lighting systems for a medium area seminar hall using LED luminaires

Exterior lighting design- selection of luminaires - Familiarization of DIALux

Design of electrical installation in domestic buildings–connected load calculation, sub circuit determination - Pre-commissioning tests of domestic installations. MS-Excel for load calculation and equipment selection for domestic buildings.

Design of distribution systems with light power and motor loads for small and medium industries. Design of MSB & SSB including Motor Control Centre (MCC) for motor controls - Design of indoor and outdoor 11kV substations up to 500kVA - MS-Excel for Motor load calculation and component selection.

Short circuit calculations: Short circuit calculations and earthing design for the HV and LV sides of a 11kV substation - Application of AI for Electrical design.

v) (a) TEXT BOOKS

1) S. K. Bhattacharya, K. B. Raina, *Electrical Design Estimating and Costing*, New Age International Publishers 2nd edition, 2017.
2) M. K. Giridharan, *Electrical Systems Design*, I K International Publishers, New Delhi, 2nd edition, 2016.
3) Theodore R Bosela, *Electrical Systems Design*, Prentice Hall, 1st edition, 2002.
4) J.B. Gupta, *Course in Electrical Installation Estimating & Costing*, S. K. Kataria & Sons. 9th edition, 2012.
5) Steven J. Marrano, *Electrical System Design and Specification Handbook for Industrial Facilities*, Fairmont Press, 1998.

(b) REFERENCES

1) U.A. Bakshi, V.U. Bakshi, *Electrical Technology*, Technical publications, Pune, 1st Edition, 2020.
2) S. C. Bloch, *Excel for Engineers and Scientists,* Wiley edition, 1st edition, 2000.
3) *Electrical Installation Design Guide: Calculations for Electricians and Designers*, The Institution of Engineering and Technology (IET), 5th edition, 2022.
4) IEEE Recommended Practice for Electric Power Distribution for Industrial Plants.
5) V. K. Jain & Amitabh Bajaj, *Design of Electrical Installations*, Lakshmi Publications Pvt. Ltd., 2nd edition 2012.
6) Kevin Warwick, Arthur Ekwue, Raj Aggarwal, *Artificial Intelligence Techniques in Power Systems,* IET, reprint 2008.
7) https://www.dialux.com

vi) COURSE PLAN

Module	Contents	No. of hours
I	**General awareness of IS Codes:** IS 732 - IS 3043 IS 2026- IS 3646- part 1&2 - IS 5216 part 1&2 - Electricity supply code-2014. The Electricity Act 2003- National Electric Code (NEC 2011) – Scope. Graphical symbols and signs as per NEC for electrical installations. **Introduction to Computer aided design tools** - AutoCAD Electrical, MS Excel, MATLAB/Simulink. MS Excel - formulas, functions - Cell referencing (relative, absolute, mixed) - mathematical operations in cells- LOOK UP – VLOOKUP and XLOOK UP- LOOKUP table for electrical component selection examples.	**8**
II	**Lighting design calculations** - Definitions of luminous flux, Lumen, Luminous intensity/illuminance (Lux), Illumination calculations, factors affecting Coefficients of Utilisation (CoU) - and Light Loss Factor (LLF). Design of illumination systems - Average lumen method - Space to mounting height ratio - Design of lighting systems for a medium area seminar hall using LED luminaires.	**9**

	Exterior lighting design- point to point method - road lighting design - selection of luminaires. Familiarization of DIALux for interior lighting design- simple indoor lighting design using DIALux.	
III	**Design of electrical installation in domestic buildings:** General aspects of the design of electrical installations for domestic dwellings (low and medium voltage installations)–connected load calculation, sub circuit determination, selection of main distribution board, sub distribution board, MCB, ELCB, MCCB and cables for sub circuits. Pre-commissioning tests of domestic installations. MS-Excel for load calculation and equipment selection for domestic buildings.	**10**
IV	**Design of Industrial Installations:** Design of distribution systems with light power and motor loads for small and medium industries. Design of MSB & SSB including Motor Control Centre (MCC) for motor controls - Selection of transformer substations, switchgears and protective devices. **Substations:** Classification –components of indoor and outdoor substations- single line diagram - Design of indoor and outdoor 11kV substations up to 500kVA. MS-Excel for Motor load calculation and component selection.	**10**
V	**Short circuit calculations:** Short circuit calculations and earthing design for the HV and LV sides of a 11kV substation. Touch, Step and Transfer potentials at EHT Sub-Stations, Earth-mat. **Application of AI for Electrical design** - Fault detection in transformers, motors, and cables using AI- Load forecasting using AI (concepts only).	**8**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2U44H	POWER QUALITY	PEC	3	0	0	3	2022

i) PRE-REQUISITE: Nil

ii) COURSE OVERVIEW: This course offers an introduction to the key concepts of power quality in electrical systems. This course covers different power quality issues and its mitigation methods. It also gives insights about techniques and technologies used for monitoring and mitigating these problems.

