PUNE VIDYARTHI GRIHA'S

COLLEGE OF ENGINEERING AND TECHNOLOGY & G. K. Pate (Wani) Institute of Management, PUNE-9

(AFFILIATED TO SAVITRIBAI PHULE PUNE UNIVERSIT, PUNE)

DEPARTMENT OF ELECTRICAL ENGINEERING

CURRICULUM BOOK

ACADEMIC YEAR : 2021-22

FOR THE PROGRAMME

SECOND YEAR – ELECTRICAL ENGINEERING

PUNE VIDYARTHI GRIHA'S

COLLEGE OF ENGINEERING AND TECHNOLOGY

VISION

TO ACHIEVE EXCELLENCE IN ENGINEERING EDUCATION

MISSION

- **To satisfy all stakeholders**
- **To develop ethical, highly motivated engineering professionals with good human values, requisite skills and competencies**
- **To adopt innovative teaching mechanisms**
- **To promote research culture**
- **To contribute to country's economic development**
- **To be responsive to changes in technology, socio-economic and environmental conditions**

DEPARTMENT OF ELECTRICAL ENGINEERING

VISION

To develop Electrical Engineering Department as one of the premier facility centre for disseminating the state of the art education.

MISSION

- **Providing Quality education in the field of Electrical Engineering.**
- **Developing State of the art facilities in the department.**
- **Creating platform Training, Research and Development**
- **Producing Sound electrical engineers catering need of industry and other stake holders.**

PROGRAM EDUCATIONAL OBJECTIVES

PEO1 To produce students with knowledge base of Electrical Engineering to excel in industry and higher studies.

PEO2 To produce competent students with analytical abilities and problem solving capabilities on the basis of strong fundamentals in Electrical Engineering.

PEO3 To produce responsible students developing sustainable solutions for society with ethics and professionalism.

PEO4 To produce students with professional qualities such as team work, leadership, entrepreneurial thinking and communication skills.

PEO5 To produce students habitual to lifelong learning abilities.

PROGRAMME OUTCOMES

Electrical Engineering Graduates will have:

PO1: Engineering Knowledge: An ability to apply knowledge of mathematics, science and Engineering fundamentals to analyze complex engineering problems.

PO2: Problem Analysis: An ability to identify, formulate and analyze complex engineering problems by reviewing research literature to arrive at substantiated conclusions.

PO3 : Design/Development of Solutions: An ability to design solutions for complex engineering problems, system components or processes to meet the specified needs of the society, considering safety and environment.

PO4: Conduct Investigations of Complex problems: An ability to carry out experiments, simulations and apply research methodologies to investigate the data for providing valid conclusions.

PO5 :Modern tool usage : An ability to select and apply appropriate techniques, resources and modern engineering tools such as advanced controllers and application softwares for engineering activities

PO6: The Engineer and society: An ability to assess and develop professional engineering practices catering the need of society considering safety, health, regulatory and other relevant issues.

PO7: Environment and sustainability: An ability to apply professional engineering knowledge to understand the impact on society and environment demonstrating the need for the sustainable development.

PO8: Ethics: An ability to adopt professional ethics while committing professional and social responsibilities.

PO9: Individual and Team work: An ability to develop multidisciplinary skills as an individual and as a member or leader in diverse teams.

PO10: Communication: An ability to communicate effectively with engineering community and society at large with effective documentation and presentation on engineering activities.

PO11: Project management and Finance: An ability to demonstrate knowledge of Engineering and Management principles as a member or a leader to manage project and multidisciplinary tasks.

PO12: Life-long Learning: An ability to understand need and develop the habit of being lifelong learner to adopt to technological changes.

Program Specific Outcomes (PSO)

Electrical Engineering graduates will have

PSO1 An ability to acquire adequate proficiency in the area of Energy Systems and Sustainability.

PSO2 An ability to acquire multidisciplinary skills in the area of Control and Drives.

PSO3 An ability to acquire enhanced skills and core competency in the field of Electrical Engineering through hands on training.

