AC –

Item No. –

As Per NEP 2020

University of Mumbai

Syllabus for Major Vertical – 1, 4 & 5		
Name of the Programme – B.E. (Electrical Engineering)		
Faculty of Engineering		
Board of Studies in Electrical Engineering		
U.G. Third Year Programme	Exit Degree	B.Sc. Tech Engineering- Electrical Engineering
Semester		V & VI
From the Academic Year		2026-27

University of Mumbai

(As per NEP 2020)

Sr. No.	Heading	Particulars
1	**Title of program** **O:____________________**	**B.E. (Electrical Engineering)**
2	**Exit Degree**	**B.Sc. Tech Engineering -Electrical Engineering**
3	**Scheme of Examination** **R: ____________**	NEP 40% Internal 60% External, Semester End Examination Individual Passing in Internal and External Examination
4	**Standards of Passing** **R: ______________**	**40%**
5	**Credit Structure** **R: ______________**	**Attached herewith**
6	**Semesters**	**Sem. V & VI**
7	**Program Academic Level**	**5.5**
8	**Pattern**	**Semester**
9	**Status**	**New**
10	**To be implemented from Academic Year**	**2026-27**

Sd/-
Dr. B. R. Patil
BoS-Chairman-Electrical Engineering
Faculty of Technology

Sd/-
Dr. Deven Shah
Associate Dean
Faculty of Science & Technology

Sd/-
Prof. Shivram S. Garje
Dean
Faculty of Science & Technology

Preamble

To meet the challenge of ensuring excellence and NEP 2020 policy in engineering education, the issue of quality needs to be addressed, debated, and taken forward systematically. Accreditation is the principal means of quality assurance in higher education. The major emphasis of the accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Science and Technology in Electrical Engineering of the University of Mumbai has taken the lead in incorporating the philosophy of NEP 2020 education in the process of curriculum development.

The third-year engineering course consists of a core and elective training program to impart scientific and logical thinking training to learners in general, with a choice of course selection from the program core course, program elective course, multidisciplinary minor, IKS, PCE and vocational skill-enhanced course. Simultaneously, the objectives of NEP 2020 demand nurturing the core program, elective program, communication skills and skills required for the Electrical Engineering Branch of engineering in the learner. Keeping this in view, a pool of courses is offered in Core Courses covering fundamentals required to understand core and modern engineering practices and emerging trends. Elective courses are offered to the learners to understand the concepts of emerging technology. This will help with the holistic development of learners through interdisciplinary skills development and mobility among other departments as real-time solutions. Considering the shift in pedagogy and the convenience of a stress-free learning process, a choice-based subject pool is offered in the coursework under the heads of Electrical Engineering for open electives and multidisciplinary minor courses in sem V and VI. Essentially, to give a glimpse of trends in the industry under vocational and enhanced skill practices, the pool is offered to nurture and develop creative skills in contemporary industrial practices. Criteria met in the structure is the opportunity for learners to choose the course of their interest in all disciplines.

Program Core Course and Program Elective Courses Cover Electrical Engineering core and elective courses. Also, MDM is where a pool of subjects is given for selection. In addition to this learner will have IKS and PCE courses. Considering the present scenario, diverse choices need to be made available to fulfil the expectation of a learner to aspire for a career in the field of current trends of Technology and interdisciplinary research. The IKS course will be program-specific, which can be achieved in Undergraduate training by giving an objective viewpoint to the learning technology, from ancient time and how it was learned and the process and transitioning a learner from a rote learner to a creative professional. For this purpose, PCE is introduced in the First Semester to orient a communication skill to become skilled professionals for placement and higher education entrance exams. Considering the NEP-2020 structure of award of Certificate after U.G. First Year, U. G. Diploma after the Second Year and B.Sc. Tech Engineering after the Third Year at multiple exit-point pools of Vocational skills, is arranged to give exposure to the current Industry practices.

The faculty resolved that course objectives and course outcomes are to be clearly defined for every core and elective course so that all faculty members in affiliated higher education institutes understand the depth and approach of the course to be taught to the learners, which will enhance the learners' learning process. NEP 2020 grading system enables a much-needed shift in focus from teacher-centric to continuous-based learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on the holistic development of the learners through mobility and continuous evaluation, which will enhance the quality of education. Credit assignment for courses is based on a 15-week teaching-learning process for NEP 2020; however, the content of courses is to be taught in 12-13 weeks, and the remaining 2-3 weeks are to be utilized for revision, self learning, tutorial, guest lectures, coverage of content beyond the syllabus, etc.

There was a concern that in the present system, the third-year syllabus must not be heavily loaded for the learner and it is of utmost importance that the learner entering into the third year of an engineering course should feel at ease by lowering the burden of syllabus and credits. This is necessary for a learner to get accustomed to the new environment of a college and to create a bond between the teacher and the learner. The present curriculum will be implemented for the Third Year of Engineering from the academic year 2026-27. Subsequently, this system will be carried forward for Final Year Engineering in the academic years 2027-28, respectively.

Sd/-	Sd/-	Sd/-
Dr. B. R. Patil	**Dr. Deven Shah**	**Prof. Shivram S. Garje**
BoS-Chairman- Electrical Engineering	**Associate Dean**	**Dean**
Faculty of Technology	**Faculty of Science & Technology**	**Faculty of Science & Technology**

B.Sc. Tech Engineering (Electrical Engineering)

Credit Structure (Sem. V & VI)

	R: ________________C									
Level	**Semester**	**Major**		**Minor**	**OE**	**VSC, SEC (VSEC)**	**AEC, VEC, IKS**	**OJT, FP, CEP, CC,RP**	**Cum. Cr. / Sem.**	**Degree/ Cum. Cr.**
		Mandatory	**Electives**							
5.5	V	PCC501:3 PCC502:3 PCC503:3 PCL501: 1 PCL502:1 PCL503:1	PEC501:3 PEL501:1	MDC:3 MDL:1	OE:2	--	IKS: 2	--	24	**B.Sc. Tech Engineering (Electrical Engineering) 48**
	R:_________________D									
	VI	PCC601:3 PCC602:3 PCL601:1 PCL602:1	PEC601:3 PEC602:3 PEL601:1 PEL602:1	MDC: 3 MDL:1	--	VSEC:2	AEC: 2	--	24	
	Cum Cr.	20	12	8	2	2	*2+2*	--	48	

Exit option: Award of BSc. Tech Engineering with 138 credits and additional 4 credits core **one** theory subject with 3 credits and **one** lab with 1 credit from one final year from where they want to take Exit degree. Along with theory and practical course student must compulsory do internship for **one month or 160 hours** which internship is equal to 4 credits.

[Abbreviation - OE – Open Electives, VSC – Vocation Skill Course, SEC – Skill Enhancement Course, (VSEC), AEC – Ability Enhancement Course, VEC – Value Education Course, IKS – Indian Knowledge System, OJT – on Job Training, FP – Field Project, CEP – Continuing Education Program, CC – Co-Curricular, RP – Research Project]

Sem. – V & VI

Program Structure for T.E. Electrical Engineering

Program Structure for Third Year of Electrical Engineering

UNIVERSITY OF MUMBAI (With Effect from 2026-2027)

SEMESTER V

Course Code	Course Description	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Practical	Tutorial	Theory	Tutorial	Practical	Total Credits
2225111	Control System	3	--	--	3	--	–	3
2225112	Power System -I	3	–	--	3	–	–	3
2225113	Renewable Energy & Energy Storage	3	--	--	3	–	–	3
222511X	Program Elective Course-I (PEC-I)	3	--	--	3	–	–	3
MDC501	Multidisciplinary Minor (MDM)	3	--	--	3	–	–	3
2225117	Control System Lab	--	2	–	–	–	1	1
2225118	Power System -I Lab	--	2	–	–	–	1	1
2225119	Renewable Energy & Energy Storage Lab	--	2	–	–	–	1	1
222512X	Program Elective Lab-I (PEL-I)	--	2	–	–	–	1	1
MDL501	Multidisciplinary Minor (MDM) Lab	--	2@	–	–	–	1	1
OEC501	To be taken from the bucket provided by the University from another Faculty	2#	--	---	2	–	–	2
IKS501	IKS as per Groups	--	2*+2	--	–	–	2	2
Total		**17**	**14**	**00**	**17**	**00**	**07**	**24**

* Two hours of practical class to be conducted for full class as demo/discussion.

Theory / Tutorial 1 credit for 1 hour and Practical 1 credit for 2 hours

Institute shall offer a course for Open Elective from Science/Commerce/Management stream bucket provided by the University of Mumbai.

@ Institute shall offer a course for MDM from other Engineering Boards Group.

	222511X		222512X	
	Program Elective Course-I (PEC-I)		**Program Elective Lab-I (PEL-I)**	
Program Elective -I	Course Code	Course Description	Lab Code	Lab Description
	2225114	Utilization of Electrical Energy	2225120	Utilization of Electrical Energy Lab
	2225115	Advanced Power Electronic Converters	2225121	Advanced Power Electronic Converters Lab
	2225116	Power Plant Technology	2225122	Power Plant Technology Lab

Program Structure for Third Year of Electrical Engineering

UNIVERSITY OF MUMBAI (With Effect from 2026-2027)

SEMESTER V

Course Code	Course Description	Examination Scheme							
		Internal Assessment Test (IAT)			End Sem. Exam Marks	End Sem. Exam Duration (Hrs)	Term Work (Tw) Marks	Oral & Pract. Marks	Total Marks
		IAT-I	IAT-II	Total (IAT-I) + IAT-II)					
2225111	Control System	20	20	40	60	2	--	--	100
2225112	Power System -I	20	20	40	60	2	--	--	100
2225113	Renewable Energy & Energy Storage	20	20	40	60	2	--	--	100
222511X	Program Elective Course-I (PEC-I)	20	20	40	60	2	--	--	100
MDC501	Multidisciplinary Minor (MDM)	20	20	40	60	2	--	--	100
2225117	Control System Lab	--	--	--	--	--	25	25	50
2225118	Power System -I Lab	--	--	--	--	--	25	25	50
2225119	Renewable Energy & Energy Storage Lab	--	--	--	--	--	25	25	50
222512X	Program Elective Lab-I (PEL-I)	--	--	--	--	--	25	--	25
MDL501	Multidisciplinary Minor (MDM) Lab	--	--	--	--	--	25	25	50
OEC501	To be taken from the bucket provided by the University from another Faculty	--	--	--	--	--	50	--	50
IKS501	IKS as per Groups						50	--	50
Total Marks				**200**	**300**		**225**	**100**	**825**

Program Structure for Third Year of Electrical Engineering

UNIVERSITY OF MUMBAI (With Effect from 2026-2027)

SEMESTER VI

Course Code	Course Description	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Practical	Tutorial	Theory	Tutorial	Practical	Total Credits
2226111	Electrical Machines -II	3	--	--	3	--	--	3
2226112	Power System Protection and Switchgear	3	--	--	3	--	--	3
222611X	Program Elective Course-II (PEC-II)	3	--	--	3	--	--	3
222611X	Program Elective Course-III (PEC-III)	3	--	--	3	--	--	3
MDC601	Multidisciplinary Minor (MDM)	3	--	--	3	--	--	3
2226411	Industrial Automation	--	4	--	–	--	2	2
2226511	Professional Skill	--	2*+2	--	–	--	2	2
2226119	Electrical Machines -II Lab	--	2	--	--	--	1	1
2226120	Power System Protection and Switchgear Lab	--	2	--	--	--	1	1
222612X	Program Elective Lab-II (PEL-II)	--	2	--	--	--	1	1
222612X	Program Elective Lab-III (PEL-III)	--	2	--	--	--	1	1
MDL601	Multidisciplinary Minor (MDM) Lab	--	2@	--	--	--	1	1
Total		**15**	**18**	**00**	**15**	**00**	**09**	**24**

* Two hours of practical class to be conducted for full class as demo/discussion.

Theory / Tutorial 1 credit for 1 hour and Practical 1 credit for 2 hours

@ Institute shall offer a course for MDM from other Engineering Boards.

Program Elective -II	**222611X**		**222612X**	
	Program Elective Course-II (PEC-II)		**Program Elective Lab-II (PEL-II)**	
	Course Code	Course Description	Lab Code	Lab Description
	2226113	Microgrid & Smart Grid	2226121	Microgrid & Smart Grid Lab
	2226114	Electric Vehicle Technology	2226122	Electric Vehicle Technology Lab
	2226115	Solar Energy Technology	2226123	Solar Energy Technology Lab

Program Elective -III	**222611X**		**222612X**	
	Program Elective Course-III (PEC-III)		**Program Elective Lab-III (PEL-III)**	
	Course Code	Course Description	Lab Code	Lab Description
	2226116	Lighting System Design	2226124	Lighting System Design Lab
	2226117	Special Electrical Machines	2226125	Special Electrical Machines Lab
	2226118	Wind Energy Technology	2226126	Wind Energy Technology Lab

Program Structure for Third Year of Electrical Engineering

UNIVERSITY OF MUMBAI (With Effect from 2026-2027)

SEMESTER VI

Course Code	Course Description	Examination scheme							
		Internal Assessment Test (IAT)			End Sem. Exam Marks	End Sem. Exam Duration (Hrs)	Term Work (Tw) Marks	Oral & Pract. Marks	Total Marks
		IAT-I	IAT-II	Total (IAT-I) + IAT-II)					
2226111	Electrical Machines -II	20	20	40	60	2	--	--	100
2226112	Power System Protection and Switchgear	20	20	40	60	2	--	--	100
222611X	Program Elective Course-II (PEC-II)	20	20	40	60	2	--	--	100
222611X	Program Elective Course-IIII (PEC-IIII)	20	20	40	60	2	--	--	100
MDC601	Multidisciplinary Minor (MDM)	20	20	40	60	2	--	--	100
2226411	Industrial Automation	--	--	--	--	--	50	--	50
2226511	Professional Skill	--	--	--	--	--	25	--	25
2226119	Electrical Machines -II Lab	--	--	--	--	--	25	25	50
2226120	Power System Protection and Switchgear Lab	--	--	--	--	--	25	25	50
222612X	Program Elective Lab-II (PEL-II)	--	--	--	--	--	25	25	50
222612X	Program Elective Lab-III (PEL-III)	--	--	--	--	--	25	25	50
MDL601	Multidisciplinary Minor (MDM) Lab	--	--	--	--	--	25	25	50
Total Marks				**200**	**300**		**200**	**125**	**825**

Vertical-1
Major

Sem. – V

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2225111	Control System	3	--	-	3	-	-	3

Course Code	Course Name	Examination Scheme					
		Theory Marks				Exam. Duration (in Hrs.)	Total Marks
		Internal Assessment Test (IAT)			End Sem. Exam.		
		IAT-I	IAT-II	IAT-I + IAT-II (Total)			
2225111	Control System	20	20	40	60	2	100

Course Objectives: The course is aimed to

1. Model of electrical, mechanical, electromechnical.
2. Analyse and design system parameters to meet transient and steady state error, performance specifications.
3. Learn time response analysis and demonstrate their knowledge to frequency response.
4. Learn stability analysis of system using Root locus, bode plot, polar plot, and Nyquist plot.

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

CO1. Explain and derive transfer function of various system.
CO2. Apply the block diagram reduction technique and SFG.
CO3. Describe stability, transient and steady state performance of second order system.
CO4. Draw the root locus and derive stability from root locus.
CO5. Draw Bode plot and Polar plot and define stability through bode, polar and Nyquist criteria
CO6. Derive various state space representation of control system

Detailed Syllabus:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Introduction to Control System	Elements of control systems, concept of open loop and closed loop systems, Examples and application of open loop and closed loop systems. Concept of feedback and Automatic control, Effects of feedback, Transfer function of electrical, mechanical (translational and rotational) System. Force Voltage and Force Current analogies.	6	CO1
II	Mathematical Model of Physical System	Block diagram reduction technique and signal flow graph, Mason’s rule, Signal flow graph of electrical network. Conversion of BDR to SFG and vice versa.	4	CO2

		Self-Learning topic: Transfer function model of AC & DC servomotor, potentiometer & tacho-generator		
III	Time Domain Analysis	Time Domain Analysis: Time domain analysis of a standard second order closed loop system. Concept of un-damped natural frequency, damping, overshoot, rise time and settling time. Dependence of time domain performance parameters on natural frequency and damping ratio. Step response of first and second order systems. Effects of Pole and Zeros on transient response. Stability by pole location. Routh-Hurwitz criteria and applications. Error Analysis: Steady state errors in control systems due to step, ramp and parabolic inputs. Concepts of system types and error constants	8	CO3
		Self-Learning topics: Step Response of first order system, impulse response of first and second order system		
IV	Root locus Techniques	Definition and properties of root locus, rules for plotting root locus, stability analysis using root locus.	6	CO4
V	Frequency Domain Analysis	Polar plots, bode plot, gain margin and phase margin, stability through bode and polar plot, relation between time response and frequency response, Nyquist stability criterion.	9	CO5
VI	State Variable Analysis	Introduction to state variable, General state space representation, State space representation of Electrical systems. Conversion between state space and transfer function. Alternative representations in state space: (Phase variable, canonical, parallel & cascade). Similarity transformations, Laplace Transform solution of state equation, stability in state space	6	CO6

Text Books:

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

Reference Books:

1. Linear Control system Analysis and design with MATLAB, by J.J. Azzo, C. H. Houpis S.N. Sheldon, Marcel Dekkar
2. Feedback control of Dynamic System, G.F. Franklin, Pearson higher education,
3. Control System Engineering, Shivanagraju s. Devi L., New Age International

4. Control Systems Technology, Curtis Johnson, Heidar Malki, Pearson
5. Control Systems Engineering, S. K. Bhattacharya, Pearson.
6. Control Systems, Theory and applications, Smarajit Ghosh, Pearson

Online References:

Sr. No.	Website Name
1.	NPTEL Course: Control Engineering by Prof. Ramkrishna Pasumarthy, Department of Electrical Engineering, IIT Madras: -Web link- https://nptel.ac.in/courses/108/106/108106098/
2.	NPTEL Course: Control Systems by Prof. C.S. Shankar Ram, Department of Design Engineering, IIT Madras: - Web link- https://nptel.ac.in/courses/107/106/107106081/
3.	NPTEL Course: Control Engineering by Prof. S.D. Agashe, Department of Electrical Engineering, IIT Bombay: -Web link- https://nptel.ac.in/courses/108/101/108101037/

Internal Assessment (IA):

- IA will consist of Two Compulsory Internal Assessment Tests (Each Test of 20 Marks). Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

End Semester Theory Examination Question Paper Format:

- Question Paper will comprise of a total of six questions each carrying 15 marks. Q.1 will be compulsory and should cover maximum contents of the syllabus.
- Remaining questions will be mixed in nature [part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules].
- A total of four questions needs to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2225112	Power System -I	3	--	-	3	-	-	3

Course Code	Course Name	Examination Scheme					
		Theory Marks				Exam. Duration (in Hrs.)	Total Marks
		Internal Assessment Test (IAT)			End Sem. Exam.		
		IAT-I	IAT-II	IAT-I + IAT-II (Total)			
2225112	Power System-I	20	20	40	60	2	100

Prerequisite:

1. PCC2017: Elements of Electrical Systems
2. 2223111: Engineering Mathematics for Electrical Circuits

Course Objectives: The course is aimed to

1. Provide fundamental understanding of the structure and operation of electric power systems, including generation, transmission and distribution.
2. Develop knowledge of overhead and underground transmission components, their constructional features and performance.
3. Enable students to analyse transmission line parameters such as inductance and capacitance using analytical methods.
4. Introduce per-unit system and equivalent circuit representation of power system components for simplified analysis.
5. Familiarize students with distribution networks, their components and operational characteristics.
6. Provide basic understanding of power system substations, including equipment, protection and earthing practices.

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

CO1. Describe and analyze the components of overhead and underground transmission systems, including sag and insulator performance.
CO2. Calculate transmission line inductance and capacitance for single-phase and three-phase systems.
CO3. Apply the per-unit system and develop equivalent circuit representations of power system components.
CO4. Explain the structure of electrical distribution networks and identify standard distribution voltage levels in India.
CO5. Explain the components of AC/DC distribution system
CO6. Describe different types of substations and explain the function of substation equipment, protection and earthing systems.