iii) COURSE OUTCOMES

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

CO1	Classify the sources and effects of power quality problems.	Understand
CO2	Apply Fourier Transform concepts for harmonic analysis.	Apply
CO3	Explain the important aspects of power quality monitoring.	Understand
CO4	Illustrate power quality mitigation techniques.	Understand
CO5	Explain power quality issues in grid connected renewable energy systems and the need for grounding and wiring.	Understand

iv) SYLLABUS

Power quality phenomenon, Sources and effects of power quality problems, classification and origin of power quality disturbances. Harmonics mechanism of harmonic generation, Harmonic sources, Harmonic analysis using Fourier series and Fourier transforms. Harmonic indices, Power quality Monitoring Mitigation of Power quality problems, passive filters, active filters, hybrid filters, DVR, DSTATCOM and UPQC. Power factor correction, Single phase active power factor converter, Power Quality issues of Grid connected Renewable Energy Systems, Grounding and wiring.

v) (a) TEXT BOOKS

1) R. C. Dugan, M. F. Me Granaghen, H. W. Beaty, *Electrical Power System Quality*, McGraw-Hill, 2012.
2) C. Sankaran, *Power Quality*, CRC Press, 2002.
3) G. T. Heydt, *Power Quality*, Stars in circle publication, Indiana, 1991.
4) Jose Arillaga, Neville R. Watson, *Power System Harmonics*, Wiley, 1997.
5) Math H. Bollen, '*Understanding Power Quality Problems*' Wiley-IEEE Press, 1999.
6) Bhim Singh, Ambrish Chandra and Kamal Al-Haddad, *Power Quality problems and Mitigation Techniques*, John Wiley and Sons Ltd, 2015.

(b) REFERENCES

1) Surajit Chattopadhyay, '*Electric power quality'* – Springer, 2011.

2) Angelo Baggini (Ed.) *Handbook of Power Quality*, Wiley, 2008.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Power quality** - Sources and effects of power quality problems, Need for concern of Power quality, types of power quality disturbances – Transients – classification and origin, Short duration voltage variation – interruption, sag, swell, Long duration voltage variation, voltage unbalance, waveform distortion - notching, harmonics and voltage flicker.	**9**
II	**Harmonics** - mechanism of harmonic generation, Triplen harmonics, Harmonic sources – switching devices, arcing devices and saturable devices, Effects of harmonics on power system equipment and loads – transformers, capacitor banks, motors and telecommunication systems, Effect of triplen harmonics on neutral current, line and phase voltages. **Harmonic analysis**: using Fourier series and Fourier transforms – simple numerical problems.	**10**
III	**Harmonic indices**: CF, DF, THD, TDD, TIF, DIN, C – message weights, Displacement and total power factor. **Standards**: Overview of power quality standards: IEEE 519, IEEE 1433 and IEC 61000. **Power quality Monitoring**: Objectives and measurement issues, different monitoring instruments – Power quality analyzer, harmonic spectrum analyzer, flicker meters.	**9**
IV	**Mitigation of Power quality problems** - Harmonic elimination - Design simple problems and analysis of passive filters to reduce harmonic distortion – demerits of passive filters –description of active filters - shunt, series, hybrid filters, sag and swell correction using DVR. **Power quality conditioners** - DSTATCOM and UPQC - Configuration and working.	**9**
V	**Power factor correction** – Single phase active power factor converter – circuit schematic and control block diagram. Power Quality issues of Grid connected Renewable Energy Systems – operating conflicts. **Grounding and wiring**– reasons for grounding – wiring and grounding problems - solutions to these problems.	**8**
	Total hours	**45**

vii) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	10 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**50 marks**

viii) MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

MINORS/HONOURS

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL0M49A/ EL0M49B	MINI PROJECT	VAC	0	1	6	4	2022

i) PREAMBLE:

A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The objective of Project Work is to enable the student to take up investigative study in the broad field of Electrical and Electronics Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on a group of three/four students, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. Each project assignment should typically include the following components:

- Survey and study of relevant published literature on the assigned topic
- Preparation of an action plan for conducting the investigation, including team roles and responsibilities
- Development of a preliminary approach to the problem related to the assigned topic
- Documentation of block-level design
- Conducting preliminary analysis, modeling, simulation, experimentation, design, or feasibility study
- Preparation of a written report on the study conducted, for presentation to the department

ii) COURSE OUTCOMES

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

CO1	Identify engineering problems and formulate appropriate solutions.	Apply
CO2	Plan project activities and coordinate effectively within a team to meet deadlines.	Apply
CO3	Evaluate proposed solutions through theoretical analysis and experimental validation.	Evaluate
CO4	Develop technical reports and demonstrate effective communication skills.	Create
CO5	Present technical content clearly and justify ideas with logical reasoning.	Evaluate

iii) COURSE PLAN

In this course, each group consisting of three/four members is expected to design and develop a moderately complex software/hardware system with practical applications. This should be a working model. The basic concept of product design may be taken into consideration. Students should identify a topic of interest in consultation with Faculty-in-charge of mini project /Advisor. Review the literature and gather information pertaining to the chosen topic. State the objectives and develop a methodology to achieve the objectives.