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Second Year (2019 PAT) Curriculum Book

Savitribai Phule Pune University

Syllabus: Second Year (SE) Electrical Engineering (2019 Course)
w.e.f. AY:2020-2021

SEMESTER-I

Course Code	Courses Name	Teaching Scheme			Examination Scheme and Marks						Credits			
		TH	PR	TUT	ISE	ESE	TW	PR	OR	Total	TH	PR	TUT	Total
207006	Engineering Mathematics-III	03	--	--	30	70	--	--	--	**100**	03	--	--	**03**
203141	Power Generation Technologies	03	--	--	30	70	--	--	--	**100**	03	--	--	**03**
203142	Material Science	03	04#	--	30	70	25	--	25	**150**	03	02	--	**05**
203143	Analog and Digital Electronics	03	02	--	30	70	--	50	--	**150**	03	01	--	**04**
203144	Electrical Measurement & Instrumentation	03	04#	--	30	70	25	25	--	**150**	03	02	--	**05**
203150	Applications of Mathematics in Electrical Engineering	--	02*	--	--	--	25	--	--	**25**	--	01	--	**01**
203151	Soft Skill	--	02	--	--	--	25	--	--	**25**	--	01	--	**01**
203152	Audit Course-III	--	--	--	--	--	--	--	--	--	**Grade: PP/NP**			
Total		**15**	**14**	--	**150**	**350**	**100**	**75**	**25**	**700**	**15**	**07**	--	**22**

SEMESTER-II

Course Code	Courses Name	Teaching Scheme			Examination Scheme and Marks						Credits			
		TH	PR	TUT	ISE	ESE	TW	PR	OR	Total	TH	PR	TUT	Total
203145	Power System-I	03	--	--	30	70	--	--	--	**100**	03	--	--	**03**
203146	Electrical Machines-I	03	02	--	30	70	--	50	--	**150**	03	01	--	**04**
203147	Network Analysis	03	02	--	30	70	25	--	--	**125**	03	01	--	**04**
203148	Numerical Methods & Computer Programming	03	02	--	30	70	--	25	--	**125**	03	01	--	**04**
203149	Fundamental of Microcontroller and Applications	03	04$	--	30	70	25	--	25	**150**	03	02	--	**05**
203152	Project Based Learning	--	04	--	--	--	50	--	--	--	--	02	--	--
203153	Audit Course-IV	--	--	--	--	--	--	--	--	--	**Grade: PP/NP**			
Total		**15**	**14**	--	**150**	**350**	**100**	**75**	**25**	**700**	**15**	**07**	--	**22**

SE (ELECTRICAL)

Semester I&II

Power Generation Technologies

Course Name : Power Generation Technologies **Course Number : 203141**		
Teaching Scheme **Theory : 3 Hrs. / week**	**Credits** **Th / Tut : 03**	**Examination Scheme [Marks]** **In Sem: 30 Marks** **End Sem : 70 Marks**
Designation of the Course : Professional-Core		
Prerequisites :		
1. Fuel calorific value 2. Semi conduction material for PV cells 3. Work, power and energy calculation		

Course Objectives :

1.	Learn the basic fundamentals, working principle, different theories related to power generation with respect to thermal, hydro and nuclear
2.	Understand design of different power plants along with performance characteristics, operational aspects and environmental issues
3.	Understand the role of renewable energy resources in power generation specially wind, solar, biomass and municipal waste
4.	Study of design and working of power plants using renewable resources along with their performance characteristics.

Course Outcomes :
At the end of the course, a graduate will be able to –

CO1.	Describe the basic fundamentals, working principle, different theories related to power generation with respect to thermal and nuclear power plant.
CO2.	Describe the working of different systems involved in Gas & Diesel power plant.
CO3.	Describe the working of different equipments involved in hydro power plant.
CO4.	Describe the operational, performance peculiarities of renewable energy resources such as wind & solar energy systems
CO5.	Explain the importance of renewable energy resources and their utilization in power generation
CO6.	Explain the importance of other renewable energy resources such as biomass, municipal solid waste, geothermal, tidal, wave & ocean thermal energy system.

Course Contents :

Unit 1 :	**Thermal Power Plant**	**[6 Hrs]**

Basic thermodynamic cycles: Carnot cycle, Rankine cycle; Actual Rankine cycle; Reheat cycle (theoretical only); heat rate (Numerical on Heat rate).
Thermal Power Plants: Site selection, Main parts and its working. Types of boilers (FBC, Fire tube, and Water tube). Assessment of heat recovery systems Steam turbines Fuel Handling, Ash disposal and dust collection, Draught systems, electrostatic precipitator.

Unit 2 :	**Nuclear, Diesel, Gas Power Plant**	**[6 Hrs]**

A. Nuclear Power Plant: Introduction, atomic physics, nuclear reaction, materials, site selection, nuclear reactors and working of each part, classification of nuclear reactor, nuclear waste disposal.

B. Diesel Power Plants: Main components and its working, Diesel plant efficiency and heat balance (Numerical), Site selection of diesel power plant.

C. Gas Power Plant: Introduction to gas cycles. Simple gas turbine power plant, methods to improve thermal efficiency, open loop and closed loop cycle power plants, gas fuels, gas turbine materials, plant layout. Combined cycle power plants, concept of heat to power ratio.