Detailed Syllabus:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Components of Overhead Transmission and Underground Transmission	Main component of overhead lines, line supports, span, conductor configuration, sag in overhead lines, calculation of sag for equal and unequal supports, effect of ice and wind loading. Insulators, type of insulators, potential distribution across insulator string, string efficiency, methods for improving string efficiency. (Numerical included) Underground Cables, types of cables, insulation resistance, voltage stress, grading of cables, capacitance of single core and 3-core cables.	07	CO1
II	Transmission Line Parameters	Definition of inductance, Internal and external flux linkage of single conductor, inductance of single phase two wire line, composite and bundled conductor, inductance of three phase line with symmetrical and unsymmetrical spacing, concept of GMR and GMD, necessity of transposition, inductance of three phase double circuit line with symmetrical and unsymmetrical spacing, inductance of bundle conductor. (Numerical included) Capacitance of transmission line, capacitance of single-phase line, capacitance of three phase line with symmetrical and unsymmetrical spacing, effect of earth on transmission line capacitance. (Numerical included)	08	CO2
III	Per-Unit and Equivalent Circuit Representation of Power System Components	Introduction, single phase solution of balanced three phase networks, one-line diagram and impedance or reactance diagram. Per Unit (PU) system, advantage of PU system. PU impedance diagram, representation of load. (Numerical included)	07	CO3
IV	Distribution Networks in Power Systems	Structure of power system – role of distribution system, classification of distribution systems, primary and secondary distribution, AC and DC distribution systems, standard distribution voltage levels in India.	07	CO4
V	Components of Distribution Systems	Feeders, distributors and service mains, distribution transformers, conductors and cables, poles and insulators, switchgear used in distribution systems.	04	CO5

VI	Power System Substations: Equipment, Protection and Earthing	Classification of substations based on voltage level and service requirement, indoor and outdoor substations, bus-bar arrangements (single bus, double bus, ring bus). Power transformers, circuit breakers, isolators, instrument transformers (CTs and PTs), lightning arresters. Basic principles of substation protection, earthing methods, necessity of grounding, overview of substation safety practices.	06	CO6

Text Books:

1. Power Plant Engineering, III Ed., Fredrick T Morse, East-West Press Pvt Ltd, 1974.
2. Power Plant Engineering, II Ed.,Mahesh Verma, Metrolitan Book Co Pvt Ltd, 1969
3. A Text Book of Power System engineering, I Ed.,RK Rajput, Laxmi Publication,2006.
4. Power System Engineering, 3 Edition, D. P. Kothari, I. J. Nagrath, Mc Graw Hill,2019.
5. Power System Analysis And Design, I Ed.,B.R. Gupta, S.Chand, 1998.
6. A Course in Power System, 11 Ed., J B. Gupta, S. K. Kataria & Sons,2013.
7. Principles of Power System, I Ed., Mehta V.K., S Chand, 1982.

Reference Books:

1. Elements of Power System Analysis, 4 Edition, W. D. Stevenson, TMH Publication,1955.
2. Electrical Power Systems, Sixth Edition,Wadhwa C. L., New Age International,2012.

Online References:

Sr. No.	Website Name
1.	NPTEL course on Power System Engineering: Prof. Debapriya Das,IIT Kharagpur . https://onlinecourses.nptel.ac.in/noc22_ee17/preview
2.	**Power System Protection and Switchgear** *Prof. Bhaveshkumar R. Bhalja, IIT Roorkee* https://onlinecourses.nptel.ac.in/noc24_ee89/preview

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- Remaining questions will be mixed in nature [part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules].
- A total of four questions needs to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2225113	Renewable Energy and Energy Storage	3	--	-	3	-	-	3

Course Code	Course Name	Theory Marks				Exam. Duration (in Hrs.)	Total Marks
		Internal Assessment Test (IAT)			End Sem. Exam		
		IAT-I	IAT-II	IAT-I + IAT-II (Total)			
2225113	Renewable Energy and Energy Storage	20	20	40	60	2	100

Course Objectives: The course aims to

1	Introduce the new paradigm of power generation in the form of renewable energy
2	Introduce the various means used for power processing and optimization.
3	Understand and study the various energy storage and to increase awareness of ES suitability.
4	Relate and study the significance of various energy storage technology in the context of renewable energy-based applications.

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

CO1	Recognize the need to adapt and engage in operations RE related activities for sustainable future.
CO2	Identify and analyse the process of power generation through solar thermal and solar photovoltaic technologies.
CO3	Identify and describe the various components and types of Wind Energy system Fuel cell technology, tidal, wave, and biomass systems.
CO4	Identify and describe the importance of various forms of energy storage (ES) in new power generation scenario based on renewable energy.
CO5	Identify and describe the issues related to use of fossil fuels and to recognize means of mitigation through adaptation of renewable energy (RE).
CO6	Recognize the necessity to adapt and engage in operations ES related activities for sustainable future.

Detailed Syllabus:

Sr. No	Name of Module	Detailed Contents	Hours	CO Mapping
I	Introduction	Distributed generation, Future trends in power generation and distribution. Interruptions in Energy Supply, Demand for Portable Energy, environmental and sustainability issues, Necessity of energy storage. Different types of energy storage, mechanical, chemical, electrical, electrochemical, magnetic, electromagnetic, thermal, comparison of energy storage technologies.	04	CO1
		Self-Learning Topic: Statistics of net potential and current generation status of different energy alternatives.		
II	Solar Energy	Review of solar thermal applications-solar thermal conversion devices and storage applications. Solar Photovoltaic- solar cell: characteristics, losses, model of a solar cell, emerging solar cell technologies; Solar PV modules, mismatch in module, hot spots, bypass diode; PV module: I-V and power curve, effect of variation in temperature and solar radiations. MPPT – P & O, Incremental Conductance method.	07	CO2
		Self-Learning Topic: Other sources- Tidal, Ocean Thermal Electric Conversion, geothermal, and Micro-hydro and Wave energy. Role of non-conventional sources in futuristic power system scenario.		
III	Wind Energy	Review of wind energy system and its components, types of wind turbines, characteristics; Power generation and control in wind energy systems, performance calculations of wind energy systems. Topologies of WES, WES with rectifier / inverter system, Power Converters for Doubly Fed Induction Generators (DFIG) in Wind Turbines.	07	CO3
IV	Energy Storage Technologies	Electrical Energy Storage: Energy storage in Capacitor, comparative magnitudes of energy storage. Superconducting magnetic energy storage (SMES). Mechanical Energy Storage: Potential Energy Storage, Energy Storage in	07	CO4

		Pressurized Gas, Compressed air energy storage (CAES), Flywheel, SME, pumped hydro storage system, Applications. Electrochemical Energy Storage: Battery technologies: Flow battery, Rechargeable battery, Lead-acid, Nickel-Metal hydride, Lithium Ion; Battery system model, parameters;		
		Self-Learning Topic: Emerging trends in batteries, Review of fuel cells and their principle of operation, Review of types of fuel cell and their performance comparison. Topologies of fuel cell power systems, applications		
V	Micro grids and Smart grids	Concept of microgrid, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC Microgrids; Grid connected and islanded mode, Role of energy Storage in Microgrid operations. Concept of Smart-Grid, Definitions, Need of Smart-Grid, Functions of Smart-Grid, Opportunities & Barriers of Smart Grid.	08	CO5
VI	Design and sizing of different types of energy storage	Sizing of battery energy storage for Electric Vehicle. (Simple Numericals) Design consideration for energy storage sizing for power system application (No numericals)	06	CO6
		Self-Learning Topic: Application of different energy technologies in real life		

Text Books:

1. Robert Huggins, Fundamentals, Materials and Applications Second Edition, Springer, 2016
2. Dincer I., and Rosen M. A. (2011); Thermal Energy Storage: Systems and Applications, Wiley
3. Leo J.M.J. Blomen and Michael N. Mugerwa, “Fuel Cell System”, New York, Plenum Press, 1993
4. Ahmed Faheem Zobaa, Energy storage – Technologies and Applications, Intech Publication 2013
5. Jiuchun Jiang and Caiping Zhang, Fundamentals and Applications of Lithium-Ion Batteries in Electric Drive Vehicles, Wiley, 2015
6. K.T. Chau, Energy Systems for Electric and Hybrid Vehicles, IET, UK, 2016
7. M. Broussely and G. Pistoia, Industrial Applications of Batteries from Cars to Aerospace and Energy Storage, Elsevier, 2007.

References:

1. S. Kalaiselvam and R. Parameshwaran , Thermal Energy Storage Technologies for Sustainability Systems Design, Academic Press, 2014
2. Trevor M. Letcher, Storing Energy with Special Reference to Renewable Energy Source, Elsevier, 2016

3. Frank S. Barnes and Jonah G. Levine, Large Energy Storage Systems Handbook, CRC Press, 2011
4. Chetan Singh Solanki , *Solar Photo Voltaics* , PHI Learning Pvt Ltd., New Delhi,2009
5. https://onlinecourses.nptel.ac.in/noc19_cs47/preview

Internal Assessment (IA):

- IA will consist of Two Compulsory Internal Assessment Tests (Each Test of 20 Marks). Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

End Semester Theory Examination Question Paper Format:

- Question Paper will comprise of a total of six questions each carrying 15 marks. Q.1 will be compulsory and should cover maximum contents of the syllabus.
- Remaining questions will be mixed in nature [part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules].
- A total of four questions needs to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2225114	Utilization of Electrical Energy	3	--	-	3	-	-	3

Course Code	Course Name	Examination Scheme					
		Theory Marks				Exam. Duration (in Hrs.)	Total Marks
		Internal Assessment Test (IAT)			End Sem. Exam.		
		IAT-I	IAT-II	IAT-I + IAT-II (Total)			
2225114	Utilization of Electrical Energy	20	20	40	60	2	100

Course Objectives: The course is aimed to

1. Introduce various electric drives and their applications
2. Discuss different methods of electrical heating and electric welding.
3. Discuss the concept of Power Tariff and Power factor improvement.
4. Explain various concepts of illumination schemes
5. Illustrate the fundamentals of domestic appliances.
6. Illustrate the fundamentals of Electric Traction.

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

CO1. Select suitable motors and electric drives by analyzing load characteristics, speed control methods, temperature rise, and industrial applications.

CO2. Explain and compare electric heating and welding methods and select appropriate equipment for different applications.

CO3. Explain and compare electric welding methods and select appropriate equipment for different applications.

CO4. Apply illumination laws and lighting design principles to select and design efficient lighting systems.

CO5. Explain the working of electrolytic process, anodizing and galvanizing process.

CO6. Analyze electric traction systems, speed–time curves, and motor control methods for efficient train operation.

Detailed Syllabus:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Electric Drives	Choice of motor, type of electric drives, starting and running characteristics– Speed control– Temperature rise–Applications of electric drives–Types of industrial loads–continuous– Intermittent and variable loads–Load equalization.	8	CO1

II	Electric Heating	Advantages and methods of electric heating–Resistance heating induction heating and dielectric heating. Electric ovens, their temperature range properties of resistance heating elements. Induction heating, principle of core and coreless induction furnace, electric arc heating, direct and indirect arc heating, construction, working and application of arc heating.	8	CO2
III	Electric Welding	Electric welding, Resistance and arc welding, Electric welding equipment– Comparison between AC and DC Welding. Advantage of electric welding.	6	CO3
IV	Illumination Fundamentals	Introduction, terms used in illumination–Laws of illumination, Lux meter–Sources of light, Discharge lamps, MV and SV lamps – Basic principles of light control– Types and design of lighting and flood lighting–LED lighting.	4	CO4
V	Electrolytic Processes	Need of electrolytic depositions, laws of electrolysis, process of electro deposition, cleaning, operation, deposition of metal, polishing and buffing. Principle anodizing and principle of galvanizing and their applications.	5	CO5
VI	Electric Traction	System of electric traction and track electrification–Review of existing\ electric traction systems in India–Special features of traction motor– Mechanics of train movement–Speed–time curves for different services – Trapezoidal and quadrilateral speed time curves. Motor control methods ---starting and speed control by using rheostat control, series parallel method, transition from series to parallel (numerical)	8	CO6

Text Books:

1. Art and Science of Utilization of Electrical Energy by H Partap, Dhanpat Rai & Sons, Delhi
2. Utilization of Electrical Energy by JB Gupta, Kataria Publications, Ludhiana
3. A.Text Book. of Electrical Power by Dr. SL Uppal, Khanna Publications, Delhi
4. Modern Electric Traction by H Partap, Dhanpat Rai & Sons, Delhi
5. Utilization of Electrical Energy by OS Taylor, Pitman Publications
6. Generation, Distribution and Utilization of Electrical Power by CL Wadhwa, Wiley Eastern Ltd., New Delhi

Reference Books:

1. Open Shaw, Taylor, Utilization of electrical energy., Orient Longmans, 1962.
2. H. Pratap, Art and Science of Utilization of Electrical Energy.
3. Gupta, J.B., Utilization of Elect. Energy, Katariya and sons, New Delhi.

4. Garg, G.C., Utilization of Elect. Power and Elect. Traction.
5. N V Suryanarayan, Utilization of Elect. Power including Electric Drives and Elect.Traction, New Age International.
6. Hancok N N, Electric Power Utilisation, Wheeler Pub.
7. Mehrdad,Ehsani,Yimin Gao,Sabastien.E. Gay,Ali Emadi, “Modern electric, hybrid electric and fuel cell vehicles”, CRC Press.

Internal Assessment (IA):

- IA will consist of Two Compulsory Internal Assessment Tests (Each Test of 20 Marks). Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

End Semester Theory Examination Question Paper Format:

- Question Paper will comprise of a total of six questions each carrying 15 marks. Q.1 will be compulsory and should cover maximum contents of the syllabus.
- Remaining questions will be mixed in nature [part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules].
- A total of four questions needs to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2225115	Advanced Power Electronic Converters	3	--	-	3	-	-	3

Course Code	Course Name	Examination Scheme						
		Theory Marks					Exam Duration (in Hrs.)	Total Marks
		Internal Assessment (IAT)			End Sem. Exam.			
		IAT-I	IAT-II	IAT-I + IAT-II (Total)				
2225115	Advanced Power Electronic Converters	20	20	40	60		2	100

Course Objectives: The course is aimed to impart knowledge on

1. DC-DC conversion with isolation, the underlying principles of converter operation and hence to analyze different converter circuits for power conversion.
2. Design of magnetics such as high frequency transformers and inductors.
3. Modelling of converter and design the controller for deeper understanding and detailed analysis.
4. Latest technologies and research going on in different areas related to power electronics.

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

CO1. Analyse the operation of dc to dc converters in CCM and DCM mode.
CO2. Analyze the operation of isolated dc to dc power electronic converters for energy conversion applications
CO3. Apply the basic concepts of magnetics to design high frequency transformers and Inductors for dc to dc converter topologies
CO4. Analyze resonant power electronic converter topologies for high frequency applications.
CO5. Model and design controllers for the closed loop operation of dc to dc converters.
CO6. Analyse the different topologies of multi-level converters.

Detailed Syllabus:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
	Prerequisite	**Basic Power Electronic devices and Circuits**		
I	Dc to Dc switch mode converters	Control of Dc to Dc controller. Concept of CCM and DCM mode, boundary between CCM and DCM. Buck, boost and buck-boost converter in boundary and DCM. Output voltage ripple, derivation of voltage ratio, ripple in inductor current and capacitor voltage. Numerical problems, comparison of CCM and DCM operation.	**07**	**CO1**

II	Switching Voltage Regulators	Comparison of Linear power supply (voltage regulators); and Switching voltage regulators; DC to DC convertor with electrical isolation. Flyback converter, Forward converter, Full bridge convertor working wave forms, derivation of output to input voltage, ripple in inductor current and capacitor voltage. Push-pull converter (Numerical problems).	**08**	**CO2**
III	Design of DC to DC converters	Review of magnetic concepts, area product, and design of inductor for non-isolated buck and boost DC to DC convertor, numerical on design of inductor. Design steps of high frequency transformer, design of high frequency transformer for fly back Dc to Dc convertor.	**07**	**CO3**
IV	Resonant Converters	Introduction, Need of resonant converters, Classification of resonant converters, Resonant switch converters, ZCS resonant switch convertor, ZVS resonant switch convertor, comparison of ZVS and ZCS topologies. Application of resonant converter.	**05**	**CO4**
V	Modelling and Control	State space model of buck, boost and fly back converters in CCM mode, effect of ESR of capacitor and inductor resistance on the state space models, state space averaging technique, small signal analysis, derivation of transfer function for ideal and non-ideal convertor. feedback control, voltage mode control and current mode control (block diagram approach).	**06**	**CO5**
VI	Multi-level Inverters	Need for multi-level inverters, Concept of multi-level, Topologies for multi-level: Diode Clamped, Flying capacitor and Cascaded H-bridge multilevel converters configurations; comparison of multilevel inverter topologies. Introduction to carrier based PWM technique for multi-level converters. Application of multi-level inverter.	**06**	**CO6**

Text Books:

1. M.H. Rashid, Hand book of Power Electronics", Third edition Butterworth-Heinemann, 2011.
2. N. Mohan and T. M. Undeland, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, 2007.
3. L. Umanand, Bhatt, "Design Of Magnetic Components for Switched Mode Power Converters", John Wiley& Sons
4. Simon Ang, Alejandro Oliva, "Power-Switching Converters", Taylor and Francis group
5. Bin Wu, "High Power Converters and AC drives", IEEE press, John Wiley & Sons

References:

1. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, 2009

2. R.W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science & BusinessMedia, 2007

3. Joseph Vithayathil, “Power Electronics”, Tata McGraw hill, 1995
4. P. T. Krein, Elements of Power Electronics, Oxford University Press.
5. V. Ramanarayanan, “Course Material on Switched Mode Power Conversion”, 2007
6. Simone Buso and Paolo Mattavelli “Digital Control in Power Electronics”, Morgan & Claypool Publishers.

Online References:

Sr. No.	Website Name
1.	NPTEL Course: **Advance Power Electronics And Control** By Prof. Avik Bhattacharya, Dept. of Electrical Engineering, IIT Roorkee :-Web link- https://nptel.ac.in/courses/108/107/108107128/
2	NPTEL Course: **Switched Mode Power Conversion** By Prof. L. Umanand and Prof. V. Ramanarayanan, IISC Bangalore :-Web link- https://nptel.ac.in/courses/108/108/108108036/

Internal Assessment (IA):

- IA will consist of Two Compulsory Internal Assessment Tests (Each Test of 20 Marks). Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

End Semester Theory Examination Question Paper Format:

- Question Paper will comprise of a total of six questions each carrying 15 marks. Q.1 will be compulsory and should cover maximum contents of the syllabus.
- Remaining questions will be mixed in nature [part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules].
- A total of four questions needs to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2225116	Power Plant Technology	3	-	-	3	-	-	3

Course Code	Course Name	Examination Scheme					
		Theory Marks				Exam. Duration (in Hrs.)	Total Marks
		Internal Assessment Test (IAT)			End Sem. Exam		
		IAT-I	IAT-II	IAT-I + IAT- II (Total)			
2225116	Power Plant Technology	20	20	40	60	2	100

Course Objectives: The course is aimed to

1. Introduce the economic aspects of power generation and plant selection.
2. Understand the principles, components, and operations of thermal power plants.
3. Learn hydroelectric power plant design, equipment, and operation.
4. Study nuclear power plants and safety considerations.
5. Explain gas turbine and diesel power plants.
6. Overview renewable energy generation and its role in modern power systems.

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

CO1. Analyze the economic principles and cost components involved in power generation.
CO2. Describe the working, components, and operation of thermal power plants.
CO3. Illustrate and analyze hydro power plant components, site selection, and turbine operation.
CO4. Outline the layout, functioning, and safety features of nuclear power plants.
CO5. Compare and analyze the operation and performance of gas turbine power plants.
CO6. Compare and analyze the operation and performance of diesel power plants.

Detailed Syllabus:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Economics of Power Plant	Load curve, load duration curves, load factor, capacity factor, diversity factor, plant utilization factor, fixed and operating cost, fuel cost, depreciation of plant, Economic scheduling principles & Effect of load factor on unit cost of energy.	06	CO1
II	Thermal Power Plants	Laws of thermodynamics, Rankine cycles, Layout and components of thermal power plant, selection of site, ***Fuel handling system:*** coal handling plant, pulverized coal handling. ***Combustion system:*** fluidized bed combustion. **Accessories**: feed pump, injector, economizer, air preheater, super heater, condenser, cooling tower. Different efficiencies of thermal power plant.	08	CO2

III	Hydro Power Plants	Hydrology: rainfall, runoff, hydrograph, Flow duration curve and mass curve, Principles and classification of hydroelectric plants, Types of dams, Layout and components of hydro power plant, selection of site. Pumped storage plants and mini/micro hydro system.	07	CO3
IV	Nuclear Power Plants	Basics of nuclear energy (fission & chain reactions), Nuclear fuels and moderators, Layout and components of nuclear power plants, selection of site, Types of reactors: PWR, BWR, Reactor control, shielding and safety system, fast breeder reactors, Economic & environmental issues of nuclear generation.	06	CO4
V	Gas Power Plants	Layout and components of gas power plants, Brayton cycle operation, Types of gas turbine plants,	06	C05
VI	Diesel Power Plants	Layout and components of diesel power plants, Diesel cycle operation, Applications, advantages, and limitations. Comparative analysis: gas turbine vs diesel plants	06	CO6

Text Books:

1. P. K**.** Nag, *Power Plant Engineering*, Tata McGraw-Hill
2. M. M. El-Wakil, *Power Plant Technology*, McGraw-Hill Education, 3rd Edition
3. M. V. Deshpande, *Elements of Power Station Design*, Tata McGraw-Hill

Reference Books:

1. R. K. Arora, S. Domkundwar, *Power Plant Engineering*, Dhanpat Rai & Co.
2. R. K. Rajput, *Power System Engineering*, Laxmi Publications,
3. Fredrick T. Morse, *Power Plant Engineering*, East-West Press Pvt. Ltd.
4. Mahesh Verma, *Power Plant Engineering,* Metropolitan Book Co. Pvt. Ltd.
5. Black & Veatch, *Power Plant Engineering*, CBS Publishers

Online References:

Sr. No.	**Website Name**
4.	NPTEL/ Swayam Course: Power Plant Engineering by Prof. Ravi Kumar, IIT Roorkee https://onlinecourses.nptel.ac.in/noc25_me113/preview
5.	NPTEL/ Swayam Course: Power Plant System Engineering by Prof. Niranjan Sahoo, IIT Guwahati https://onlinecourses.nptel.ac.in/noc25_me62/preview

Internal Assessment (IA):

- IA will consist of Two Compulsory Internal Assessment Tests (Each Test of 20 Marks). Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

End Semester Theory Examination Question Paper Format:

- Question Paper will comprise of a total of six questions each carrying 15 marks. Q.1 will be compulsory and should cover maximum contents of the syllabus.
- Remaining questions will be mixed in nature [part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules].
- A total of four questions needs to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2225117	Control System Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme					
		Theory Marks			Term Work	Oral Examination	Total Marks
		Internal assessment (IAT)					
		IAT-I	IAT-II	IAT-I +IAT-II (Total)			
2225117	Control System Lab	--	--	--	25	25	50

Course Objectives: The course aims to

1. Study basic concepts of control system
2. Familiarize with the modelling of dynamical systems and the characteristics of control components like AC servo motor, DC servo motor, DC position control system and synchro
3. Employ time domain analysis to predict and diagnose transient performance parameters of the system for standard input functions
4. Ascertain the required dynamic response from the system

Course Outcomes: Learners will be able to

CO1 Demonstrate Basic control system
CO2 Illustrate the functioning of various components of control system.
CO3 Analyse the response of physical system for various inputs.
CO4 Analyse and interpret stability of the system through Root Locus, Bode plot and Nyquist plots
CO5 Execute time response analysis of a second order control system using MATLAB
CO6 Describe the system in state space using Matlab

Suggested List of Experiments

Syllabus: Same as Course: 2225111 Control Systems

Suggested List of Laboratory Experiments: Minimum four from Group (A) and four from Group (B), in all minimum eight experiments need to be performed.