Carryout the design/fabrication or develop codes/programs to achieve the objectives. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on a minimum of two reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The product has to be demonstrated for its full design specifications. Innovative design concepts, reliability considerations, aesthetics/ergonomic aspects taken care of in the project shall be given due weight.

iv) CONTINUOUS ASSESSMENT EVALUATION PATTERN

The End Semester Evaluation (ESE) will be conducted as an internal evaluation based on the product, the report and a viva- voce examination, conducted by a 3-member committee appointed by Head of the Department comprising HoD or a senior faculty member, academic coordinator for that program and project guide/coordinator. The Committee will be evaluating the level of completion and demonstration of functionality/specifications, presentation, oral examination, working knowledge and involvement.

The Continuous Internal Evaluation (CIE) is conducted by evaluating the progress of the mini project through minimum of TWO reviews. At the time of the 1st review, students are supposed to propose a new system/design/idea, after completing a thorough literature study of the existing systems under their chosen area. In the 2nd review students are expected to highlight the implementation details of the proposed solution. The review committee should assess the extent to which the implementation reflects the proposed design. A well coded, assembled and completely functional product is the expected output at this stage. The final CIE mark is the average of 1st and 2nd review marks.

A zeroth review may be conducted before the beginning of the project to give a chance for the students to present their area of interest or problem domain or conduct open brain storming sessions for innovative ideas. Zeroth review will not be a part of the CIE evaluation process.

v) CONTINUOUS INTERNAL EVALUATION (CIE) PATTERN

Attendance	:	10 marks
Marks awarded by Guide	:	15 marks
Project Report	:	10 marks
Evaluation by the Committee	:	40 marks
Total	:	**75 marks**

vi) END SEMESTER EXAMINATION (ESE) PATTERN

Level of completion	:	10 marks
Demonstration of functionality	:	25 marks
Project Report	:	10 marks
Viva-voce	:	20 marks
Presentation	:	10 marks
Total	:	**75 marks**

vii) MARK DISTRIBUTION

Total Marks	CIE	ESE
150	75	75

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EL2H49A	MINI PROJECT	VAC	0	1	6	4	2022

i) PREAMBLE:

A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The objective of Project Work is to enable the student to take up investigative study in the broad field of Electrical and Electronics Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on a group of three/four students, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. Each project assignment should typically include the following components:

- Survey and study of relevant published literature on the assigned topic
- Preparation of an action plan for conducting the investigation, including team roles and responsibilities
- Development of a preliminary approach to the problem related to the assigned topic
- Documentation of block-level design
- Conducting preliminary analysis, modeling, simulation, experimentation, design, or feasibility study
- Preparation of a written report on the study conducted, for presentation to the department

ii) COURSE OUTCOMES

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

CO1	Identify engineering problems and formulate appropriate solutions.	Apply
CO2	Plan project activities and coordinate effectively within a team to meet deadlines.	Apply
CO3	Evaluate proposed solutions through theoretical analysis and experimental validation.	Evaluate
CO4	Develop technical reports and demonstrate effective communication skills.	Create
CO5	Present technical content clearly and justify ideas with logical reasoning.	Evaluate

iii) COURSE PLAN

In this course, each group consisting of three/four members is expected to design and develop a moderately complex software/hardware system with practical applications. This should be a working model. The basic concept of product design may be taken into consideration. Students should identify a topic of interest in consultation with Faculty-in-charge of mini project /Advisor. Review the literature and gather information pertaining to the chosen topic. State the objectives and develop a methodology to achieve the objectives. Carryout the design/fabrication or develop codes/programs to achieve the objectives. Demonstrate the novelty of the project through the results and outputs. The progress of the

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Project Report	:	10 marks
Evaluation by the Committee	:	40 marks
Total	:	**75 marks**

vi) END SEMESTER EXAMINATION (ESE) PATTERN

Level of completion	:	10 marks
Demonstration of functionality	:	25 marks
Project Report	:	10 marks
Viva-voce	:	20 marks
Presentation	:	10 marks
Total	:	**75 marks**

vii) MARK DISTRIBUTION

Total Marks	CIE	ESE
150	75	75