Unit 3 :	**Hydro Power Plant**	**[6 Hrs]**

Site selection, Hydrology, storage and pondage, general arrangements and operation of hydro power plant, Hydraulic turbines, turbine size, pelton wheel turbine, Francis and Kaplan turbines, selection of turbines, Dams, Spillways, gates, intake and out take works, canals and layout of penstocks, water hammer and surge tank, simple numerical on hydro graphs and number of turbine required. Small, mini and micro hydro power plant (Introduction only).

Unit 4 :	**Wind Energy Systems**	**[6 Hrs]**

Historical Development of Wind Power, Types of wind turbine, Impact of Tower Height, Power in the Wind. Maximum Rotor efficiency, Speed control for Maximum Power, Average Power in the wind (Numerical). Wind Turbine Generators (WTG) - Synchronous and Asynchronous (block diagrams only), Wind Turbine Economics, Simple Estimates of Wind Turbine Energy, Environmental Impacts of Wind Turbines. Change in wind pattern and its effect on power generation. Control of wind turbine generator.

Unit 5 :	**Solar Energy**	**[6 Hrs]**

Principles of solar radiations, solar constant, cloudy index and concentration ratio, measurement of solar radiation. Solar energy collectors (solar thermal applications), principle of energy conversion, collection systems and their features, types of collectors with comparison. Solar thermal power plants. Over view of recent development of PV technologies. A Generic Photovoltaic Cell, The Simplest Equivalent Circuit for a Photovoltaic Cell From Cells to Modules to Arrays, Numerical on number of solar panel selection. The PV I–V Curve under Standard Test Conditions (STC), Impacts of Temperature and Insolation on I–V Curves, Shading Impacts on I– V curves, System: Introduction to the Major Photovoltaic System Types.

Unit 6 :	Other sources and Grid connection	[6 Hrs]
Biomass energy, conversion to electricity, municipal solid waste to energy conversion, geothermal energy and ocean energy and Fuel cell Energy storage requirements and selection criteria, stand alone, hybrid stand alone and grid connected renewable systems and their requirements.		
Industrial Visit: One industrial visit to conventional /non-conventional power plant is necessary. A separate report file should be maintained in the department.		
Text Books :		
[T1]	Power Plant Engineering, by P. K. Nag, Tata McGraw Hill Publications.	
[T2]	Power Plant Engineering by Dr. P. C. Sharma, S.K. Kataria Publications.	
[T3]	A text book on Power System Engineering,by R.K.Rajput, Laxmi Publications (P) Ltd.	
[T4]	A text book on Power System Engineering by Chakrabarti, Soni, Gupta, Bhatnagar, Dhanpat Rai publication	
[T5]	Non-Conventional Energy Sources and Utilization, by R.K. Rajput, S. Chand Publications	
[T6]	Power plant engineering, M.M. Wakil McGraw Hill, Indian edition	
[T7]	Renewable Energy Sources by G. D. Rai, Khanna Publications.	
[R8]	Solar Photovotaics: Fundamentals, Technology and Application by Chetan singh Solanki, PHI Publications.	
Reference Books :		
[R1]	A Course in Power Plant Engineering, by Arora and Domkundwar, Dhanpat Rai Publication	
[R2]	Solar Energy by Dr. S. P. Sukhatme. Tata McGraw Hill Publication.	
[R3]	Wind and Solar Power Plants, by Mukund Patel, CRC Press.	
[R4]	Renewable Energy by Gilbert Masters, John wiley and sons publications	
[R5]	Solar Energy by Robert Foster, Majid Ghassemi, Alma Cota, CRC Press	
Self-Learning Topics :		
1. Feed water and its treatment. 2. Biomass energy, conversion to electricity. 3. Municipal solid waste to energy conversion. 4. Geothermal energy and Ocean energy. 5. Fuel cell Energy storage requirements and selection criteria. 6. Stand alone, hybrid stand alone and grid connected renewable systems and their requirements		
Assignment Topics :		
Unit-I:- 1. Explain the operation of a steam power plant with the help of schematic diagram. 2. What are the advantages of Reheat cycle explain with the help of schematic & T-s diagram. **Unit-II:-** 1. Explain the working of Pressurized Water Reactor and Boiling Water Reactor. 2. Describe the Breeder Reactor with a neat sketch. What are its advantages and disadvantages?		

3. Draw the schematic diagram of diesel power plant. Discuss its working.
4. Draw and explain open and closed loop cycle gas power plant.