Group No.	List of Experiments	CO Mapping
A	• **Laboratory Experiments** 1. Study of AC Servomotor 2. Study of DC Servomotor 3. Study of potentiometer as an error detector 4. Study of Synchros as an error detector 5. Study of AC position control system 6. Study of DC position control system 7. Obtain time response of first order to step ramp and parabolic input 8. Obtain time response of second order system to step input. 9. open loop and closed loop control system 10. type of system	CO1, CO2, CO3
B	**Simulation Based Experiments** (on Simulation Platform like MATLAB/SCILAB or Python Programming tool) 1. a) Simulation of a typical second order system and determination of step response and evaluation of time domain specifications b) Evaluation of the effect of additional poles and zeroes on time response of second order system c) Evaluation of effect of pole location on stability d) Effect of loop gain of a negative feedback system on stability 2. Draw the Root loci for a given transfer function and verification of breakaway point and imaginary axis crossover point. 3. Obtain the phase margin and gain margin for a given transfer function by drawing bode plots and verify the same. 4. Draw the Nyquist plot for a given transfer function 5. Obtain State model from Poles and zero and also from transfer function 6. Determination of step, ramp & impulse response of a state model	CO4, CO5, CO6

Any other experiment based on syllabus which will help students to understand topic /concept.

Note: Students and teachers are encouraged to use the virtual labs whose links are as given below the remote access to Labs in various disciplines of Science and Engineering is available. Students can conduct online experiments which would help them in learning basic and advanced concepts through remote experimentation.

Virtual Lab Website Reference

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

Term Work (25 Marks):

1. Minimum 8 experiments are compulsory for the term work. (Maximum 4 from each group A and B)
2. Min 1 Assignment on self-learning topics and 1 assignment on rest.

Marks Distribution:

1. Lab Performance: 15 Marks
2. Lab attendance:05 Marks
3. Journal Submission:05 Marks

Oral Examination:

Marks: 25

An Oral Examination will be held on entire syllabus

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2225118	Power System -I Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme					
		Theory Marks			Term Work Marks	Oral Examination	Total Marks
		Internal assessment (IAT)					
		IAT-I	IAT-II	IAT-I +IAT-II (Total)			
2225118	Power System -I Lab	--	--	--	25	25	50

Lab Objectives: The lab course is aimed to

1. **Understand the practical aspects of transmission and distribution systems**, including overhead lines, underground cables, substations, and distribution networks.
2. **To verify theoretical concepts through experiments**, such as sag calculation, inductance, capacitance, per-unit system, and voltage regulation.
3. **To analyze electrical and mechanical parameters** of transmission lines under normal and abnormal loading conditions (ice, wind, earth effect).
4. **To develop skills in measurement and testing**, including insulation resistance testing, earth resistance measurement, and parameter estimation.
5. **To interpret system representation models**, such as one-line diagrams, impedance diagrams, and per-unit equivalent circuits for power system analysis.

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

1. **Analyze and compute transmission line parameters** (inductance, capacitance, sag, voltage drop) under various operating conditions.
2. **Evaluate performance of underground cables and insulators**, including insulation resistance, voltage stress, and string efficiency.
3. **Apply per-unit system for simplifying power system calculations** and convert system quantities into base values accurately.
4. **Design and analyze distribution networks**, understanding feeders, distributors, voltage regulation, and reliability aspects.
5. **Perform basic testing and safety procedures in substations**, including earthing measurement and identification of protection equipment.

Detailed Syllabus:

The Syllabus is same as the Theory Courses “2225112: Power System -I”.

Online Resources:

Sr. No.	Website Name
1.	**Virtual Labs** https://ee.iittp.ac.in/Power_Systems_and_SmartGrid_Lab.html
2.	**Simscape Electrical Documentation (MATLAB)** https://in.mathworks.com/help/physmod/sps

List of Experiments:

Sr No	List of Experiments	Hrs
1.	Sag Calculation under Wind Loading (Demonstration Model)	2
2.	Measurement of Insulation Resistance of Underground Cable	2
3.	Measurement of Capacitance of Single-Core Cable	2
4.	Inductance Calculation of 3-Phase Line (Symmetrical Spacing) (Using MATLAB/Simulink / ETAP / PSCAD)	2
5.	Preparation of Single-Line & Impedance Diagram	2
6.	Study of Radial and Ring Distribution Systems	2
7.	Study of Primary and Secondary Distribution System	2
8.	To determine voltage, drop in a DC/AC distributor at various load points.	2
9.	To compare indoor and outdoor layouts.	2
10.	Analyze importance of grounding in substation safety.	2
11.	Study feeders, distributors, service mains, conductors, poles, cables and insulators.	
12.	Study of Transmission Line Insulators	

Note: Any other experiment based on syllabus which will help students to understand topic /concept.

Assessment:

Term Work: Term Work shall consist of at least 8 experiments.
Term Work Marks: - The distribution of marks shall be as follows:

- Performance: 05 marks
- Journal: 15 marks
- Attendance (Theory and Practical): 05 marks

The final certification and acceptance of term work ensure the minimum passing in the term work

Oral Examination: An Oral examination will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2225119	Renewable Energy & Energy Storage Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme					
		Theory Marks			Term Work Marks	Oral Examination	Total Marks
		Internal assessment (IAT)					
		IAT-I	IAT-II	IAT-I +IAT-II (Total)			
2225119	Renewable Energy & Energy Storage Lab	--	--	--	25	25	50

Course Objectives: The course aims to	
1	To introduce the new paradigm of power generation in the form of renewable energy
2	To introduce the various means used for power processing and optimization.
3	To understand and study the various energy storage and To increase awareness of ES suitability.
4	To relate and study the significance of various energy storage technology in the context of renewable energy-based applications.
Course Outcomes: Learners will be able to	
1	Recognize the need to adapt and engage in operations RE related activities for sustainable future.
2	Identify and analyse the process of power generation through solar thermal and solar photovoltaic technologies.
3	Identify and describe the various components and types of Wind Energy system Fuel cell technology, tidal, wave, and biomass systems.
4	Identify and describe the importance of various forms of energy storage (ES) in new power generation scenario based on renewable energy.
5	Identify and describe the issues related to use of fossil fuels and to recognize means of mitigation through adaption of renewable energy (RE).
6	Recognize the necessity to adapt and engage in operations ES related activities for sustainable future.

Detailed Syllabus:

The Syllabus is same as the Theory Courses “2225113: Renewable Energy &Energy Storage”.

Suggested List of Experiments

Sr. No.	List of Experiments	CO Mapping
01	Introduction to Solar Panels on MATLAB	CO2
02	Case study Solar Energy	CO2
03	To study Wind turbine blade with MATLAB software	CO3
04	Case study of Fuel cell	CO4
05	Case study of energy storage	CO5, CO1
06	Lithium-Ion Battery Case Studies	CO4
07	Case study on energy sustainable development	CO6
08	Case study on solar charging device	CO2
09	To study and plot VI characteristics of solar PV system.	CO2
10	Simulate a Doubly Fed Induction Generator (DFIG) using MATLAB	CO3
11	To study the V-I Discharge Curve Mapping: (Discharge a Lead acid battery at a constant current to plot the voltage drop over time, identifying the nominal voltage and cut off points.)	CO4
12	To observe the Self-Discharge Rate Study: (Charge a Supercapacitor to its rated voltage and monitor the voltage drop over 24 hours to analyse "leakage current" and storage efficiency.)	CO5
13	To measure Ripple Voltage Reduction: (Use capacitors as filter components) in a bridge rectifier circuit and observe how increasing capacitance reduces the output voltage ripple (smoothing).)	CO5

Any other experiment based on syllabus which will help students to understand topic /concept.

Continuous Internal Evaluation (25 Marks)

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

Oral Exam (25 Marks)

An Oral exam will be held based on entire syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2225120	Utilization of Electrical Energy Lab	-	2	-		2	-	2

Course Code	Course Name	Examination Scheme					
		Theory Marks			Term Work Marks	Oral Examination	Total Marks
		Internal assessment (IAT)					
		IAT-I	IAT-II	IAT-I +IAT-II (Total)			
2225120	Utilization of Electrical Energy Lab	--	--	--	25	25	50

Lab Objectives: The Lab course is aimed to

1. To develop the ability to measure, analyze, and evaluate the performance of various electrical equipment such as lighting systems, heating appliances, motors, elevators, and traction systems used in industries and domestic applications.
2. To provide hands-on experience in selecting, testing, maintaining, and preparing technical reports on lamps, luminaires, electric drives, domestic appliances, and industrial systems.
3. To enhance students' understanding of energy utilization, efficiency improvement, and practical application of electrical engineering concepts through field visits, demonstrations, surveys, and comparative studies.

Lab Outcomes: After completing the course students will be able to

1. **Identify and explain** different types of lamps, luminaires, lighting accessories, domestic appliances, and traction components used in electrical systems. *(Understanding)*
2. **Measure and interpret** illumination levels, power consumption, and performance parameters of electrical equipment using appropriate instruments. *(Applying)*
3. **Analyze** the suitability of various electric drives, motors, heating furnaces, and lighting systems for specific industrial and domestic applications. *(Analyzing)*
4. **Evaluate** the efficiency, technical specifications, and energy utilization characteristics of lamps, appliances, and electrical drives. *(Evaluating)*

5. **Select appropriate motors and equipment** based on load requirements, operational conditions, and performance criteria. *(Applying / Evaluating)*
6. **Prepare professional technical reports, comparison charts, and maintenance procedures** for lighting systems, heating furnaces, elevators, and domestic appliances. *(Creating)*

Detailed Syllabus:

The Syllabus is same as the Theory Courses "2225114: Utilization of Electrical Energy".

Sr No	List of Experiments	Hrs
01	Measure Illumination at different places in college by luxmeter.	2
02	Prepare a survey report after collecting technical information of various lamps available in the local market.	2
03	Prepare an industrial visit report after visiting nearby lamp manufacturing industry (otherwise from internet)	2
04	Prepare a report on different luminaries available in the market & collect the technical data	2
05	Identify the different lighting accessories required for various types of lamps.	2
06	Prepare a technical report after visiting an industry, manufacturing electrical heating furnaces. (otherwise from internet)	2
07	Prepare a report of specification of various heating furnaces used in industries.	2
08	Prepare a report on various elevators after visiting nearby elevators	2
09	Compare various Electric Drives for Traction	2
10	Select the appropriate motors and justify selection for given different load situations (at least 5)	2
11	Given a specific load condition determine the rating of a motor (motor for a pump, motor for a lift).	2

12	Demonstration of different components of domestic appliances and their functions with study of their energy consumption and procedures for basic testing and maintenance. Also study their specifications and costs. (Any two of following) a) Electric toaster. b) Electric Oven c) Electric water heater. d) Microwave oven. e) Fans (ceiling and table fan) f) Washing Machine. g) Grinder / mixer / juicer.	2
13	Prepare a report after visiting nearby electric-traction substation. (otherwise from Internet)	2
14	Prepare a report /chart on various types of traction systems. 2	2
15	Prepare a report/chart on speed time curves	2
16	Write the procedure of servicing of any two domestic appliances after visiting nearby servicing centers of electrical domestic appliances,	2
17	Prepare a report on manufacturing of a domestic appliance by visiting a manufacturing unit of electrical domestic appliances (or from the internet).	2
18	Prepare a comparative chart of two different manufacturing companies in India for any two electrical domestic appliances	2
19	Prepare test reports & bills for servicing of electrical domestic appliances.	2
20	To measure voltage, current and power for various types of illumination lamps (SVL, ML, CFL.)	2
21	To observe the working of anyone industrial drive, with characteristics.	2
22	Improve the power factor of available inductive load using static capacitor. Prepare a report based on comparative study of various tariff structure (home tariff, industrial tariff)	2

23	Energy Bill based on energy consumption of residence/commercial building	2

Any other experiment based on syllabus which will help students to understand topic /concept.

Sr No	List of Assignments / Tutorials
1	Assignments/Tutorials should be based on the entire course of Utilization Electrical Energy as per the mentioned Modules.

Assessment:

Term Work: Term Work shall consist of at least 6 practicals based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Oral Exam: An Oral examination will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2225121	Advanced Power Electronic Converters Lab	**-**	**2**	**-**	**-**	**1**	**-**	**1**

Course Code	Course Name	Examination Scheme					
		Theory Marks			Term Work	Oral Exam.	Total Marks
		Internal assessment (IAT)					
		IAT-I	IAT-II	IAT-I +IAT-II (Total)			
2225121	Advanced Power Electronic Converters Lab	**--**	**--**	**--**	**25**	**25**	**50**

Lab Objectives: The Lab course is aimed to

1. To provide knowledge of the different dc-dc isolated & non-isolated converters.
2. To learn and implement the design of magnetics for high frequency inductor and transformer.
3. To provide hands on / skill-sets to model / design and implement the power electronics system / sub-systems.
4. To impart knowledge on practical aspects of power electronics converter design.

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

CO1	Analyse dc to dc convertor in CCM & DCM conduction mode in simulation/hardware implementation
CO2	Analyse the operation and waveforms of isolated dc to dc convertor in simulation/hardware implementation.
CO3	Design and fabricate the high frequency inductor and transformer for power electronics application.
CO4	Illustrate the control strategies for Power Electronic systems.
CO5	Design and implement a power electronic converter for given application.

Detailed Syllabus:

The Syllabus is same as the Theory Course "**Advanced Power Electronic Converters** (Course Code: **2225151**)".

List of Experiments /Tasks:

Expt. No	Name of the Experiment / Task	Hours
1	Simulation of buck, boost, buck -boost convertor in CCM & DCM mode	2
2	Simulation of fly back convertor, forward convertor & push pull convertor	2
3	Simulation of ZVS resonant switch convertor	2
4	Simulation of ZCS resonant switch convertor	2

5	Simulation of multilevel invertor for diode clamp/flying capacitor topologies	2
6	Simulation of cascaded H bridge multilevel invertor	2
7	Simulation of single phase or three phase SPWM technique for control of bridge inverter for an AC load	2
8	Simulation of carrier based PWM technique for multilevel invertor	2
9	Design and fabrication of High frequency inductor for non -isolated buck/boost converter	4
10	Design and fabrication of non-isolated DC-DC convertor for power electronics application.	4
11	Design and fabrication of isolated DC-DC convertor for a power electronics application.	4
12	Design and fabrication of a single-phase bridge inverter for a standalone AC load	4
13	Implementation of PWM Controller /microcontroller / DSP based voltage mode control (VMC) of DC-DC converter.	4
14	Implementation of PWM Controller /microcontroller / DSP based current mode control (CMC) of DC-DC converter.	4
15	Implementation of microcontroller / DSP code for VMC/ CMC of an inverter	4
16	Implementation and testing of any auxiliary circuits used in Power electronics applications	4

Assessment:

Term Work Requirement: (Sr. No 1 to 8)

1. Term Work shall consist of at least 06 practical experiments or tasks listed above (Sr. No 1 to 8) & 02 hardware experiments from the tasks Sr. No. 9 to 16. Also, Term work Journal must include at least 2 assignments.
2. Institute shall arrange a visit to power electronic industry or seminar/workshop based on power electronic convertors. Report for the same shall be submitted as a part of term work.

Term Work Marks: 25 Marks

Laboratory Performance : 15 Marks (Experiment & Attendance)
Industry Visit/Seminar : 05 Marks
Assignments : 05 Marks

Oral Examination: Oral examination will be held based on experiment carried out in laboratory course.

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2225122	Power Plant Technology Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme					
		Theory Marks			Term Work Marks	Oral Examination	Total Marks
		Internal assessment (IAT)					
		IAT-I	IAT-II	IAT-I +IAT-II (Total)			
2225122	Power Plant Technology Lab	--	--	--	25	25	50

Lab Objectives: The lab course is aimed to

1. Provide practical exposure to the working principles, components, and performance parameters of conventional and non-conventional power plants.
2. Enable students to analyse power plant economics through load curves, cost calculations, and performance indices.
3. Develop understanding of thermodynamic cycles used in thermal, nuclear, gas, and diesel power plants using experiments and simulations.
4. Familiarize students with hydro power plant hydrology, turbine characteristics.
5. Introduce students to renewable energy systems such as solar, wind, tidal
6. Develop technical reporting and presentation skills through simulations, assignments, and field visits.

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

1. Explain the working principles, components, and performance parameters of conventional and non-conventional power plants.
2. Apply and calculate power plant economics using load curves, cost data, and performance indices.
3. Describe and interpret thermodynamic cycles used in thermal, nuclear, gas, and diesel power plants.
4. Describe hydro power plant parameters including hydrology aspects and turbine characteristics.
5. Compare renewable energy systems such as solar, wind, and tidal power plants.
6. Prepare and present technical reports based on simulations, assignments, and field visits.

Detailed Syllabus:

The Syllabus is same as the Theory Course - “2225116: Power Plant Technology”

Online Resources:

Sr. No.	Website Name
1.	https://virtual-labs.github.io/exp-pelton-turbine-nitk/
2.	https://fm-iitk.vlabs.ac.in/exp/pelton-wheel/
3.	https://fmc-nitk.vlabs.ac.in/exp/kaplan-turbine/
4.	https://fm-iitk.vlabs.ac.in/exp/kaplan-turbine/
5.	https://ep-iitb.vlabs.ac.in/exp/characteristics-solar-cell/
6.	https://in.mathworks.com/matlabcentral/fileexchange/

List of Experiments:

Sr No	List of Experiments	Hrs
(Perform at least 04 practical)		
1.	Performance Characteristics of Turbines for thermal power plant	2
2.	Performance Characteristics of Turbines for hydropower plant	2
3.	Draw the IV Characteristics of Solar Cell	2
4.	Plot the PV Characteristics and efficiency of Solar Cell	2
5.	Study of boilers, mountings and accessories.	2
6.	Comparative study of PWR and BWR Nuclear reactors	2
Case Study (At least 01 case study from the list)		
1.	Case Study 1 — Campus Load Analysis and Energy Costing • Load Assessment, Load Factor, Demand Factor, and Energy Billing for an Educational Institute Campus. •	2
2.	Case Study 2 — National Power Scenario: Installed Capacity & Generation • Present Scenario of India's Power Installed Generation Capacity and Electricity Production •	2
Field Visit (At least 01 field visit from the list)		
1.	Arrange a field visit on conventional power generation plant (Thermal/ Hydro etc.) and submit the field visit report.	2
2.	Arrange a field visit on non-conventional power generation plant (Solar/ wind/ Tidal etc.) and submit the field visit report.	2

Any other experiment based on syllabus which will help students to understand topic /concept.

List of Assignments:

Sr No	**List of Assignments (At least 02 assignments from the list)**	Hrs
1.	Performance Analysis of Thermal Power Plant. • Draw layout • Explain the working of: Boiler, Turbine, Condenser, Cooling tower • Using assumed or given data: Calculate thermal efficiency, heat rate, specific fuel consumption	2
2.	Hydro Power Plant – Load and Efficiency Study. • Draw layout • Classify turbines and state applications. • Using given head and discharge: Calculate turbine power, overall efficiency	2
3.	Solar and Wind Power Plant Simulation Study. • Solar and wind power generation • Compare solar and wind in terms of: Cost, Reliability, Land requirement, Environmental impact	2
4.	Nuclear & Diesel Power Plant Comparative Study. • Draw block diagram of: Nuclear power plant, Diesel power plant • Compare nuclear and diesel plants based on: Capital cost, Running cost, Fuel requirement, Safety, Pollution	2

Term Work:

- The Term-Work Journal shall consist of at least 06 Experiments, including minimum 04 from practical performance, minimum 01 from case studies and minimum 01 from field visits.
- The Term-Work Journal shall also consist of 02 Assignments from given list of assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) +5 Marks (Attendance)

Oral Exam: An Oral examination will be held based on the above syllabus.

Vertical-1
Major

Sem. – VI

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2226111	Electrical Machines -II	3	--	-	3	-	-	3

Course Code	Course Name	Examination Scheme					
		Theory Marks				Exam. Duration (in Hrs.)	Total Marks
		Internal Assessment (IAT)			End Sem. Exam.		
		IAT-I	IAT-II	IAT-I + IAT-II (Total)			
2226111	Electrical Machines -II	20	20	40	60	2	100

Course Objectives:

This course is aimed to impart knowledge of operation and performance of synchronous machine

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

CO1. Impart the knowledge of construction details of synchronous machines
CO2. Explain the construction and working principles of a synchronous generator
CO3. Determine the voltage regulation of synchronous generator by different methods
CO4. Apply Blondel's two reaction theory for analysis of salient pole synchronous machines
CO5. Analyze the parallel operation of synchronous generators.
CO6. Analyze the operation of a synchronous motor.

Detailed Syllabus:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Introduction to Synchronous Machine	Construction, Types- salient & non-salient, Comparison, Working - Generator & motor, winding details and derivations of pitch factor and distribution factor of synchronous machine (no numerical)	4	CO1
II	Analysis of three phase Non salient pole synchronous generator	EMF equation -derivation & numerical, Effect of harmonics on EMF equation, Armature reaction at different pf, Phasor diagrams at different load conditions.	5	CO2
III	Voltage regulation of Synchronous generator	OC and SC test, Voltage regulation by - direct loading, EMF and MMF method, Numerical on only EMF method.	6	CO3
IV	Analysis of three phase Salient pole synchronous generator	Concept of direct and quadrature axis reactance, Blondel's two reaction theory, Phasor diagram of salient pole generator, Power angle characteristics, Derivation & numerical of synchronizing power and torque,	7	CO4
V	Performance of Synchronous generator and parallel operation	Power flow equations and maximum power conditions, need for parallel operation and conditions, Effect of variation of field current and prime mover input on parallel operation, Concept of infinite bus, Concept of load sharing & numericals in parallel operation.	8	CO5

VI	Three phase Synchronous motor	Principle of operation, Self-starting methods, Phasor diagram, Load angle (δ), Power flow and angle equations & numericals, Effect of change in excitation and mechanical power on performance of motor, V and Inverted V curves, concept of Hunting, Applications, use of Synchronous motor as a condenser, comparison between Synchronous and Induction motor	9	CO6

Text Books:

- Bimbhra, P. S. Electric Machinery. New Delhi: Khanna Publishers.
- Bimbhra, P. S. Generalized Machine Theory. New Delhi: Khanna Publishers.
- Husain, Ashfaq. Electric Machines. New Delhi: Dhanpat Rai & Co.
- Mehta, V. K., & Mehta, Rohit. Principles of Electrical Machines. New Delhi: S. Chand Publishing.
- B L Theraja vol II Electrical Technology New Delhi S. Chand & Publication

Reference Books:

- Say, M. G. Performance and Design of Alternating Current Machines. New Delhi: CBS Publishers & Distributors.
- Fitzgerald, A. E., Kingsley, C., & Umans, S. D. Electric Machinery. New Delhi: Tata McGraw-Hill.

Online References:

Sr. No.	Website Name
1.	NPTEL/ Swayam Course: Electrical machine II By Prof. Tapas Kumar Bhattacharya (IIT Khragpur) https://nptel.ac.in/courses/108105131
2.	NPTEL/ Swayam Course:Electrical Machines, By Prof. G.Bhuvaneshwari (IIT Delhi) https://nptel.ac.in/courses/108102146

Internal Assessment (IA):

- IA will consist of Two Compulsory Internal Assessment Tests (Each Test of 20 Marks). Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

End Semester Theory Examination Question Paper Format:

- Question Paper will comprise of a total of six questions each carrying 15 marks. Q.1 will be compulsory and should cover maximum contents of the syllabus.
- Remaining questions will be mixed in nature [part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules].
- A total of four questions needs to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
2226112	Power System Protection and Switchgear	3	-	3	-	3

Course Code	Course Name	Examination Scheme					
		Theory Marks				Exam Duration (Hrs.)	Total
		Internal Assessment Test			End Sem. Exam		
		Test-I	Test-II	Total (Test-I + Test-II)			
2226112	Power System Protection and Switchgear	20	20	40	60	02	100

Course Objectives	**1.** To impart basic knowledge of power system protection, substation equipment and protection schemes. **2.** To introduce the fundamental principles, operating characteristics, and applications of protective relaying used in modern power systems, with emphasis on industry practices and relevant IEC standards.
Course Outcomes	Upon successful completion of this course, the learner will be able to: **CO1.** Select the appropriate switching/protecting device for substations. **CO2.** Discriminate between the application of circuit breaker and fuses as a protective device. **CO3.** Explain the basic concept of relay, types of relays and their applications in power system. **CO4.** Select the specific protection required for different components of power system according to the type of fault. **CO5.** Apply the specific protection provided for different types of transmission lines. **CO6.** Explain and analyze the principles, architecture, and operation of static and numerical relays, including IEC standards and signal sampling concepts, for effective power system protection.

Module No.	Contents	Hours	CO Mapping
I	**Substation Equipment and switching devices:** Substation Equipment: Instrument Transformers: Role of instrument transformers in measuring and protection, difference between measuring and protection CTs, selection of technically suitable instrument transformers; Switchgear-Definition, Types, Location of switchgear in typical power system, single line diagram to show the measuring and protection scheme Switching Devices- Isolator & Earthing switch (Requirements & definitions, types and construction, Pantograph Isolators, Ratings), Load break switches- Ratings and applications; Contactors- Basic working principle, Terms & Definitions, applications.	03	CO1

II	**Circuit Breakers and Fuses:** Fuses & their applications: Introduction, classification, working principle and applications of re-wirable and HRC fuses, Expulsion and drop out fuses, fusing factor, selection of fuse link and cut off characteristics Circuit Breaker: Arc initiation, arc quenching principles, Re-striking voltage, RRRV, Recovery voltage, Types of Circuit Breakers: For LV application- MCB, MCCB, ELCB, air circuit breakers. For HV application- SF6 circuit breakers, vacuum circuit breakers (working principle, Construction, operating mechanisms, ratings & applications), Mechanical life, Electrical life and testing of circuit breakers. Principle and applications of LV and HV DC circuit breakers	09	CO2
III	**Introduction to Protective Relaying:** Need and objectives of protective relaying, Desirable qualities of protective relaying, overview of IEC standards for protective relays (IEC 60255 series). Evolution of protective relays – electromechanical, static, and numerical relays. Classification of power system faults – shunt and series fault, causes and effects of faults, concept of protection zones, zone overlapping, role of current and voltage transformers in defining protection zones. Primary protection and backup protection Types of back-up protection, breaker failure protection, protection coordination. Principle of overcurrent protection, non-directional and directional overcurrent and earth fault relays, time–current characteristics as per IEC standards (standard inverse, very inverse, extremely inverse), concept of plug setting multiplier and time setting multiplier, applications in radial and interconnected power systems (IEC 60255-151). Principle of differential protection, current differential protection, Limitations of simple current differential protection, Percentage/ biased differential protection (IEC 60255-149). Principle of distance protection, impedance measurement, zones of protection, impedance relay, reactance relay, and mho relay – operating characteristics and applications, overreach and underreach, power swing blocking (IEC 60255-121). Under-voltage and over-voltage protection, over-frequency and under-frequency protection, applications in generators and power systems, load shedding schemes.	10	CO3
IV	**Protection Schemes Provided for major Apparatus:** Generators - Stator side (Differential, Restricted Earth fault, protection for 100% winding, Negative phase sequence, Reverse power, turn-turn fault), Rotor side (Field suppression, field failure, Earth fault, turn to turn fault) Transformers-Differential protection for star delta Transformer, Harmonic restraint relay, REF protection, Protection provided for incipient faults (Gas actuated relay). Induction motors - Protection of motor against over load, short circuit, earth fault, single phasing, unbalance, locked rotor, phase reversal, under voltage, winding temperature, Protection co-ordination	06	CO4

V	**Protection of Transmission Lines:** Feeder protection - Time grading, current grading, combined time & current grading protection provided for Radial, Ring Main, Parallel, T-Feeder. Bus Zone Protection - Differential protection provided for different types of bus zones. LV, MV, HV Transmission Lines - Protection provided by over current, earth fault, Differential and Stepped distance protection. EHV & UHV Transmission lines - Type and nature of faults, Need for auto-reclosure schemes, Carrier aided distance protection (Directional comparison method), Power Line Carrier Current protection (Phase comparison method). Introduction to the concept of Islanding	06	CO5
VI	**Introduction to Static & Numerical Relays:** Definition, block diagram and working of static relays, comparison with electromechanical relays, advantages and limitations. Introduction to numerical relays and their role in modern power systems, advantages of over static relays. Multifunction capability, self-monitoring and diagnostics features, overview of relevant IEC standards (IEC 60255, IEC 61850). Block diagram and functional description: input transformers (CTs and VTs), signal conditioning circuits, anti-aliasing filters, analog-to-digital converters (ADC), microprocessor/DSP, memory units, logic and output interface, human–machine interface (HMI), and communication ports. Concept of signal sampling, sampling rate and its significance, Nyquist criterion, need for anti-aliasing filters, implementation and importance in numerical relay accuracy.	05	CO6

Books Recommended:

Text Books:

1. Switchgear & Protection by Sunil.S.Rao, Khanna Publications
2. Power system Protection & Switchgear by Badriram Vishwakarma, TMH
3. Power System Protection and Switchgear by Bhuvanesh A O, Nirmal CN, Rashesh PM, Vijay HM, Mc Graw Hill

Reference Books:

1. Fundamentals of protection by Paithanker & Bhide.S.R, P.H.I
2. Static Relays by Madhava Rao, TMH
3. A text book on Power System Engineering by Soni, Gupta, Bhatnagar & Chakraborthi, Dhanpat Rai & Co
4. Protective Relaying by Lewis Blackburn, Thomas.J.Domin
5. Power System Protection by P.M. Anderson, Wiley Interscience
6. Modern Power System Protection – Divyesh Oza, TMH Publication

Website Reference / Video Courses:

1. NPTEL Course: Power System Protection By Prof. S.A. Soman, Dept. of Electrical Engineering, IIT Bombay: - Web link- https://nptel.ac.in/courses/108/101/108101039/
2. NPTEL Course: Power System Protection and Switchgear By Prof. Bhaveshkumar Bhalja,

Dept. of Electrical Engg, IIT Roorkee: - Web link- https://nptel.ac.in/courses/108/107/108107167/

3. NPTEL Course: Power System Protection by Prof. Ashok Kumar Pradhan, Dept. of Electrical Engineering, IIT Kharagpur: - Web link- https://nptel.ac.in/courses/108/105/108105167/

Internal Assessment (IA):

- IA will consist of Two Compulsory Internal Assessment Tests (Each Test of 20 Marks). Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

End Semester Theory Examination Question Paper Format:

- Question Paper will comprise of a total of six questions each carrying 15 marks. Q.1 will be compulsory and should cover maximum contents of the syllabus.
- Remaining questions will be mixed in nature [part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules].
- A total of four questions needs to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2226113	Microgrid & Smart Grid	3	--		3	-		3

Course Code	Course Name	Examination Scheme					
		Theory Marks				Exam. Duration (in Hrs.)	Total Marks
		Internal Assessment Test (IAT)			End Sem. Exam		
		IAT-I	IAT-II	IAT-I + IAT-II (Total)			
2226113	Microgrid & Smart Grid	20	20	40	60	2	100

Course Objectives: The course is aimed to

1. Introduce the energy scenario and renewable integration challenges.
2. Explain distributed generation and grid interconnection concepts.
3. Provide understanding of microgrid architecture and control.
4. Explain microgrid operation, islanding and energy storage.
5. Introduce smart grid concepts, technologies and applications
6. Create awareness of automation, communication, IoT, cyber security and the role of AI in smart grids.

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

CO1. Explain and analyze the energy scenario, sustainability concerns, and challenges of renewable energy integration.

CO2. Describe distributed generation concepts and grid interconnection requirements.

CO3. Explain and analyze microgrid architecture and control concepts.

CO4. Analyze microgrid operation, islanding issues and the role of energy storage.

CO5. Explain and analyze smart grid concepts, technologies, and applications.

CO6. Describe automation, communication, IoT, cyber security, and basic applications of AI in smart grids.

Detailed Syllabus:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Energy Scenario and Grid Integration Challenges	Comparison of renewable technologies (features and applications). Challenges of renewable integration: variability, intermittency, reliability, stability and power quality issues. Emerging role of digitalization, IoT and Artificial Intelligence in future power grids (overview).	5	CO1

		Self-Study: Global and Indian energy scenario; energy security, climate change and sustainability. Overview of renewable energy technologies: Solar PV, wind energy systems, biomass, fuel cells, micro-turbines.		
II	Distributed Generation and Grid Interconnection	Distributed generation (DG): concepts and need. Basic DG topologies and configurations. Interconnection of distributed generation with utility grid. Overview of interconnection standards: IEEE 1547 series. Grid abnormal operating conditions: voltage and frequency deviations. Islanding phenomenon and its implications in DG systems.	5	CO2
III	Microgrid Concepts, Architecture, and Control	Concept and definition of microgrids. Structure and typical configurations of microgrids. Sources in microgrids: solar PV, wind, biomass, small generators and storage. Types of microgrids: AC, DC and hybrid. Microgrid control architectures: centralized, decentralized and hierarchical. Basics of power sharing in microgrids (conceptual). Coordinated operation of multiple microgrid units. Power Conditioning Units (PCUs) in DC and AC microgrids.	7	CO3
IV	Microgrid Operation, Islanding and Energy Storage	Grid-connected and islanded operation of microgrids. Active and reactive power control (conceptual understanding only). Protection challenges in microgrids. Anti-islanding schemes: passive, active and communication-based techniques. Role of energy storage in microgrid operation. Storage contribution to stability and reliability.	6	CO4
V	Smart Grid Concepts and Technologies	Concept and definition of smart grid (IEEE / NIST). Functions of smart grid. Opportunities and challenges in smart grid implementation. Resilient and self-healing grids. National Smart Grid Mission (NSGM). Smart grid technologies: smart meters, Advanced Metering Infrastructure (AMI). Real-time pricing. Demand Response (DR) and Demand Side Management (DSM). Case study: smart grid pilot projects in India.	**8**	CO5

VI	Smart Grid Automation, Communication and Cyber Security	Smart substations and substation automation. Feeder automation. Intelligent Electronic Devices (IEDs). Wide Area Measurement System (WAMS) and PMUs. Communication networks for smart grid and micrograds: HAN, WAN, 5G, wireless mesh networks. Introduction to IoT in smart grid (overview). Smart grid cyber security: state of the art, cyber security risks and threats, mitigation approaches. Role of Artificial Intelligence in smart grids (applications and benefits – overview).	**8**	CO6

Textbooks:

- Microgrids: Architectures and Control, Edited by Nikos Hatziargyriou, Wiley / IEEE Press, 2014
- Integration of Green and Renewable Energy in Electric Power Systems, A. Keyhani, M. N. Marwali, M. Dai, Wiley, 2009
- Microgrids: Design and Implementation, Antonio Carlos Zambroni de Souza, Miguel Castilla, Springer, 2019

References:

- Voltage Source Converters in Power Systems: Modeling, Control and Applications, Yezdani & Reza Iravani, John Wiley, 2010
- Smart Grids – Fundamentals and Technologies in Electricity Networks, B. M. Buchholz, Z. Styczynski, Springer, 2014
- IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems, IEEE 1547-2003
- IEEE Guide for Design, Operation & Integration of Distributed Resources Island System with Electric Power System, IEEE 1547.4-2011

Online References:

Sr. No.	Website Name
6.	DC Microgrid and Control System, NPTEL, Prof. Avik Bhattacharya, IIT Roorkee
7.	Introduction to Smart Grid, NPTEL, Prof. N. P. Padhy & Prof. Premalata Jena, IIT Roorkee
8.	National Smart Grid Mission (NSGM) Official Website: https://www.nsgm.gov.in

Internal Assessment (IA):

- IA will consist of Two Compulsory Internal Assessment Tests (Each Test of 20 Marks). Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

End Semester Theory Examination Question Paper Format:

- Question Paper will comprise of a total of six questions each carrying 15 marks. Q.1 will be compulsory and should cover maximum contents of the syllabus.

- Remaining questions will be mixed in nature [part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules].
- A total of four questions needs to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2226114	Electric Vehicle Technology	3	--	-	3	-	-	3

Course Code	Course Name	Examination Scheme					
		Theory Marks				Exam. Duration (in Hrs.)	Total Marks
		Internal Assessment Test (IAT)			End Sem. Exam		
		IAT-I	IAT-II	IAT-I + IAT-II (Total)			
2226114	Electric Vehicle Technology	20	20	40	60	2	100

Course Objectives: The course is aimed to

1. Introduce fundamentals and need for electric vehicles.
2. Explain EV architecture and subsystems.
3. Understand motors and power electronics used in EVs.
4. Learn energy storage systems and battery management systems.
5. Explain EV charging systems, standards and infrastructure.
6. Discuss EV performance, safety and Indian EV policies.

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

CO1. Explain the need, evolution and classification of electric vehicles.
CO2. Describe architecture and subsystems of electric vehicles.
CO3. Explain electric motors and power electronic converters used in EVs.
CO4. Analyze battery characteristics and battery management systems.
CO5. Explain EV charging methods, standards and infrastructure.
CO6. Discuss EV performance, safety standards and Indian EV policies.

Detailed Syllabus:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Introduction to Electric Vehicles	Conventional vehicles vs electric vehicles, need for EVs, environmental and energy concerns. History and evolution of EVs. Classification of EVs: BEV, HEV, PHEV, FCEV. Comparison of EVs and IC engine vehicles.	04	CO1
II	EV Architecture and Subsystems	Vehicle dynamics, total tractiv force calculations, EV architecture and block diagram. Major subsystems: traction motor, power electronic converter, energy	06	CO2

		storage system, battery management system, transmission system, auxiliary systems. Vehicle control unit and communication overview.		
III	Motors and Power Electronics for EVs	Permanent magnet motor drives and BLDC motor Electric motors used in EVs: DC motor, BLDC motor, PMSM, induction motor – construction, working principle and characteristics. Power electronic converters used in EVs: DC–DC converters, inverters. Motor control basics for EV applications.	08	CO3
		Self-Study: Configuration and Control of DC motor drives, Induction motor drives, Power source characteristics of vehicles.		
IV	Energy Storage Systems and BMS	Introduction to energy management and their strategies used in EVs. Classification of different energy management strategies. Battery types for EVs: lead-acid, NiMH, lithium-ion batteries. Battery characteristics: capacity, C-rate, SOC, SOH, DOD. Battery pack configuration. Battery Management System (BMS): functions, cell balancing, thermal management, safety aspects.	07	CO4
V	EV Charging Systems and Infrastructure	EV charging methods: On board chargers, off board chargers, conductive and wireless charging. AC and DC charging, slow and fast charging. Charging standards: IEC, CHAdeMO, CCS, Bharat EV standards. EV charging infrastructure and grid impact (introductory).	10	CO5
VI	EV Performance, Safety and Policies	EV performance parameters: range, efficiency, gradeability. Thermal issues in EVs. Safety standards and testing of EVs. Overview of Indian EV policies: FAME scheme, EV adoption challenges and future trends.	04	CO6

Text Books:

1. Mehrdad Ehsani, Yimin Gao, Sebastien Longo, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles*, CRC Press.
2. Iqbal Husain, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press.
3. S. Chandra Mouli, *Electric Vehicles*, McGraw Hill Education.

References:

1. Larminie J., Lowry J., *Electric Vehicle Technology Explained*, Wiley.
2. James Larminie, *Electric Vehicle Engineering*, Wiley.

Online References:

Sr. No.	Website Name
9.	Electric Vehicles – art 1, Prof. Iqbal Husain, IIT Delhi https://onlinecourses.nptel.ac.in/noc23_ee82/
10.	**Power Electronics for Electric Vehicles,** *Prof. Bhim Singh, IIT Delhi* https://onlinecourses.nptel.ac.in/noc24_ee90

Internal Assessment (IA):

- IA will consist of Two Compulsory Internal Assessment Tests (Each Test of 20 Marks). Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

End Semester Theory Examination Question Paper Format:

- Question Paper will comprise of a total of six questions each carrying 15 marks. Q.1 will be compulsory and should cover maximum contents of the syllabus.
- Remaining questions will be mixed in nature [part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules].
- A total of four questions needs to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2226115	Solar Energy Technology	3	-	-	3	-	-	3

Course Code	Course Name	Examination Scheme					
		Theory Marks					
		Internal Assessment Test (IAT)			End Sem. Exam	Exam. Duration (in Hrs.)	Total Marks
		IAT-I	IAT-II	IAT-I + IAT-II (Total)			
2226115	Solar Energy Technology	20	20	40	60	2	100

Course Objectives: The course is aimed to

1. Provide fundamental knowledge of solar energy resources and technologies.
2. Develop understanding of solar radiation characteristics and energy estimation.
3. Explain operating principles and performance of solar photovoltaic systems.
4. Enable students to understand design aspects of solar PV systems.
5. Introduce solar thermal energy systems and their applications.
6. Develop ability to analyze real-world solar energy applications and system performance.