Unit-III:-

1. Explain the working of Hydro Power Plant with the help of neat sketch.
2. Write a short note on Surge Tank & Penstocks?
3. Explain with neat sketch the working of Pelton Turbine.
4. Explain with neat sketch the working of Kaplan Turbine.

Unit-IV:-

1. Derive the relation of power in the wind in case of wind energy system.
2. Explain how change in wind pattern affects the power generation in wind power plant.
3. Explain stand-alone, hybrid stand alone and grid connected renewable energy systems.
4. Explain with neat sketch Wind electric generation system.

Unit-V:-

1. Explain the methods of measurement of solar radiation.
2. Compare flat type solar collector with concentric solar collector.
3. Explain the performance curve of PV cell with the help of I-V curves.
4. Differentiate between stand alone and grid connected PV systems.

Unit-VI:-

1. Write a short note on Ocean Thermal energy conversion.
2. Describe the fuel cells. How are they used for energy storage requirements?
3. Explain the process of municipal solid waste to energy conversion.
4. Write a short note on biomass energy conversion to electricity.

Presentations :

1. Feed water and its treatment.
2. Biomass energy, conversion to electricity.
3. Municipal solid waste to energy conversion.
4. Geothermal energy and Ocean energy.
5. Fuel cell Energy storage requirements and selection criteria.
6. Stand alone, hybrid stand alone and grid connected renewable systems and their requirements

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Engineering Mathematics-III

Course Name : ENGINEERING MATHEMATICS -III **Course Number : 207006**		
Teaching Scheme **Theory : 4 Hrs./Week** **Tutorial : 01 Hr./Week**	**Credits** **Th : 04** **Tut : 01**	**Examination Scheme (Marks)** **Online : 50 Marks** **End Sem : 50 Marks** **Term Work : 25 Marks**
Designation of the course : Professional		
Course Prerequisites :		
A student requires sufficient amount of knowledge of certain topics related to Engineering Mathematics – I & Engineering Mathematics-II, to understand the concepts of Engineering Mathematics-III.		

Course Objectives:

1.	Linear Differential Equation with constant coefficient & its application.
2.	Laplace Transform ,its properties ,LT of some special functions ,applications of LT for solving differential equations .
3.	Fourier Transform ,application to FT problems on one & two dimensional heat flow problem. Z-Transform ,its properties , definition & standard properties of Z Transform &heir inverses , solving difference equation
4.	Vector Differential Calculus ,physical interpretation of vector differentiation ,Gradient ,Curl , Divergence ,Directional Derivative ,Solenoidal ,Irrotational .
5.	Vector Integral Calculus & its application ,line surface & volume integrals ,Stokes Theorem , Divergence Theorem.
6.	Functions of complex variable ,Analytic functions ,C-R Equations ,Conformal Mapping ,Cauchy`s Integral Theorem ,Residue Theorem.

Course Outcomes:
At the end of the course ,a graduate will be able to –

CO1.	Demonstrate wide knowledge in topics like Linear Differential Equations & its application.
CO2.	Demonstrate the ability for understanding the concepts of laplace transform ,LT of standard functions ,Inverse LT
CO3.	Demonstrate the ability for understanding the concepts of Fourier Transform,& Z-Transform ,its standard properties ,& its sequences &their inverses.
CO4.	Demonstrating the physical interpretation of vector differentiation, by understanding Gradient ,Divergence ,Solenoidal Field ,Irrotational Field.
CO5.	Demonstrating the interpretation of vector integral calculus & its application by understanding line , surface ,volume integrals green`s lemma theorem, Gauss Divergence Theorem ,Stokes Theorem.
CO6.	Demonstrate the knowledge of functions of complex variables ,Analytic Functions ,C-R Equations ,Conformal Mapping ,Cauchy`s Integral Formula .Residue Theorem .