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

CO1: Explain the role, potential, and applications of solar energy systems.

CO2: Analyze solar radiation and geometry for energy estimation.

CO3: Describe operating principles and characteristics of solar PV cells and modules.

CO4: Describe the functional components of a microgrid and configurations of solar PV systems.

CO5: Analyze solar thermal collectors and low-temperature solar applications.

CO6: Perform basic design, performance, and economic analysis of solar energy systems.

Detailed Syllabus:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Introduction to Solar Energy	Need and scope of solar energy, solar energy potential in India, advantages and limitations, classification of solar energy systems, applications.	6	CO1

II	Solar Radiation and Geometry	Solar constant, extra-terrestrial radiation, beam, diffuse and global radiation, air mass, solar angles (declination, hour angle, altitude, azimuth), measurement of solar radiation, sunshine duration, estimation of solar radiation.	7	CO2
III	Solar Photovoltaic Fundamentals	Principle of solar cell, p-n junction under illumination, equivalent circuit, I–V and P–V characteristics, efficiency, fill factor, effect of temperature and irradiance, Types of Solar Cell, series and parallel connections, PV modules and arrays.	7	CO3
IV	Solar PV System Components and Configurations	Balance of system components, batteries, charge controllers, inverters, MPPT- Mechanical & Electrical, standalone PV systems, grid-connected PV systems, net metering concept, basic system configuration.	7	CO4
V	Solar Thermal Systems	Solar thermal conversion principles, flat plate collectors, concentrating collectors, collector efficiency, solar water heating systems, solar cookers, solar dryers, solar air heaters.	6	CO5
VI	Solar Energy Applications, System Design and Performance Analysis	Applications of solar PV and solar thermal systems, load estimation, module orientation and tilt, shading effects, system losses, performance ratio (PR), CUF, basic economic analysis (payback period, life-cycle cost), introduction to design and analysis tools. Self-Study: Case studies of rooftop and institutional solar systems.	6	CO6

Text Books:

1. Chetan Singh Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications," PHI Learning
2. H. P. Garg & J. Prakash, "Solar Energy: Fundamentals and Applications," Tata McGraw-Hill
3. C. S. Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications," Academic Press
4. J. F. Manwell, J. G. McGowan & A. L. Rogers, "Wind and Solar Power Systems: Design, Analysis and Operation," CRC Press

Reference Books:

1. Sukhatme S.P. and Nayak J.K., "Solar Energy: Principles of Thermal Collection and Storage," Tata McGraw-Hill.
2. Duffie J.A. and Beckman W.A., "Solar Engineering of Thermal Processes," Wiley.
3. Godfrey Boyle, Renewable Energy: Power for a Sustainable Future, Oxford University Press.
4. Messenger R. and Ventre J., Photovoltaic Systems Engineering, CRC Press.

Online References:

Sr. No.	Website
1.	Solar Energy Engineering and Technology, By Prof. Pankaj Kalita, IIT Guwahati, Weblink: https://nptel.ac.in/courses/115103123

Internal Assessment (IA):

- IA will consist of Two Compulsory Internal Assessment Tests (Each Test of 20 Marks). Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

End Semester Theory Examination Question Paper Format:

- Question Paper will comprise of a total of six questions each carrying 15 marks. Q.1 will be compulsory and should cover maximum contents of the syllabus.
- Remaining questions will be mixed in nature [part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules].
- A total of four questions needs to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2226116	Lighting System Design	3	--	-	3	-	-	3

Course Code	Course Name	Examination Scheme					
		Theory Marks				Exam Duration (in Hrs.)	Total Marks
		Internal Assessment (IAT)			End Sem. Exam.		
		IAT-I	IAT-II	IAT-I + IAT-II (Total)			
2226116	Lighting System Design	20	20	40	60	2	100

Course Objectives: This course is aimed to

1. Introduce various laws of illumination and lighting parameters,
2. Understand working of luminaries and their characteristics to be used for lighting design.
3. Introduce lighting design considerations for interior applications.
4. Introduce lighting design considerations for exterior applications.
5. Understand different lighting control technologies.
6. Understand LED based solid state lighting with standards

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

CO1. Identify and describe the various laws of illumination, lighting parameters.
CO2. Identify and describe light sources, luminaries and their characteristics.
CO3. Formulate and design an Interior Lighting system for different application areas.
CO4. Formulate and design an Exterior Lighting system for different application areas.
CO5. Identify and describe different Lighting Control schemes.
CO6. Identify and describe Solid-State Lighting technology.

Detailed Syllabus:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Introduction	Review of Light, Laws of illumination, terms in illumination, factors affecting the lighting-shadow, glare, reflection, color rendering and stroboscopic effect, assessment of lamp efficacy, Methods of Lighting system	04	CO1
II	Lamps and Luminaries	Lamp: Review of development, construction and characteristics: Incandescent lamp, Discharge lamps, induction lamp, and LED lamp, types, reflectors, manufacturing; LED Lighting Components and Subsystems, OLEDs, light-emitting polymers (LEPs) Thermal Management and Lifetime Studies; Control gear: standard and electronic ballast	10	CO2

III	Interior Lighting Design & Calculation	Objectives, quality and quantity of lighting. Lamp /Luminaire selection and placement, design considerations and calculation. Glare Consideration and control. Indoor lighting design by lumen method, by point by point method. Applications: residential, educational institute, industries, sports centers, commercial premises: retail stores, offices etc. Applicable standards.	08	CO3
IV	Exterior Lighting Design & Calculation	Exterior lighting system- design considerations and calculation in Road lighting system, Utility area lighting, Sports lighting, Decorative flood lighting. Applicable standards	04	CO4
V	Lighting Control	Introduction to Lighting Control, Selection of Lighting Controls, Design of Lighting Control Scheme, Lighting and LEED, Daylighting control, Controlling LED Lighting Systems, Smart Lighting Fixtures, Digital Lighting Networks, DMX control. BACnet: Building Automation Standard Protocol	05	CO5
VI	Solid-State Lighting	Drivers for LED lamps, standards and regulations, LED luminaries, LED Light Distributions, Indoor Lighting-Applications Smart Street, Lighting with Remote Monitoring and Control System, Solar Powered LED Lighting, Tunable White Lighting and RGB LED based Colored Lighting,	08	CO6

Text Books:

1. Anil Valia, “Designing with light: Lighting Handbook”, International Lighting Academy, 2002
2. Gary Gorden, “Interior Lighting for Designers”, John Wiley & Sons Inc.
3. Craig DiLouie, “Advanced Lighting Controls: Energy Savings, Productivity, Technology and Applications”, The Fairmount Press, 2006
4. Richard Cadena, “Automated Lighting”, Second Edition, Focal Press, 2010
5. W.D. van Driel l X.J. Fan, “Solid State Lighting Reliability: Components to Systems”, Springer, 2013
6. Patrick Mottier, “LEDs for Lighting Applications”, ISTE Ltd and John Wiley & Sons Inc. 2009

References:

1. Illumination Engineering Society, “The IES Lighting Handbook”, 10th Edition
2. J. L. Lindsey and S. C. Dunning, “Applied Illumination Engineering”, Third Edition, Fairmont Press, 2016
3. J. R. Coaton and A. M. Marsden, “Lamps and Lighting” Edited 4th Edition
4. “LED Lighting Systems: All you need to know”, by Anil Valia, International Lighting Academy, 2012
5. IS 3646- Part I: 1992, Code of practice for interior illumination, BIS publication

6. National Lightning Code 2025 (BIS)

Online References:

No.	bsite Name
1.	TEL Course: Illumination Engineering by Prof. N. N. Kishore (IIT Kharagpur) https://nptel.ac.in/courses/108105060

Internal Assessment (IA):

- IA will consist of Two Compulsory Internal Assessment Tests (Each Test of 20 Marks). Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

End Semester Theory Examination Question Paper Format:

- Question Paper will comprise of a total of six questions each carrying 15 marks. Q.1 will be compulsory and should cover maximum contents of the syllabus.
- Remaining questions will be mixed in nature [part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules].
- A total of four questions needs to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2226117	Special Electrical Machines	**3**	**--**	**-**	**3**	**-**	**-**	**3**

Course Code	Course Name	Examination Scheme					
		Theory Marks				Exam. Duration (in Hrs.)	Total Marks
		Internal Assessment (IAT)			End Sem. Exam.		
		IAT-I	IAT-II	IAT-I + IAT-II (Total)			
2226117	Special Electrical Machines	20	20	40	60	2	100

Course Objectives: This course is aimed to

1. To impart knowledge on special electrical machines and their control

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

CO1. Exemplify the working of Stepper motor and its control
CO2. Demonstrate the functioning of SRM motor and its control
CO3. Illustrate the working of BLDC motor and its control
CO4. Illustrate the operational features of PMSM motor and its control
CO5. Illustrate the working of Linear motors
CO6. Illustrate the working of Axial Flux Motors

Detailed Syllabus:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
I	Stepper Motor	Construction and working of -VR, PMSM, HSM, Characteristics -static and dynamic, Control- open loop, closed loop and microprocessor based. Applications. Simple Numerical.	07	CO1
II	Switched reluctance Motor	Construction and working, Power converter circuits, Control of SRM, Rotor position sensors, microprocessor based and sensor less control, Applications.	07	CO2
III	Brushless DC Machines	Construction, Electronic commutation, Principle of operation, types of BLDC, Control of BLDC, Microprocessor based and DSP based control, Sensor less control, Applications.	07	CO3

IV	Permanent Magnet Synchronous Machine	Construction, principle of operation, comparison between conventional and PMSM. Control of PMSM, vector control, self-control, sensor less control, microprocessor/DSP based control, Applications.	07	CO4
V	Linear Induction Machine	Construction, Types, Working, Feature, Thrust Equation, Equivalent circuit, Characteristics, Control, Application	06	CO5
VI	Axial Flux Motors	Construction, working and applications. Difference between Axial Flux Motor and Radial Flux Motor	05	CO6

Text Books:

1. E. G. Janardanan — Special Electrical Machine PHI, publication
2. G. K. Dubey- Fundamentals of Electrical Drives, CRC press 2002 - Technology & Engineering
3. K. Venkataratnam- Special Electric Machines, Universities Press, Apr-2009 - Technology & Engineering

Reference Books:

1. D. C. Hanselman — Brushless Permanent-Magnet Motor Design—Eman Press LLC
2. R. Krishnan, SWITCHED RELUCTANCE MOTOR DRIVES Modeling, Simulation, Analysis, Design, and Applications, CRC Press.
3. M. Ramamoorty, O. Chandra Sekhar—Electrical Machines - PHI publication
4. R Krishnan — Permanent Magnet Synchronous and Brushless DC Motor Drives—CRC press

Online References:

Sr. No.	**Website Name**
1.	NPTEL Course: Advanced Electric Drives By Dr. S.P. Das, Department of Electrical Engineering, IIT Kanpur Web link- https://nptel.ac.in/courses/108/104/108104011/
2.	NPTEL Course: Fundamentals of Electric Drives By Dr. S.P. Das, Department of Electrical Engineering, IIT Kanpur: Web link- https://nptel.ac.in/courses/108/104/108104140/

Internal Assessment (IA):

- IA will consist of Two Compulsory Internal Assessment Tests (Each Test of 20 Marks). Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

End Semester Theory Examination Question Paper Format:

- Question Paper will comprise of a total of six questions each carrying 15 marks. Q.1 will be compulsory and should cover maximum contents of the syllabus.
- Remaining questions will be mixed in nature [part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules].
- A total of four questions needs to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2226118	Wind Energy Technology	3	-	-	3	-	-	3

Course Code	Course Name	Examination Scheme					
		Theory Marks				Exam. Duration (in Hrs.)	Total Marks
		Internal Assessment Test (IAT)			End. Sem. Exam.		
		IAT-I	IAT-II	IAT-I + IAT-II (Total)			
2226118	Wind Energy Technology	20	20	40	60	2	100

Course Objectives: The course is aimed to

1. Introducing students to wind energy as a viable renewable energy source.
2. Understanding wind characteristics and fundamentals of energy extraction from wind.
3. Providing detailed knowledge of Horizontal Axis Wind Turbines (HAWT) and Vertical Axis Wind Turbines (VAWT), with greater emphasis on HAWT.
4. Explaining construction, working principles, characteristics, and performance of wind energy conversion systems.
5. Familiarizing students with electrical generators, grid integration, and power conditioning used in wind power plants.
6. Enabling students to analyze performance, design basic wind power plants, and carry out economic evaluation.

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

CO1. Explain wind energy fundamentals, wind characteristics, and wind power potential.
CO2. Describe construction, working principles, and classification of HAWT and VAWT.
CO3. Analyze aerodynamic performance and power characteristics of wind turbines.
CO4. Analyze electrical generators, control systems, and grid connection of wind energy conversion systems using block diagrams.
CO5. Evaluate performance parameters and operational aspects of wind power plants.
CO6. Analyze techno-economic, environmental aspects, advantages, disadvantages, and limitations of wind energy systems.

Detailed Syllabus:

Sr no	Module no and Name	Detailed Content	Hours	CO Mapping
1	**Module 1: Introduction to Wind Energy**	Renewable energy overview, history and status of wind energy, global and Indian wind energy scenario, advantages and limitations of wind power, applications of wind energy	**5**	**CO1**
2	**Module 2: Wind Characteristics and Energy Extraction**	Wind formation, wind speed and direction, wind data measurement, Weibull distribution, wind power density, Betz limit, factors affecting wind power, site selection	**6**	**CO2**
3	**Module 3: Wind Turbines – HAWT and VAWT**	Classification of wind turbines, detailed construction and working of HAWT (rotor, blades, nacelle, tower, yaw and pitch control systems), VAWT types (Darrieus, Savonius), comparison between HAWT and VAWT	**10**	**CO3**
4	**Module 4: Aerodynamics and Performance Analysis**	Lift and drag forces, blade element theory, power coefficient (Cp), torque and speed characteristics, tip speed ratio, performance curves, losses in wind turbines	**8**	**CO4**
5	**Module 5: Electrical Systems and Grid Integration**	Wind turbine generators (SCIG, WRIG, DFIG, PMSG), power electronics converters, control strategies, grid-connected and standalone wind systems, block diagrams, grid codes, power quality issues	**5**	**CO5**
6	**Module 6: Wind Power Plants and Economic Analysis**	Wind farm layout concepts, estimation of annual energy production, capacity factor, environmental impacts, economic analysis (capital cost, O&M cost, payback period, levelized cost of energy), advantages and disadvantages	**5**	**CO6**

Text Books:

1. Sathyajith Mathew, *Wind Energy: Fundamentals, Resource Analysis and Economics*, Springer.
2. R. Gasch and J. Twele, *Wind Power Plants: Fundamentals, Design, Construction and Operation*, Springer.

References:

1. G. D. Rai, *Non-Conventional Energy Sources*, Khanna Publishers.
2. T. Burton et al., *Wind Energy Handbook*, Wiley.
3. B. H. Khan, *Non-Conventional Energy Resources*, McGraw Hill.
4. MNRE technical reports on wind energy systems.

Standards:

- IS 875 (Part 3): Wind loads on structures

- IEC 61400 series: Wind turbine design, performance, and safety
- IEC 61400-21: Power quality of grid-connected wind turbines
- ISO 9001 & ISO 14001: Quality and environmental management systems (applicable to wind projects)

Internal Assessment (IA):

- IA will consist of Two Compulsory Internal Assessment Tests (Each Test of 20 Marks). Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

End Semester Theory Examination Question Paper Format:

- Question Paper will comprise of a total of six questions each carrying 15 marks. Q.1 will be compulsory and should cover maximum contents of the syllabus.
- Remaining questions will be mixed in nature [part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules].
- A total of four questions needs to be answered.

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2226119	Electrical Machines-II Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme					
		Theory Marks			Term Work	Practical & Oral Exam.	Total Marks
		Internal assessment (IAT)					
		IAT-I	IAT-II	IAT-I +IAT-II (Total)			
2226119	Electrical Machines-II Lab	--	--	--	25	25	50

Lab Objectives: The lab course is aimed to

1. To understand performance of synchronous machines and their characteristics
2. To find Voltage regulation and study Parallel operation of Synchronous generators

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

CO1. To understand the operation of synchronous machines
CO2. To determine the voltage regulation of synchronous generator
CO3. To demonstrate the synchronization of alternator
CO4. To analyze the performance of a synchronous motor.

Detailed Syllabus:

The Syllabus is same as the Theory Courses “Electrical Machines-II (Course Code: 2226111)”

List of Experiments:

- At least 8 experiments from a list must be conducted. Min 1 experiment from Vlab & Min. 1 experiment must be on MATLAB/ Scilab/Simulink

Sr No	List of Experiments for Measurement	Hrs
1.	Study of constructional details of Synchronous machines	2
2.	Determine Voltage regulation of Alternator by Direct loading method	2
3.	Determine Voltage regulation of Alternator by EMF method	2
4.	Determine Voltage regulation of Alternator by MMF method	2
5.	Determine Xd and Xq of Synchronous machine by Slip test	2
6.	Perform Synchronization / Parallel operation of Alternator	2
7.	Study of Starting methods of Synchronous motor	2

8.	Perform Load test on Synchronous motor	2
9.	Perform test on Synchronous Motor for variable excitation & plot ‘V’ and ‘inverted V’ curves.	2
10.	Study of use of Synchronous motor as a Synchronous condenser	2
11.	To determine positive sequence, negative sequence and zero sequence reactance of an alternator.	2
12	To demonstrate the effect of change of Mechanical input on frequency of generated EMF of alternator.	2

Students should submit min 2 Assignments based on Syllabus contents.

Any other experiment based on syllabus which will help students to understand topic / concept.

Note: Students and teachers are encouraged to use the virtual labs whose links are as given below the remote access to Labs in various disciplines of Science and Engineering is available. Students can conduct online experiments which would help them in learning basic and advanced concepts through remote experimentation.

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

Online Resources:

Sr. No.	Website Name
3.	https://www.vlab.co.in/broad-area-electrical-engineering
4.	https://elms-iitr.vlabs.ac.in/
3.	https://asnm-iitkgp.vlabs.ac.in/
4.	https://sl-coep.vlabs.ac.in/

Assessment:
Term Work: Term Work shall consist of at least 8 practicals’ based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical & Oral Exam: A Practical & Oral examination will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credit Assigned		
		Theory	Practical	Theory	Practical	Total
2226120	Power System Protection And Switchgear Lab	-	2	-	1	1

Course Code	Course Name	Examination Scheme					Total Marks
		Theory Marks			Term Work Marks	Oral Exam.	
		Internal Assessment					
		Test 1	Test 2	(Test 1+ Test 2) Total			
2226120	Power System Protection And Switchgear Lab	-	-	-	25	25	50

Course Objectives	• To introduce the concept of different protection schemes
Course Outcomes	Upon successful completion of this course, the learner will be able to: **CO1.** Explain the working principle of various protective devices like Circuit breakers, fuses, switches and contactors. **CO2.** Explain the concept of various over current protection scheme and its applications in power system. **CO3.** Demonstrate the different protection schemes of transformer and Induction motor. **CO4.** Explain the protection schemes of transmission line.

Syllabus: Same as that of Course: "2226112-Power System Protection and Switchgear"

Suggested List of Laboratory Experiments: Minimum six experiments need to be performed.

1. Demonstration of working parts of different Fuses and Contactor.
2. Demonstration of working parts of MCB, MCCB, RCCB & Circuit breakers.
3. To perform overcurrent protection using Induction Disc relay by setting different TSM and plot time vs current characteristics.
4. To perform overvoltage protection using Induction Disc relay by setting different TSM and plot time vs current characteristics.
5. Demonstration of different protection schemes like protection against overload, locked rotor, single phasing of 3 phase Induction motor.
6. Demonstration of differential protection of 3 phase transformer.
7. Demonstration of Directional Over-current protection relay.
8. To perform simulation of Numerical Based relay.
9. To perform simulation of distance protection in transmission line.
10. To study about substation equipment and distributed control system.
11. To study about feeder parameter monitoring & Load Transfer.

- Any other experiment based on syllabus, which will help students to understand topics/concept.
- It is desirable to arrange the Visit to a substation and a report preparation.
  <u>Industry Visit:</u> Students' visit to be arranged to the nearby industry involved in design/ manufacturing/ processing in the following electrical engineering domains: Electrical Switchgears / Electrical Substation / Electrical Machines / Traction Locomotives / HV

Equipments / Energy Storage. All students shall submit visit report in appropriate format as a part of the submission for EL601.

Note: Students and teachers are encouraged to use the virtual labs whose links are as given below the remote-access to Labs in various disciplines of Science and Engineering is available. Students can conduct online experiments which would help them in learning basic and advanced concepts through remote experimentation.

Virtual Lab Website Reference

1. http://vlab.co.in/broad-area-electrical-engineering
2. http://vlab.co.in/broad-area-electronics-and-communications
3. https://sa-nitk.vlabs.ac.in/List%20of%20experiments.html

Term work:

Term work shall consist of minimum six experiments. The distribution of marks shall be as follows:

Experiments Performance	: 10 marks
Journal	: 05 marks
Industrial Visit Report	: 05 Marks
Attendance (Theory and Practical)	: 05 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Oral Examination:

Oral examination will be based on entire syllabus of "2226112-Power System Protection and Switchgear".

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2226121	Microgrid & Smart Grid Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme					
		Theory Marks			Term Work Marks	Oral Exam. Marks	Total Marks
		Internal assessment (IAT)					
		IAT-I	IAT-II	IAT-I +IAT-II (Total)			
2226121	Microgrid & Smart Grid Lab	--	--	--	25	25	50

Lab Objectives: The lab course is aimed to

1. Provide practical exposure to fundamental concepts of microgrid and smart grid systems.
2. Develop the ability to study and analyze microgrid operation with distributed generation, storage, and loads.
3. Introduce basic monitoring, control, and protection aspects of microgrid and distribution systems.
4. Familiarize students with smart grid technologies such as smart metering, automation, and demand response.
5. Enable the use of appropriate tools and platforms for modeling, monitoring, and analysis of microgrid and smart grid systems.

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

CO1. Explain the working of functional components and principles of microgrid and smart grid systems.
CO2. Model and analyse microgrid systems with generation, storage, and loads.
CO3. Examine the effects of load variations and operating modes on performance and stability.
CO4. Apply basic control, protection, and anti-islanding concepts.
CO5. Demonstrate smart grid features: monitoring, automation, and demand response.
CO6. Use tools and platforms to acquire, monitor, and analyse system data.

Detailed Syllabus:

The Syllabus is same as the Theory Course: Microgrid & Smart Grid Lab (Course Code: 2226113)

List of Experiments:

Note:

- A minimum of 8 experiments shall be performed, including at least 4 Microgrid and 4 Smart Grid experiments, ensuring coverage of LO1–LO6.
- Experiments may be carried out using MATLAB/Simulink, PSCAD, ETAP, OpenDSS, or equivalent software/hardware setups.

Sr No	List of Experiments for Measurement	Hrs
	Microgrid Experiments (At least 4 from the list)	
1.	Model and analyse an AC or DC microgrid system.	2
2.	Set up and study a PV microgrid unit.	2
3.	Integrate battery storage and observe its effect on voltage and power stability.	2
4.	Build and study a mini integrated microgrid with generation, storage, and load.	2
5.	Study the impact of varying loads on microgrid performance and energy flow.	2
6.	Use a DC-DC converter to manage microgrid load voltage.	2
7.	Implement and observe anti-islanding techniques.	2
8.	Integrate distributed generation (PV/Wind) and observe control and stability aspects.	2
	Smart Grid Experiments (At least 4 from the list)	
1.	Explore communication and automation features of a smart grid.	2
2.	Monitor microgrid parameters using Arduino/Raspberry Pi (IoT / Smart Meter).	2
3.	Demonstrate a Smart Meter for energy measurement and monitoring.	2
4.	Demonstrate simple demand response and load control concepts.	2
5.	Analyse effects of load variation on power quality and stability.	2
6.	Simulate feeder and substation automation for grid operation.	2
7.	Industrial Visit / Field Study: Visit a smart grid facility or microgrid and submit a technical report.	2

Sr No	List of Assignments	Hrs
1.	Case study on design and operation of an AC or DC microgrid for a small community or campus.	2
2.	Case study on integration of renewable energy sources and energy storage in a microgrid.	2
3.	Case study on smart grid architecture and deployment of smart meters and AMI.	2
4.	Case study on a smart grid or smart metering pilot project in India highlighting benefits and challenges.	2

Online Resources:

Sr. No.	Website Name
1.	https://www.vlab.co.in/broad-area-electrical-engineering
2.	National Smart Grid Mission (NSGM) India – Policy and pilot projects https://www.nsgm.gov.in
3.	MATLAB/Simulink Microgrid Examples – Simscape Electrical examples https://www.mathworks.com/help/sps/examples.html
4.	OpenDSS (Distribution System Simulator) – Microgrid and smart grid modeling https://sourceforge.net/projects/electricdss/

Term Work:

- Term Work shall consist of at least 8 experiments based on the above list.
- The Term Work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks
(Total Marks) = 15 Marks (Experiment) + 5 Marks (Assignments) +5 Marks (Attendance)

Oral Exam: An Oral examination will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	**Pract.**	**Tut.**	**Theory**	**Pract.**	**Tut.**	**Total**
2226122	Electric Vehicle Technology Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme					
		Theory Marks			Term Work Marks	Oral Exam. Marks	Total Marks
		Internal assessment (IAT)					
		IAT-I	IAT-II	IAT-I +IAT-II (Total)			
2226122	Electric Vehicle Technology Lab	--	--	--	25	25	50

Lab Objectives: The lab course is aimed to

1. Provide hands-on experience with major electric vehicle subsystems and components.
2. Enable experimental analysis of battery systems, motor drives, and power electronic converters used in EVs.
3. Develop skills in testing, measurement, and safety practices related to EV technology.
4. Introduce simulation tools such as MATLAB/Simulink for modeling and analysis of EV systems.
5. Bridge the gap between theoretical concepts and practical implementation of electric vehicle systems.
6. To demonstrate the measurement of resistance, including insulation resistance, using appropriate bridge techniques.

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

CO1. Identify and explain the function of various electric vehicle subsystems and components.
CO2. Perform experimental evaluation of battery charging, discharging, and management systems.
CO3. Analyse performance characteristics of EV traction motors and power electronic converters.
CO4. Implement basic control and testing procedures for EV drives and chargers.
CO5. Model and simulate EV subsystems using MATLAB/Simulink tools.
CO6. Interpret experimental and simulation results to evaluate EV system performance.

Detailed Syllabus:

The Syllabus is same as the Theory Course: Electric Vehicle Technology (Course Code:2226114).

List of Experiments:

Sr No	**List of Experiments**	Hrs
1.	Modeling and Simulation of Lithium-Ion Battery Charge–Discharge Characteristics	2
2.	Simulation of State of Charge (SoC) Estimation Using Coulomb Counting Method	2
3.	Modeling and Simulation of DC Motor Drive for Electric Vehicle Traction Application	2
4.	Simulation of BLDC Motor Drive with PWM Control for Electric Vehicle Application	2
5.	Modeling and Simulation of Three-Phase Inverter for Electric Vehicle Motor Drive	2
6.	Simulation of DC–DC Converter for Auxiliary Power Supply in Electric Vehicles	2
7.	Simulation of Regenerative Braking System in Electric Vehicle	2
8.	Simulation of Electric Vehicle Longitudinal Dynamics and Tractive Effort Calculation	2
9.	Simulation of EV Energy Consumption and Driving Range for Standard Drive Cycles	2
10.	Simulation of EV Acceleration Performance and Gradeability.	2

Sr No	**Hardware based List of Experiments**	**Hrs**
1.	Identification and Functional Study of Major Electric Vehicle Subsystems and Safety Practices.	2
2.	Experimental Analysis of Lithium-Ion Battery Charging and Discharging Characteristics for Electric Vehicle Application	2
3.	Study and Testing of Battery Management System (BMS) Functions Including Protection and Cell Voltage Monitoring	2
4.	Determination of Speed–Torque Characteristics of DC Motor Used for Electric Vehicle Traction	2
5.	Performance Evaluation of BLDC Motor Drive with Electronic Controller for Electric Vehicle Propulsion	2
6.	Experimental Study of DC–DC Buck and Boost Converters Used in Electric Vehicle Powertrain	2
7.	Measurement of Charger Efficiency for Electric Vehicle Application	2
8.	Continuity and Insulation Testing of EV Wiring and Connectors	2
9.	Identification and Troubleshooting of Simple Faults in EV Electrical System	2

Online Resources:

Sr. No.	Website Name
1.	**Virtual Labs** https://www.vlab.co.in *Virtual experiments on electrical machines, power electronics, control systems, and battery modeling.*
2.	**Simscape Electrical Documentation (MATLAB)** https://in.mathworks.com/help/physmod/sps
3.	**AICTE NEAT (National Educational Alliance for Technology)** https://neat.aicte-india.org *Industry-supported online courses and simulation tools related to EV technology.*
4.	**Battery University** https://batteryuniversity.com *Battery fundamentals, charging methods, and performance analysis.*

Assessment:

Term Work: Term Work shall consist of at least 4 experiments & 4 Simulations based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: - The distribution of marks shall be as follows:

- Performance: 05 marks
- Journal: 10marks
- Assignments: 05 marks
- Attendance (Theory and Practical): 05 marks

The final certification and acceptance of term work ensure the minimum passing in the term work

Oral Examination: An Oral examination will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2226123	Solar Energy Technology Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme					
		Theory Marks			Term Work Marks	Oral Exam. Marks	Total Marks
		Internal assessment (IAT)					
		IAT-I	IAT-II	IAT-I +IAT-II (Total)			
2226123	Solar Energy Technology Lab	-	-	-	25	25	50

Lab Objectives: The lab course is aimed to

1. Familiarize students with solar energy resources, potential, and applications.
2. Enable analysis of solar radiation and solar geometry using standard data and calculations.
3. Study operating characteristics of solar photovoltaic cells and modules.
4. Develop basic design and sizing skills for solar PV systems.
5. Understand solar thermal systems and their practical applications.
6. Perform performance and economic analysis of solar energy systems.

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

CO1. Analyze solar energy potential and suitable applications.
CO2. Estimate solar radiation and related parameters for a given location.
CO3. Analyze characteristics and performance of solar PV modules.
CO4. Design basic standalone and grid-connected solar PV systems.
CO5. Explain working and performance of solar thermal systems.
CO6. Evaluate performance and economic feasibility of solar energy systems.

Detailed Syllabus:

The Syllabus is same as the Theory Course "Solar Energy Technology (Course Code: 2226115)".

Experiments may be conducted using hardware setups, simulation tools, standard datasets, or case studies depending on laboratory facilities available.

List of Experiments:

Expt. No.	Name of the Experiment	Hours	LO Mapping
1	Study of solar energy scenario, potential in India, and major solar applications.	2	CO1
2	Calculation of solar angles and estimation of solar radiation for a given location.	2	CO2
3	Study of solar PV cell working principle and PV module datasheet parameters.	2	CO3
4	Plotting I–V and P–V characteristics of a solar PV module using simulation or trainer kit.	2	CO3
5	Analysis of effect of temperature and irradiance on solar PV module performance.	2	CO3
6	Load estimation and design of a standalone solar PV system.	2	CO4
7	Design of grid-connected rooftop solar PV system.	2	CO4
8	Study of solar thermal systems: flat plate collector and solar water heating system.	2	CO5
9	Performance evaluation of solar PV system using PR and CUF.	2	CO6
10	Economic analysis of solar PV system including payback period and life-cycle cost.	2	CO6

Any other experiment based on syllabus which will help students to understand topic / concept.

Assessment:

Term Work: Term Work shall consist of at least 8 practicals based on the above list. Also, Term work Journal must include at least 2 assignments/tutorials.

Term Work Marks: 25 Marks
(Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) +5 Marks (Attendance)

Oral Exam: An Oral examination will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2226124	Lighting System Design Lab	--	2	--	--	1	-	1

Course Code	Course Name	Examination Scheme					
		Theory Marks			Term Work Marks	Oral Exam. Marks	Total Marks
		Internal assessment (IAT)					
		IAT-I	IAT-II	IAT-I +IAT-II (Total)			
2226124	Lighting System Design Lab	--	--	--	25	25	50

Lab Objectives: The Lab course is aimed to

1. To introduce laws of illumination.
2. To introduce different types of lamps and luminaries.
3. To understand the design of interior lighting
4. To understand the design of exterior lighting.
5. To introduce different Lighting Control Scheme
6. To introduce solid state lighting.

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

CO1. Explain the factors affecting illumination scheme.
CO2. Analyse selection and characteristics of different lamps and luminaries.
CO3. Design different interior lighting scheme using lumen method.
CO4. Design different exterior lighting scheme using lumen method.
CO5. Select and Design lighting control scheme.
CO6. Analyse solid state lighting using LED lamps.

Detailed Syllabus:
The Syllabus is same as the Theory Course “Lighting System Design (Course Code: PEC602)”.

Suggested List of Laboratory Experiment:

Sr No	List of Experiments	Hrs
01	Verification of Fundamental Laws of illumination (Inverse Square Law, Lambert’s Cosine Law)	2
02	Measure the power consumption of different lamps (LED, CFL, Incandescent) and their total luminous flux and compare lm/W	2
03	Measure the luminous intensity of a lamp at various vertical and horizontal angles and determine the light distribution pattern.	2

04	Measure the average illuminance in a real classroom or lab using a lux meter and Compare this "Measured Lux" to the "Calculated Lux" using the Lumen Method formula.	2
05	Measure variation in the average illuminance by changing the reflectance of surfaces (e.g., covering a white wall with dark paper)	2
06	Study report on observation and analysis of existing lighting in commercial/ non-commercial installation, industries/offices.	2
07	Study report on observation and analysis of existing lighting in industries/offices,	2
08	Study report on observation and analysis of existing lighting in sports complex.	2
09	Design computer aided design/software simulation and analyse interior lighting.	2
10	Design computer aided design/software simulation and analyse exterior lighting	2
11	Analyse the spectral power distribution (SPD) of various light sources and observe how different light sources (e.g., Warm White vs. Cool White LEDs) affect the appearance of colored objects.	2
12	Use a stroboscope to observe the flicker in discharge lamps (like older fluorescent tubes) and compare it with the flicker-free output of high-quality LED drivers.	2
13	Measure the "Heat Sink" temperature of an LED vs. its "Junction" temperature over 30 minutes and observe how light output (lumens) decreases as the temperature increases.	2
14	Interface an LED driver with a voltage controller. Plot a graph of "Control Signal (%)" vs. "Measured Light Output (Lux)" to determine if the dimming is linear or logarithmic.	2

Any other experiments based on syllabus which will help students to understand topic/concept.

Sr No	List of Assignments
01	Assignments should be based on the entire course of Lighting System Design as per the mentioned Modules.

Virtual Lab Website Reference:

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

Term Work: Term Work shall consist of at least 8 experiments list. Also, Term work Journal must include at least 4 assignments.

Term Work Marks: - The distribution of marks shall be as follows:

- Performance: 05 marks
- Journal: 10marks
- Assignments: 05 marks

- Attendance (Theory and Practical): 05 marks

The final certification and acceptance of term work ensures the minimum passing in the term work

Oral Examination: An Oral examination will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2226125	Special Electrical Machines Lab	-	02	-	-	1	-	1

Course Code	Course Name	Examination Scheme					
		Theory Marks			Term Work Marks	Oral Exam. Marks	Total Marks
		Internal assessment (IAT)					
		IAT-I	IAT-II	IAT-I +IAT-II (Total)			
2226125	Special Electrical Machines Lab	--	--	--	25	25	50

Lab Objectives: The lab course is aimed to

1. Provide practical exposure to construction and operation of special electrical machines.
2. Develop skills in implementing power electronic converters for special machines.
3. Train students in configuring control strategies for modern motor drives.
4. Enhance proficiency in measuring performance characteristics of special machines.
5. Strengthen ability to analyze torque-speed and dynamic responses experimentally.
6. Promote competence in integrating microcontroller/DSP-based motor control systems.

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

LO1: Operate stepper motor and evaluate its characteristics.
LO2: Implement control strategies for SRM drive systems.
LO3: Configure electronic commutation and PWM control for BLDC motor.
LO4: Validate performance characteristics of PMSM drive.
LO5: Analyze performance of synchronous reluctance motor.
LO6: Determine thrust characteristics of linear induction motor.

Detailed Syllabus:

The Syllabus is same as the Theory Courses “Special Electrical Machine (Course Code:2226117)”

List of Experiments:

Sr No	List of Experiments/Simulations	Hrs.
1.	Operate and Plot Characteristics of a Stepper Motor	2
2.	Implement/Test Open-Loop and Microcontroller-Based Stepper Motor Control	2
3.	Study of Basic Power Converter Circuit for SRM	2
4.	Identify the Constructional Features of SRM	2
5.	Analyze Torque-Speed Characteristics of SRM	2

6.	Operate a BLDC Motor with Electronic Commutation	2
7.	Regulate Speed Control of BLDC Motor Using PWM	2
8.	Compare Sensor-Based and Sensorless Control of BLDC Motor	2
9.	Verify Performance Characteristics of PMSM	2
10.	Vector Control (FOC) Simulation of PMSM	2
11.	PMSM Parameter Identification	2
12.	Compare Performance of Synchronous Reluctance Motor with PMSM	2
13.	Analysis of torque-speed characteristics and power factor in a Synchronous Reluctance Motor	2
14.	Study of Experimental setup to measure the "Thrust vs. Slip" relationship and study the "End Effect".	2
15.	Determine Thrust Characteristics of Linear Induction Motor	2
16.	Design and Integrate Closed-Loop Speed Control of BLDC or PMSM	2
17.	Develop and Demonstrate Sensorless Control Algorithm for SRM / PMSM	2

Sr No	**List of Assignments / Tutorials for Measurement Lab**	Hrs.
01	Comparative Study of Stepper Motor Types and Control Methods	2
02	Analysis of Switched Reluctance Motor Drive System	2
03	Electronic Commutation and Control of BLDC and PMSM	
04	Survey of Recent Research Trends in Special Electrical Machines	

Any other experiment based on syllabus which will help students to understand topic / concept.

Note: Students and teachers are encouraged to use the virtual labs whose links are as given below the remote access to Labs in various disciplines of Science and Engineering is available. Students can conduct online experiments which would help them in learning basic and advanced concepts through remote experimentation.

Virtual Lab Website Reference

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

Term Work: Term Work shall consist of at least 8 practicals based on the above list (but not limited to). Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Oral Exam: An Oral examination will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
2226126	Wind Energy Technology Lab	3	-	-	3	-	-	3

Course Code	Course Name	Examination Scheme					
		Theory Marks			Term Work Marks	Oral Exam. Marks	Total Marks
		Internal Assessment Test (IAT)					
		IAT-I	IAT-II	IAT-I + IAT-II (Total)			
2226126	Wind Energy Technology Lab	–	–	–	25	25	50

Course Objectives: The course is aimed to

1. Provide hands-on exposure to wind energy systems, components, and measurement tools.
2. Develop practical skills in measurement, observation, simulation, and analysis of wind energy systems.
3. Familiarize students with industry-relevant tools, standards, and real-world wind energy practices.
4. Enhance understanding of wind turbine performance, grid integration concepts, and case studies through experiments.

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

CO1. Operate wind measurement instruments such as anemometer and wind vane to record wind parameters.

CO2. Perform experiments to observe constructional features and working of wind turbine components.

CO3. Simulate wind energy conversion systems and obtain performance characteristics.

CO4. Measure and analyze electrical parameters of wind generator systems using appropriate instruments/software.

CO5. Execute performance evaluation and interpret results of wind energy systems under varying conditions.

CO6. Prepare and document technical reports based on experimental results and wind energy case studies.

List of experiments:

Sr. No.	Experiment Title	CO Mapping
1	Study of wind energy conversion system (WECS): components, layout, and safety practices	`CO2
2	Measurement of wind speed and direction using anemometer and wind vane	CO1
3	Determination of wind power density and estimation of available wind power from measured data	CO1, CO5
4	Study of HAWT and VAWT models – constructional features and working	CO2

	principles	
5	Simulation of wind turbine power characteristics using MATLAB/Simulink or equivalent software	CO3, CO5
6	Simulation of grid-connected wind energy system with different generators (SCIG / DFIG / PMSG)	CO3, CO4
7	Study of power quality issues in grid-connected wind systems using simulation or case data	CO4, CO5
8	Performance analysis of wind turbine based on tip speed ratio and power coefficient (Cp)	CO5
9	Case study on an operational wind power plant in India (site, capacity, technology, standards used)	CO6
10	Study of IEC 61400 standards related to wind turbine safety, performance, and grid integration	CO6
11	Visit to wind energy installation / virtual lab experiment on wind energy systems	CO2, CO6
12	Mini case study on techno-economic and environmental aspects of wind energy projects	CO6

Note: *Minimum 8 experiments required to be conducted in lab sessions. Any other experiment related to wind energy can be conducted in lab.*

Equipment / Software Required:

- Cup or digital anemometer
- Wind vane
- Wind turbine trainer kit / models (HAWT & VAWT)
- Electrical measuring instruments
- MATLAB/Simulink or equivalent simulation software
- Access to MNRE / IEC wind energy data and reports

Termwork Marks Distribution: 25 marks

Performance:10 marks
Journal: 5 marks
Attendance:5 marks

Oral Examination will be based on entire syllabus: 25 Marks

Relevant Standards (Exposure Level):

- IS 875 (Part 3): Wind loads on structures
- IEC 61400 series: Wind turbine design, performance, and safety
- IEC 61400-21: Power quality of grid-connected wind turbines
- ISO 9001 and ISO 14001 (overview related to wind projects)

Suggested Assessment Scheme:

- Continuous assessment based on experiment performance and observation
- Record book and timely submission
- Case study / simulation report
- Viva-voce

References:

1. Sathyajith Mathew, *Wind Energy: Fundamentals, Resource Analysis and Economics*, Springer.
2. T. Burton et al., *Wind Energy Handbook*, Wiley.
3. MNRE wind energy laboratory manuals and reports**.**

Vertical – 4
VSEC

Sem.VI

Course Code	Course Name	Teaching Scheme (Contact Hours/Week)		Credits assigned		
		Theory	Pract. / Tut.	Theory	Pract./Tut.	Total
2226411	Industrial Automation	--	2*+2	--	2	2

Course Code	Course Name	Examination Scheme				
		Theory			Term Work Marks	Total Marks
		Internal Assessment				
		IAT-I	IAT-II	IAT-I+IAT-II Total		
2226411	Industrial Automation	--	--	--	50	50

Course Objectives: The lab course is aimed to

1. To introduce students to the fundamentals of industrial automation and modern control systems.
2. To study the construction, working, and application of industrial components such as sensors, actuators, PLCs, drives, and HMIs.
3. To provide hands-on experience in wiring, programming, and testing PLC-based automation systems.
4. To understand basic pneumatic, hydraulic, motion control, and IoT-based automation applications.
5. To create awareness about industrial safety practices, standards, and ethical considerations.

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

1. Identify and explain the function of various industrial automation components and subsystems.
2. Design and implement PLC-based control systems for real-life industrial applications.
3. Develop ladder logic programs and interface sensors, actuators, and drives effectively.
4. Configure and use HMI/SCADA systems for monitoring and control applications.
5. Implement basic pneumatic, hydraulic, and motion control systems.
6. Apply IoT concepts for monitoring, data acquisition and automation in industrial and smart systems.
7. Demonstrate awareness of industrial safety practices, standards, and ethical considerations.

Section A

Note: * Lab contents shall be covered through some of the following ways:

1) Class room discussions / Expert Lectures
2) Visiting various industries involving such facilities to illustrate industrial automation
3) Multiple day webinar specifically organized to cover such contents
4) In-house facility for demonstration of Industrial automation

5) Hands-on Workshop
6) Exhibitions showcasing these technologies
7) Using Virtual Instrumentation platform
8) Using Virtual Lab platform (Virtual Labs (vlab.co.in))

Contents:

1) Components and subsystems used in Industrial automation:

1. Controllers: Computers, Programmable Logic Controllers (PLC), Distributed Control Systems (DCS), Programmable Automation Controllers, Embedded Controllers.
2. Operator Interfaces (HMI & Visualization): Text-based and Graphical HMI, Touchscreens Panels, Web-based HMI, Mobile and Cloud-based Dashboards, Human-Centric Interfaces (Cobots and AI as Assistant).
3. Sensors: Analog & Digital; Encoders, Proximity sensor, Ultrasonic Sensors, Photoelectric Sensors; Limit Switches, Energy, Temperature, Pressure, Flow, Piezoelectric Sensors.
4. Actuators: Pneumatic, Hydraulic, Electric; Motors-AC, DC, Linear, Servo and Stepper motor, BLDC and PMSM (EV & Industry relevance).
5. Mechanisms and Industrial Motion Systems: Gear systems, Linkages and Couplings: Linear motion systems (Ball screw, Linear motors); Mechatronic Systems; Automated Guided Vehicles (AGVs) – Introductory.
6. Material handling and Conveying Systems: Belt, Roller, Chain, Vibrating, Pneumatic, Automated Warehousing and Logistics Systems.
7. Motion Control and Control Architectures: Motion Profile (trapezoidal velocity motion, S-curve velocity motion and Multi-axis motion), Distributed Control System Architectures, DCS Functional Block Diagrams, and Sequential Flow Charts.
8. Industrial Communication & Networks: Fieldbus: Modbus, Profibus, CAN; Industrial Ethernet: Profinet, EtherCAT, Ethernet/IP; Wireless: Industrial Wi-Fi, 5G basics; OPC-UA & MQTT; Cybersecurity in Industrial Systems.
9. Industrial Automation Software Platforms: PLC programming, SCADA, Digital Twin and System Modelling Tools (Introductory), Data Acquisition and Monitoring Software etc.

2) Industry 4.0:

Concept, components and architecture of Industry 4.0 systems; Technology roadmap and digital transformation in manufacturing; Key technologies and applications: Industrial Internet of Things (IIoT), Data analytics in manufacturing, Robotics and collaborative robots, Additive manufacturing and 3D printing, Augmented/Virtual Reality (AR/VR); Introduction to Digital Twin and transition towards Industry 5.0, Key concept of Industry 5.0: Human-Centric, Sustainable, and Resilient Industrial Systems.

3) Real life Applications:

a) Smart Agriculture Systems: Automated crop sorting, grading, irrigation and greenhouse monitoring using sensors and IoT.
b) Automated / Robotic Assembly line
c) Temperature Control in Process Industries
d) Cyclic Operation of Traffic Lights
e) Conveyor System for an Assortment of Objects
f) Automatically filling of two tanks with liquid
g) Automated warehouse management system
h) Automated packaging & bottle filling plant
i) Software Development: Continuous Integration/Continuous Deployment (CI/CD) for automated testing and release

4) Industrial Safety, Standards & Ethics:
Electrical & Machine Safety, Safety Integrity Levels (SIL), Emergency Stop categories, and the use of Safety Relays or Safety PLCs., Functional Safety, PPE & Industrial Acts, Sustainability & Green Automation, Ethics in Automation & AI

Section B

Based on the insights received with the coverage of syllabus contents specified in section A, the students should carry out detailed study of **at least six** different applications listed below (**maximum two from any group is desirable**). They should have hands-on experience with each of these applications. Wherever possible; design of digital twin/ software development / coding/ should be done by students.

Group 1: Pneumatic and Hydraulic based Industrial Automation systems
a) Electro-Pneumatic System for Pickup and Place Applications
b) Design and assembly of Pneumatic / Hydraulic circuit and wiring of control interface for any application
c) PLC controlled Pneumatic / Hydraulic valves and actuators for any application
d) Design and implementation of a PLC-controlled multi-cylinder Electro-Pneumatic sequence using State-Machine logic
(Any other application which incorporates Pneumatic and Hydraulic components)

Group 2: Drives and Control- Industrial Automation systems
a) Linear Motion Control System
b) PLC based Motion Control System
c) VFD control of Motor
d) HMI/ SCADA interface-based Control
e) Control of conveyors and storage operations
f) Sorting and grading System for Agriculture Applications
g) Web-based Monitoring of an Industrial Process

h) Lift control System (Demo)
i) Automated Guided Vehicles (Demo)
j) Solar tracking system (Demo)
(Any other application which incorporates Drives and Control)

Group 3: Industrial IoT based Applications
a) Smart Agriculture
b) Smart City and Infrastructure Automation
c) Smart Healthcare Systems
d) Wearable and Smart Life Systems
e) Smart Monitoring Systems
f) Smart Grid and Energy
g) Predictive Maintenance or Remote Condition Monitoring
h) Industrial Energy Analytics
i) Industrial Asset Monitoring
j) Smart Communication
(Any other application which incorporates IoT)

Group 4: Other Applications: Based on PLC/ Embedded micro-controller
a) To wire up hardware, write and implement ladder programs for the following controls.
    i. Traffic light control
    ii. Water level control
    iii. Bottle Filling & Packaging System
    iv. Material Sorting System
b) Tune PID controller for heat exchanger using DCS
c) Implementation of an Interlock Logic for a Multi-Motor System
d) Implementing Safety Interlocks and Fault Diagnostics for Industrial Machine Protection
e) Implementing and Tuning a PID Controller for Level or Temperature using DCS/PLC
e) PID Speed Control of DC/AC Motor
(Any other suitable application)

Note: For each of the experiment carried out, students should prepare a detailed report, clearly specifying following:
[1] Technical description and specification of the system
[2] Drawing/ schematic/ block diagram for system visualization
[3] Components used and their specification
[4] Interconnectivity between the components
[5] Working principle
[6] Software tools used
[7] Program code (if any) developed
[8] Observations

[9] Photographs of the system

Books Recommended:

1. Industrial Automation Hands-On, by Frank Lamb, McGraw-Hill, 2013
2. Industrial Motion Control- Motor Selection, Drives, Controller Tuning, Applications, by Hakan Gürocak Wiley, 2025
3. Industry 4.0: Managing The Digital Transformation, by Alp Ustundag and Emre Cevikcan, Springer, 2018
4. Industry 5.0: The Human-Centric Future of Industry, by Muhammad Hammad, Hassan Ali, Ghulam Hussain, Xiaoping Wang, Springer (2025–2026)
4. Introduction to Industrial Automation, by Stamatios Manesis and George Nikolakopoulos, CRC Press, 2018

List of Recommended Software (Open source/multi-platform):

1. **Software platforms**
   a) Programming: CODESYS
   b) SCADA/HMI platform: Rapid SCADA, ScadaBR
   c) IIoT: Things Board (Community Edition), Node-RED, Grafana, Ignition (SCADA).
2. **Simulation & Virtual Labs**
   a) Wokwi (Browser-based): Simulator for Arduino and ESP32 for the "Embedded" and "Sensor" parts.
   b) CADE Simu (Freeware): Designing and simulating electrical circuits and basic PLC logic.
   c) Virtual Labs
   d) Hopsan: Simulating Fluid Power (Pneumatics and Hydraulics)
3. **Mobile Apps Learning**
   a) Macro PLC (Android): Ladder Logic simulator
   b) PLC AI (iOS/Android): AI based PLC concepts and troubleshoot code.
   c) MQTT Dash (Android): Designing IoT dashboard to control devices via the MQTT protocol.
   d) NIOSH Ladder Safety: Simulator for Industrial Safety

Term Work: 50 Marks

Term work shall consist of minimum requirement as given in the syllabus. The distribution of marks for term work shall be as follows:

Presentation & Report Submission:	25 marks
Laboratory Performance:	15 marks
Journal:	05 marks
Attendance:	05 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Vertical - 5
AEC
Sem. VI

PROFESSIONAL SKILLS 2026

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
AEC601	Professional Skills	--	2*+2	--	--	2	-	2

		Theory					Term Work	Practical / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
AEC 601	Professional Skills	--	--	--	--	--	25		25

Course Rationale:

This course equips engineering students with professional communication, ethical values and soft skills essential for global industry demands. It enhances technical writing, presentation and interpersonal abilities through practical sessions, fostering confidence, teamwork and social responsibility as competent engineering professionals.

Course Objectives - Students are expected to learn to:

1. **Develop** effective speaking, presentation, group discussion and interview skills required for employability and professional success.
2. **Analyse and evaluate** AI-generated content for accuracy, bias, credibility and ethical professional use.
3. **Prepare** clear, concise and professional technical/business documents such as resumes, reports, SOP and formal correspondence.
4. **Demonstrate** managerial and collaborative skills required for conducting meetings, preparing proposals and workplace communication.
5. **Apply** interpersonal, critical thinking, negotiations, time management, leadership, decision-making and adaptability skills for lifelong learning and career growth.
6. **Exhibit** ethical values, intellectual property awareness, digital responsibility and professionalism in workplace practices.

Course Outcomes - Students will be able to:

1. **Demonstrate** effective speaking skills through participation in group discussions, interviews, presentations and collaborative activities.
2. **Analyse and evaluate** AI-generated content in terms of quality, bias, reliability and ethical use for academic and professional purposes.
3. **Create** professional documents such as resumes, cover letters, statements of purpose, reports and other technical/business correspondence using standard formats.

4. **Organise and execute** professional meetings, proposals and technical papers using appropriate workplace communication strategies and digital tools.
5. **Apply and demonstrate** interpersonal skills such as leadership, critical thinking, negotiation, decision-making, time management and adaptability to support career growth and lifelong learning.
6. **Exhibit** ethical practices, digital responsibility and awareness of intellectual property rights in professional environments.

DETAILED SYLLABUS

Sr. No.	Name of the Module	Content	Hours	CO Mapping
1	**Employability Skills: Advanced Speaking**	**1.1. Group Discussions (GDs)** • Purpose, Evaluation parameters, GD etiquette • Types: Factual (Regular & Controversial), Abstract, Case-based (Textual & Picture-based) and Role-plays (Textual & Cue-card-based) • Online GDs and digital collaboration etiquette (Zoom, Google-Meet, MS Teams etc.) **1.2. Personal Interviews** • Planning and preparation for Technical and HR interviews • Interview types: Structured, Stress, Behavioural and Case-based • Virtual interviews, AI-assisted interview simulations and post-interview reflections (Google Interview Warmup, Yoodli, Pramp etc.) **1.3. Presentation Strategies** • Purpose, Audience analysis, Content organisation • Slide design, Text, Infographics and AI-based presentation design (Canva, Beautiful.ai, Gamma AI etc.) • Division of roles, collaborative preparation and seamless transitions	8	CO1
2	**Critical AI Literacy**	• **Nature of AI Generated Language -** Understanding AI-generated language as probabilistic output and distinguishing between Fluency and Accuracy while identifying risks such as AI Slop and Hallucination • **Evaluating AI Content -** Differentiating	4	CO2

		between Evidence and Assertion and applying verification strategies to assess Accuracy, Clarity and Depth • **Bias, Framing and Information Silos -** Understanding linguistic Bias, Framing, Information Silos and Selective Exposure that shape AI responses and limit perspective • **Drafting, Editing and Prompt Engineering with AI -** Using AI for Drafting and Editing through effective Prompt Engineering while maintaining originality, specificity and professional voice • **Identifying Low-Quality AI Content -** Identify markers of low-quality AI content, such as repetition, lack of depth, and absence of concrete detail, while applying ethical practices that distinguish Assistance from Substitution and ensure responsible AI use		
3	**Employability Skills: Advanced Technical Writing**	**3.1. Cover Letter & Resume** • Difference between Bio-data, Resume and CV • Resume types: Chronological, Functional and Hybrid • Resume structure and content • Digital resumes, Application Tracking System (ATS) friendly formatting and LinkedIn portfolio integration **3.2. Reports** • **Purpose:** Importance of reports in engineering and industry decision-making • **Classification of Reports:** *Subject Matter - Technical, R&D, Operations, Finance, Marketing etc.* *Time Interval - Periodic, One-time, Special* *Function - Informational, Examinational and Analytical* *Reader Writer Relationship – Administrative, Professional and Independent* *Format – Memo, Letter, Short, Long, E-Reports, Digital Dashboards* *Digital and AI-aided reporting formats (Power BI, Google Data Studio, ChatGPT etc. for summaries)* • **Parts of a Long Formal Report**	8	CO3

		Prefatory Parts: Title Fly, Title Page, Letter of Transmittal, Table of Contents, List of Illustrations, Executive Summary *Report Proper (Main Body): Introduction, Intervening chapters with headings as per the topic, Result & Analysis, Summary (Informational)* ***Or*** *Summary & Conclusions (Examinational)* ***Or*** *Summary, Conclusions & Recommendations (Analytical)* *Appended Parts: Appendix, List of References, Glossary, Index* • **Language and Style of Reports** *Tense, person and voice appropriate to reports* *Numbering and labelling conventions for figures, tables, charts, equations etc.* *Referencing formats (APA, MLA etc.)* *Plagiarism checks (Turnitin, Grammarly, other AI-detectors etc.)* **3.3. Statement of Purpose (SOP)** • **Purpose:** SOPs for international internships, funding for research programs and higher education • **Structure:** *Paragraph 1 - Hook (introducing yourself in a unique manner and demonstrating your passion for the field)* *Paragraph 2 - Academic Background* *Paragraph 3 - Research-oriented Endeavours* *Paragraph 4 - All-round Development* *Paragraph 5 - Reasons for choosing the Program and Institution* *Paragraph 6 - Conclusion and Thank-you note*		
4	**Workplace Managerial Skills**	**4.1. Conducting Business Meetings** • **Types of Meetings:** *Executive Meetings - Decide* *Management Meetings - Implement* *Committee Meetings - Recommend* *Review Meetings - Evaluate* *Planning Meetings - Design the future* *Crisis Meetings - Resolve urgency* • **Roles and Responsibilities:** *Chair - Leads meeting, maintains order, ensures decisions*	6	CO4

		Secretary - Records minutes, documents decisions, tracks actions *Core Members - Discuss issues, contribute ideas, make decisions* *Specialists - Provide expertise, clarify issues, support decisions* • **Documentation:** *Notice, Agenda and Minutes* • **Meeting Platforms and AI Assistance:** *Virtual and hybrid meeting management, online etiquette, use of collaborative tools (Google Meet, Slack, Trello etc.)* *Digital documentation, e-Minutes and collaborative platforms like Notion or Microsoft OneNote* **4.2. Writing Proposals** • **Types:** Solicited vs. Unsolicited • **Format:** Memo, Short and Long • **Parts of a Short Proposal:** *Purpose of the proposal* *Need for the proposal (SWOT analysis)* *Description of the plan (budget, timeline etc.)* *Evidence of ability to deliver* *Benefits to both parties* *Conclusion* **4.3. Structuring and Formatting Technical Papers** • **Components:** *Title, Author(s) & Affiliations, Abstract, Keywords/Index Terms, Introduction, Sections with different headings, Results, Discussion, Conclusion, Acknowledgement, References, Biography* • Formatting and referencing (IEEE style) • Use of AI tools for grammar check, plagiarism validation and submission to international conferences		
5	**21st Century Professional Skills**	**5. Interpersonal Skills** • Emotional Intelligence • Critical thinking, Reflection & Self Analysis • Leadership and Motivation Strategies • Conflict Management and Negotiation	6	CO5

		• Time Management • Anger and Stress Management • Decision Making and Adaptability		
6	**Digital Ecosystems and Ethics**	**6.1. Intellectual Property Rights (IPR)** • **Categories:** Copyrights, Trademarks, Patents, Industrial Designs, Geographical Indications, Integrated Circuits and Trade Secrets • AI-generated content ownership, open-source ethics, digital rights management • Social Media Content and Legal Responsibility **6.2. Case Studies on Corporate and Engineering Ethics** • Real-world ethical dilemmas • Corporate Social Responsibility (CSR) • Environmental Social Governance (ESG) • Sustainability and Green Engineering • AI Ethics in Design and Automation	4	CO6

ASSESSMENTS

List of Compulsory Assignments for Term Work:

Module 1: GD documentation with Topic, Type and Highlights in 5 bullet points
Module 2: Assignment on Prompt Engineering
Module 3: **A -** Cover Letter, Resume and **B** - Statement of Purpose
Module 4: Meeting Documentation (Notice, Agenda & Minutes)
Module 5: Activities on Interpersonal Skills
Module 6: Case study on Ethical Dilemma

(To be conducted in the form of short notes, quizzes, role plays, case studies, presentations or MCQs)

SUGGESTED ASSIGNMENTS

Module No. & Title	Assignments and Activities
Module 1 Employability Skills: Advanced Speaking	• Conduct 4-5 types of Group Discussions and attach the summary and photographs as proof of activity • Prepare group presentation slides, based on the report topic (Examinational or Analytical) using the latest presentation software (PowerPoint, Canva, Prezi etc.) and engage students in giving critical

	feedback • Present an ‘Elevator Pitch ’for either self-introduction or product or new business idea • Conduct mock interviews
Module 2 **Critical AI Literacy**	• Select an essay/article/video generated by AI (or give a general prompt) and analyse and detect AI bias (gender pronouns, gender-based occupational stereotypes, racial identifiers, historical bias etc.) • Differentiate between weak and strong prompts • Source verification task • AI versus human writing analysis
Module 3 **Employability Skills: Advanced Technical Writing**	• Draft a professional Cover Letter and Resume • Write a Statement of Purpose (SOP) for higher studies or internships • Develop or enhance a LinkedIn profile showcasing technical and project achievements • Prepare a book-format analytical/informational report using IEEE/APA/MLA referencing and plagiarism check tools (Grammarly/Turnitin). Main body should be minimum 20 pages excluding the Preparatory and Appended parts
Module 4 **Workplace Managerial Skills**	• Conduct a mock meeting with assigned roles (Chairperson, Secretary, Members) and generate documentation with the help of the latest software • Write a short proposal addressing an engineering or sustainability problem • A quiz on the formatting aspects of a Technical Paper
Module 5 **21st Century Professional Skills**	• Activities for developing team work, leadership, emotional intelligence etc. • Problems and Puzzles on Critical thinking • Case-studies or Role-plays or Questionnaires on Conflict Resolution, Negotiation Skills and Decision Making • Application of SWOT analysis • Eisenhower Matrix to analyse a daily time log
Module 6 **Digital Ecosystems and Ethics**	• Conduct an awareness quiz on IPR laws and ethical business practices. • Analyse a corporate ethics case study • Digital footprint audit of Self Profile • Fake News and Deep Fake verification task

IMPORTANT NOTE

1. The main project/book report should contain a minimum of 20 pages, excluding prefatory and appended matter.
2. Each project group must consist of a minimum of 4 and a maximum of 6 students.
3. End-semester presentation will be based on the book/project report.

GUIDELINES FOR TERM WORK MARKS DISTRIBUTION

Components	***Marks 25***	***Description***
6 Compulsory Assignments	***5***	*Based on completion and quality of module-wise tasks.*
Attendance & Participation	***5***	*Class engagement, teamwork, and professionalism.*
GD	***5***	*Based on group and individual performance*
Report Hardcopy	***5***	*Quality, structure and originality of the report*
Oral Report Presentation	***5***	*Based on group and individual performance*

RECOMMENDED RESOURCES:

1. Raman, M., & Sharma, S. (2022). *Technical communication: Principles and practice* (4th ed.). Oxford University Press.
2. Anderson, P. V. (2018). *Technical communication: A reader-centred approach* (9th ed.). Cengage Learning.
3. Lesikar, R. V., Flatley, M. E., & Rentz, K. (2008). *Basic business communication* (11th ed.). McGraw-Hill.
4. Institute of Electrical and Electronics Engineers. (2020). *IEEE code of ethics*. IEEE.
5. American Society of Mechanical Engineers. (2021). *ASME code of ethics of engineers*. ASME.
6. Guffey, M. E., & Loewy, D. (2018). *Essentials of business communication* (11th ed.). Cengage Learning.
7. Sharma, R. C., & Mohan, K. (2017). *Business correspondence and report writing* (4th ed.). Tata McGraw-Hill Education.
8. Ram, A. (2018). *Place mentor: Tests of aptitude for placement readiness*. Oxford University Press.
9. Kumar, S., & Lata, P. (2018). *Communication skills: A workbook*. Oxford University Press.
10. Butterfield, J. (2017). *Verbal communication: Soft skills for a digital workplace*. Cengage Learning.
11. Crawford, K. (2021). *Atlas of AI: Power, politics, and the planetary costs of artificial intelligence*. Yale University Press.
12. Kearns, M., & Roth, A. (2019). *The ethical algorithm: The science of socially aware algorithm design*. Oxford University Press.

ONLINE RESOURCES:

1. Ravichandran, T. (n.d.). *Enhancing soft skills and personality* [NPTEL course]. National Programme on Technology Enhanced Learning. https://nptel.ac.in
2. Ravichandran, T. (n.d.). *Developing soft skills and personality* [SWAYAM MOOC]. SWAYAM. https://swayam.gov.in
3. Coursera. (n.d.). *Business communication for success* [Online course]. https://www.coursera.org
4. edX. (n.d.). *Business communication for success* [Online course]. https://www.edx.org
5. All India Council for Technical Education. (n.d.). *Employability enhancement and life skills modules*. AICTE NEAT. https://neat.aicte-india.org
6. Indian Institute of Technology Guwahati. (n.d.). *Virtual English and communication virtual lab.* Virtual Labs. https://ve-iitg.vlabs.ac.in/
7. Indian Institute of Technology Bombay. (n.d.). *Professional communication virtual lab*. Virtual Labs. http://vlabs.iitb.ac.in/vlabs-dev/labs/communication/
8. TCS iON. (n.d.). *Communication skills* [Online course]. https://www.tcsion.com/courses/tcs-ion/communication-skills/
9. TCS iON. (n.d.). *Introduction to soft skills* [Online course]. https://www.tcsion.com/courses/interview-and-job-prep/introduction-to-soft-skills/
10. TCS iON. (n.d.). *Presentation skills* [Online course]. https://www.tcsion.com/courses/tcs-ion/presentation-skills/

Course	Course Name	Teaching Scheme	Credits Assigned

Vertical - 5
Indian Knowledge System (IKS)

Sem. V

Code		(Contact Hours)						
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
IKS501	Indian Knowledge System	--	2*+2	--	--	2	-	2

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Total					
IKS501	Indian Knowledge System	--	--	--	--	--	50	--	50

*** Two hours of practical class to be conducted for full class as demo/discussion.**

Rationale:

The proposed IKS modules contextualize core engineering principles across Computer, IT, EXTC, Electronics, and Electrical engineering—within scientifically analyzable Indian knowledge traditions. By mapping indigenous practices to modern technical frameworks, students critically examine foundational engineering concepts through interdisciplinary and systems-based perspectives. This approach strengthens conceptual understanding, promotes analytical reinterpretation of traditional knowledge using contemporary tools, and aligns engineering education with culturally rooted yet technically rigorous inquiry.

Prerequisite: --

Course Objectives:

1. Provide foundational knowledge of Indian acoustic practices.
2. To Understand Ancient Indian use of renewable energy.
3. Introduce Sanskrit grammar in simple language, with special attention to its rule-based structure.
4. Learners should be able to explain key contributions of ancient Indian mathematics in simple language.
5. Understand how Indian traditions of logic, language, knowledge organization, design thinking, governance, sustainability, and wellbeing can support modern IT solutions.
6. Understand the basic structure of Sanskrit grammar and relate selected grammatical ideas to computational modules used in information technology.

Course Outcomes:

On successful completion of the course learner will be able to:

1. Analyze traditional Indian acoustic practices and interpret their relevance to frequency analysis.
2. Apply the traditional knowledge to modern energy solutions and sustainable engineering.
3. Apply Indian Knowledge Systems in linguistics, Sanskrit-based NLP, traditional number systems, measurement practices, and ancient rainfall prediction techniques using calendars, nakshatras, and natural indicators.
4. Apply basic modular arithmetic, pattern recognition, and place-value ideas to simple IT examples such as coding, data representation, and checksums.
5. Apply basic concepts of Indian Knowledge Systems such as logic, language, knowledge organization, ethics, sustainability, and responsible decision-making to design simple technology-based solutions like apps, chatbots, databases, or awareness tools.
6. Apply basic Sanskrit grammar concepts and Pāṇinian rule-based principles to understand formal grammar, algorithms, and simple computational language processing applications in IT.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	**Prerequisite**	-	-	-
I	**Acoustic Science in Vedic Chanting and Indian Music**	I.1 Concept of Nāda (Sound) and Shruti • Physical interpretation: frequency, pitch, harmonic content • Shruti system (22 microtones) and frequency discrimination I.2 Resonance and Architectural Acoustics • Temple architecture and echo control • Natural acoustic amplification • Relation to reverberation time and standing waves I.3 Structured Sound Encoding in Vedic Recitation • Pada, Krama, Ghana patha recitation methods • Built-in redundancy → error detection and correction • Parallel to digital communication redundancy schemes **Self-Study:** Study of sounds and analysis in time and frequency domains.	**10**	**CO1**
II	**Tradition**	1. Introduction to IKS in renewable energy 2. Ancient Indian use of renewable energy a) Solar Energy: Solar Architecture, Solar Heating Systems b) Wind Energy: Ancient Windmills, Wind- Powered Water Lifting c) Water (Hydro) Energy: Ancient Watermills, Irrigation Systems d) Bioenergy: Biomass Fuel, Bioenergy Production 3. Integration of ancient Traditional knowledge of renewable energy with Modern Technologies.	**10**	**CO2**

		Students shall study the following to understand the use of ancient technologies in Renewable Energy: • Gujarat Windmills • Watermills in the Indus Valley • Konark Sun Temple		
III	**Linguistics, Number Systems, and rainfall Prediction**	Linguistics: • Components of language • Panini's work on Sanskrit grammar • Role of Sanskrit in Natural Language Processing Number System and Units of Measurement • Number system in India- Historical Evidence • Decimal System • Unique Approaches to represent Numbers-Katapayadi System • Pingala and the Binary System Ancient Indian techniques for predicting Rainfall • Introduction • Elements of the Indian Calendar • Panchang and Nakshtras • Non-bio indicators and Bio indicators **Self-Learning:** • An Ecosystem for Sanskrit Language Processing • Salient Features of the Indian Numeral System • Salient Features of the Indian Numeral System • Measurement for Time Distance and Weight • Measurement of Time- An Illustration from Purana	**10**	**CO3**

IV	**Mathematics Foundations in Ancient India and Its Relevance to Information Technology**	4.1 Historical context and number ideas: Indian knowledge systems, the development of numeration, zero as placeholder and number, decimal place value. 4.2 Major contributors and procedural mathematics: Aryabhata, Brahmagupta, Bhaskara II, and examples of rule-based or sutra-like calculation methods in plain language. 4.3 Algorithmic thinking and computation: Historical mathematical procedures connect to algorithms, flowcharts, decomposition, and computational logic. 4.4 Modular arithmetic, binary-style ideas, and data representation: Clock arithmetic, remainders, cyclic reasoning, two-state representation, bits, bytes, and simple binary conversion. 4.5 Relevance to IT and synthesis: Coding, checksums/parity, simple cryptography idea, data representation, and how ancient mathematical thinking supports modern IT problem-solving. **Self-Learning Topics and Activities:** • Zero and place value in daily life • Algorithmic thinking • Modular arithmetic • Binary representation	**10**	**CO4**
V	**Indian Logic and its applications in Information Technology**	5.1 Introduction to IKS and its relevance to contemporary technology. 5.2 Indian logic, language, and computation	**10**	**CO5**

		with simple examples. 5.3 Knowledge organization, data, and decision-making. 5.4 Ethics, society, sustainability, and responsible digital systems. 5.5 Mini activity where students design a small app, chatbot, database, or awareness tool using one IKS principle. **Self-Learning Topics and Activities:** • Basic ideas of Nyaya logic: observation, inference, debate, and evidence. • Introduction to Paninian grammar and why structured language matters in NLP. • Traditional knowledge classification and its connection with databases and knowledge graphs. • Technology for Indian languages, heritage preservation, digital museums, and public services. • Design thinking activity: identify a local problem and propose an IKS-inspired IT solution.		
VI	**Sanskrit Grammar and Computational Modules**	6.1 Introduction to Indian Knowledge Systems, Sanskrit as structured language, and relevance to IT. 6.2 Basic Sanskrit grammar concepts: sounds, words, roots, suffixes, sandhi, and sentence structure. 6.3 Pāṇinian grammar as a rule-based system; relation with algorithms and formal grammar.	**10**	**CO6**

		6.4 Computational modules: tokenization, morphology, parsing, language rules, and NLP examples. 6.5 Demonstration of Sanskrit digital tools, reflection activity, and discussion on interdisciplinary applications. **Self-Learning Topics and Activities:** • Basic Sanskrit alphabet and sound classification. • Simple sandhi examples and word joining rules. • Introduction to Pāṇini and the Aṣṭādhyāyī. • Dhātu, pratyaya, pada, and kāraka in simple terms. • Basics of natural language processing: tokenization, morphology, and parsing. • Exploration of Sanskrit digital dictionaries and Sanskrit reader tools. • Comparison of grammar rules and computer program rules.		

Text and Reference Books or Articles:

1. Acoustics of Chants, Conch-Shells, Bells & Gongs in Worship Spaces. Available: https://www.academia.edu/38208102/Acoustics_of_Chants_pdf?utm_source=chatgpt.com

2. V. R. S. Nalluri, V. J. K. S. Sonti, and G. Sundari, "Analysis of frequency dependent Vedic chanting and its influence on neural activity of humans," International Journal of Reconfigurable and Embedded Systems, vol. 12, no. 2, pp. 230–239, Jul. 2023, doi: 10.11591/ijres.v12.i2.pp230-239.

3. The Garland Encyclopedia of World Music: South Asia. Available: https://api.pageplace.de/preview/DT0400.9781351544399_A30892028/preview-9781351544399_A30892028.pdf?utm_source=chatgpt.com

4. J. Pattanayak, Y. Belur, and J. Ilavarasu, "Acoustic and psychological effects of Omkar chanting in novice Indian adults: A quasi-experimental study," Journal of Clinical and Diagnostic Research, 2025, doi: 10.7860/JCDR/2025/77365.21111. Available: https://www.jcdr.net/articles/PDF/21111/77365_CE%5BRa1%5D_F%28IS%29_QC%28PS_SS

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F1%28AB_IS%29_redo_PFA%28IS%29_PB%28AB_IS%29_PN%28IS%29.pdf?utm_source=chatgpt. com

5. “Indian Knowledge System: Integrating Heritage with Engineering” by Gagan Bansa, Deep Science Publishing; ISBN: 978-93-49307-77-3 E-ISBN: 978-93-49307-29-2;

6. The textbook of Indian Knowledge Systems, University of Mumbai, ISBN: 978-93-5915-553-1

7. Introduction to Indian Knowledge System: Concepts and Applications, Mahadevan, B., Bhat, Vinayak Rajat, Nagendra Pavana R.N. by PHI Learning Pvt Ltd. Delhi, ISBN: 978-93-91818-20-3

8. Echoes of the Monsoon: Ancient Indian techniques for predicting Rainfall, Janak Joshi, Kandarp

9. Parmar, Lakhan Jain, Sharmistha Bhowmik and Bindu Bhatt, DOI: https://www.doi.org/10.22271/27067483.2025.v7.i7a.386.

10. Kim Plofker, Mathematics in India: A clear historical overview of Indian mathematical developments, suitable for faculty use and advanced self-learners.

11. George Gheverghese Joseph, The Crest of the Peacock: An accessible introduction to non-European mathematical traditions, including India.

12. Charles Petzold, Code: The Hidden Language of Computer Hardware and Software: A beginner-friendly bridge from numbers and symbols to data representation and computing.

13. Simon Singh, The Code Book: Useful for simple explanations of ciphers, encryption, and the mathematics behind communication security.

14. T. A. Sarasvati Amma, Geometry in Ancient and Medieval India: A more specialized reference for deeper exploration of traditional mathematical methods.

15. Mahadevan, B., Bhat, V. R., and Nagendra Pavana R. N. Introduction to Indian Knowledge System: Concepts and Applications. PHI Learning.

16. Kapur, K., and Singh, A. K. (Eds.). Indian Knowledge Systems, Vol. 1. Indian Institute of Advanced Study, Shimla.

17. Bora, M. C. Bharatiya Knowledge Systems. Khanna Publishing House.

18. Rao, S. S. Engineering and Technology in Ancient India. Indian National Science Academy / related academic editions.

19. Selected open articles or chapters from IKS Division / AICTE / Ministry of Education resources may be used as supplementary reading.

20. S. D. Joshi and J. A. F. Roodbergen, The Aṣṭādhyāyī of Pāṇini.

21. V. N. Jha, The Philosophy of Sanskrit Grammar.

22. Peter M. Scharf, Sanskrit Syntax and Discourse Structures.

23. Daniel Jurafsky and James H. Martin, Speech and Language Processing — for introductory NLP concepts.

24. Rajeev Sangal, Akshar Bharati, and Vineet Chaitanya, Natural Language Processing: A Paninian Perspective.

Other Online Resources:

Sr. No.	Website Name
1.	NPTEL course page: For a structured academic overview of mathematics in India. https://nptel.ac.in/courses/111101080
2.	NPTEL YouTube playlist: For lecture-based learning that can support flipped or self-paced study. https://www.youtube.com/playlist?list=PLbMVogVj5nJThf31TNSQzuN7zqxe7HdRN
3.	IKS India: For broader Indian Knowledge Systems context and additional learning resources. https://www.nist.gov/cryptography
4.	Responsible AI and India-context resources: https://indiaai.gov.in/
5.	IKS Division, Ministry of Education / AICTE: https://iksindia.org/
6.	NPTEL: Introduction to Pāṇinian Grammar URL: https://onlinecourses.nptel.ac.in/noc24_hs44/preview
7.	Sanskrit Heritage Reader URL: https://sanskrit.inria.fr/

List of Practical and List of Assignments:

Sr No	List of Experiments	Hrs
01	Record a temple bell sound, conch sound, or classical “Sa” note and analyze it by plotting its time-domain waveform and frequency spectrum, identifying the fundamental frequency and harmonics, and comparing the observed harmonic structure with theoretical frequency ratios of Just Intonation and Equal Temperament.	04
02	Observe the movement of sunlight and shadow around a building, monument, or open courtyard at different times of the day, record the shadow directions and lengths, and analyze how solar position can guide orientation, time estimation, and passive architectural planning in the context of traditional Indian solar design.	04
03	Examine images, plans, or a simple model of the Konark Sun Temple or any sun-oriented structure, identify how geometry, orientation, and sunlight interaction are used in the design, and prepare a visual explanation of how ancient solar architecture supports modern sustainable building concepts.	04
04	Construct a small paper or cardboard windmill, test its rotation under natural wind or fan airflow at different speeds, and document how blade movement demonstrates the basic principle of converting wind energy into mechanical motion, linking it to traditional wind-powered systems and modern turbines.	04
05	Build a simple working model using cups, straws, thread, or cardboard to simulate water lifting or channel-based irrigation, observe how water can be moved with	04

	minimal energy input, and relate the model to ancient Indian irrigation systems and watermill-based practices.	
06	Survey homes or nearby community spaces to identify traditional biomass fuels such as wood, agricultural residue, or cow-dung cakes, record their current use, benefits, and limitations, and compare the observed practices with modern ideas of bioenergy and sustainable fuel management..	04
07	Pronounce and classify selected Sanskrit sounds into vowels and consonants using a simple sound chart, group them according to articulation patterns, and analyze how this systematic sound organization supports pronunciation training, language learning, and speech-processing applications.	04
08	Create all possible combinations of short and long syllabic patterns of a fixed length, tabulate them systematically, and compare the resulting patterns with binary 0/1 combinations to understand how ancient combinatorial thinking connects with digital representation.	04
09	Solve real-life problems based on clocks, calendars, weekdays, or repeated events using modular arithmetic, record the remainder-based reasoning used in each case, and explain how cyclic patterns support time management, scheduling, and introductory cryptographic logic.	04
10	Convert selected decimal numbers into binary form, arrange them in bit patterns, append parity bits for even or odd parity, and interpret how binary representation and simple error-detection methods are used in digital systems for reliable data storage and transmission.	04
11	Use a basic Sanskrit dictionary, transliteration tool, or reader tool to input selected words, observe the output such as root, meaning, or grammatical analysis, and describe how such tools support language technology and digital preservation.	04
12	Select a real-life problem such as fake-news verification, waste segregation, or campus awareness, identify observation, evidence, inference, and conclusion using the basic framework of Indian logic, and represent the reasoning process as a decision tree, chatbot flow, or awareness tool concept.	04
13	Take a simple historical or rule-based calculation procedure associated with Indian mathematics, rewrite it as a sequence of input-process-output steps, and convert it into a flowchart to demonstrate the connection between procedural mathematics and modern algorithmic thinking.	04
14	Represent selected large and small numbers using a place-value table, deliberately insert or remove zero in different positions, and analyze how zero functions both as a number and as a placeholder, showing its importance in arithmetic, accounting, and digital data representation.	04
Sr No	**List of Assignments**	**Hrs**
01	Study the concepts of Nāda and Shruti, temple acoustics, and Vedic recitation methods, and briefly explain their relation to modern concepts of frequency, resonance, reverberation, and redundancy/error correction in digital communication systems. Also write a short note on how Indian Knowledge Systems demonstrate scientific understanding of sound and communication.	01
02	Study the ideas of solar architecture in traditional Indian structures such as the	01

	Konark Sun Temple or courtyard-based houses, and explain how sunlight, orientation, shading, and ventilation were used for thermal comfort and energy efficiency. Also write a short note on how these traditional design ideas are relevant to modern sustainable architecture and climate-responsive planning..	
03	Study one traditional Indian renewable energy practice such as wind-powered water lifting, watermills, solar heating, or biomass use, and compare it with one modern renewable energy technology. Explain how traditional knowledge systems supported sustainable living and discuss how these ideas can inspire present-day energy conservation and green technology.	01
04	Study the basic ideas of Pāṇinian grammar as a structured rule-based system, and explain how concepts such as sounds, roots, suffixes, and word formation relate to modern ideas in natural language processing, machine translation, and language analysis. Also write a short note on why Sanskrit grammar is often considered relevant to computational linguistics.	01
05	Study the historical development of zero as both a number and a placeholder, and explain how the decimal place-value system simplified arithmetic and record keeping. Also write a short note on how zero and place value continue to be essential in digital computation, data storage, and computer-based numerical processing.	01
06	Study the basic ideas of Indian logic, especially observation, inference, debate, and evidence in the Nyāya tradition, and explain how these ideas support careful reasoning and decision-making. Also write a short note on how such logical methods can be applied in present-day contexts such as data analysis, fake-news verification, ethical decision-making, and responsible digital systems.	01
07	Identify one idea from Indian Knowledge Systems in the syllabus, such as renewable energy, Indian numeration, Indian logic, or Sanskrit grammar, and propose a simple real-life solution such as an app, chatbot, awareness campaign, digital archive, poster, database, or educational tool based on that idea. Explain the problem being addressed, the IKS principle used, and how the proposed solution can be useful in present-day society.	01
08	Study the basic Sanskrit grammar concepts of sounds, words, roots, suffixes, sandhi, and sentence structure, and explain how grammar rules work like structured instructions. Also compare grammar rules with computer program rules, and briefly discuss how tokenization, morphology, and parsing in computational systems resemble traditional rule-based language analysis.	01

Assessment:

Term Work: Term work shall consist of at least 10-12 practical's based on above list. Also Term Work Journal must include at least 4 assignments
Term Work Marks: 50 Marks (Total marks) = 25 Marks (Experiment) + 20 Marks (Assignments) + 5 Marks (Attendance)