Course Contents :		
Unit-I	**LINEAR DIFFERENTIAL EQUATION AND APPLICATIONS**	**[9 Hrs]**
Introduction to differential equation of 1st order , 1st degree ,explanation about Order and degree of differential equation.Introduction to the concepts of complimentary function and particular integral.Various methods of finding particular integral namely General Method, Variation Parameter, Short Cut Method.Introduction to LDE with constantcoefficients,Homogeneous equations,Cauchy`s & Legendre`s DE, Simultaneous & Symmetric Simultaneous DE.		
Unit-II	**LAPLACE TRANSFORM**	**[9 Hrs]**
Introduction to transform theory ,complex exponential form of Fourier series, Fourier Integral transform, sine & cosine integrals, Fourier transform, Fourier sine & cosine transform & their inverses, application to wave equation, finite transform application to Fourier transform to problems on one & two dimensional heat flow problems. Laplace transform of standard functions ,properties & theorems ,inverse Laplace transform application of Laplace transforms to solve DE, liquid level systems ,second order systems.		
Unit-III	**FOURIER AND Z- TRANSFORM**	**[9 Hrs]**
Introduction to Fourier Transform ,understanding of exponential form of Fourier series Fourier integral theorem, meaning of sine and cosine integrals and their inverses. Introductory to Z-transform ,its meaning standard properties ,standard sequences and their inverses. Uses of Z-Transform in solving difference equations.		
Unit-IV	**VECTOR DIFFERENTIAL CALCULUS**	**[9 Hrs]**
Physical Interpretation of vector differentiation, Radial ,transverse & Normal components of velocity & acceleration, vector differential operator, Gradient, Divergence & Curl.Directional derivatives Solenoidal, Irrotational & Conservative fields Scalar Potential ,Vector Identities.		
Unit- V	**VECTOR INTEGRAL CALCULUS AND APPLICATIONS**	**[9 Hrs]**
Introduction to line, surface, volume integral & its application to find work done,Green`s Lemma, Gauss`s Divergence Theorem, Stoke`s Theorem Application to problem in electromagnetic fields.		
Unit-VI	**COMPLEX VARIABLES**	**[9 Hrs]**
Introduction to functions of complex variable ,analytic functions,Cauchy-riemann equations,Conformal mapping ,Cauchy`s integral formula & residue theorem.		
Text Books:		
[T1]	Advanced Engineering Mathematics, by Erwin Kreyszig, Wiley Eastern Ltd	
[T2]	Advanced Engineering Mathematics by Peter V .O`Neil, Thompson Learning	
Reference Books		
[R1]	Applied Mathematics (Volumes I& II) by P.N.Wartikar, Pune Vidyarthi Griha Prakashan , Pune	
[R2]	Advanced Engineering Mathematics with MATLAB by Thomas L.Harman James Dabney & Norman Richert, 2eCole, Thomson Learning	

[R3]	Advanced Engineering Mathematics by M.D.Greenberg, Pearson Education 2e
[R4]	Higher Engineering Mathematics by B.S.Grewal, Khanna Publication, Delhi
[R5]	Higher Engineering Mathematics by B.V.Ramana, Tata McGraw-Hill

Self-Learning :

Handouts related to important formulas based on algebra ,trigonometric functions ,identities are provided into the initial lectures.

Contents beyond Syllabus :

Lagrange method(Method of variation of parameter) :
To understand the particular integral if short cut method fails ,then use of general method involves laborious integration ,in such cases method of variation of parameter helps to determine complete solution. Lagrange Method is also studied for 3rd order linear differential Equation. This method may also be extented to higher order linear differential equations.

Bridging Courses :

Before the commencement of regular classes ,respective teachers conducts 20 minutes session on everyday basis for the first 15 days which focuses on class 12 level basic maths,also revision of certain important topics related to Engineering Mathematics- I and Engineering Mathematics-II are covered to understand the concepts of Engineering Mathematics-III.

Assignment Topics :

AssignmentNo. 1 &2 : Numerical on C.F,P.I ,Shortcut cases Cauchys &Legendres Equation ,Symmteric and simultaneous Equations, Numerical on Laplace Transform ,inverse laplace transform
AssignmentNo. 3&4 : Numerical on Fourier transform ,inverse fourier transform ,Z-transform & its inverse Z-transform.

Tutorials :

1. Numerical on complimentary function ,particular integral ,short cut methods .
2. Numerical on cauchys legendres differential equation , symmetric and simultaneous equations.
3. Numerical on Laplace Transform & Inverse Laplace Transform.
4. Numerical on fourier transform ,fourier cosine transform ,fourier sine transform.
5. Numerical on inverse fourier transform ,inverse fourier cosine and inverse fourier sine transform .+
6. Numerical on Z-Transform & Inverse Z- Transform
7. Numerical on vector algebra ,Gradient ,Divergence ,Curl.
8. Numerical on vector identities.

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Material Science

Course Name : MATERIAL SCIENCE **Course Number : 203142**		
Teaching Scheme **Theory : 3 Hrs. / week** **Practical : 4 Hrs. / week**	**Credits** **Th : 03** **OR : 02**	**Examination Scheme [Marks]** **InSem Exam : 30 Marks** **InSem Exam : 70 Marks** **TW Marks : 25 Marks** **Oral : 25 Marks**
Designation of the Course : Professional-Core		
Prerequisites :		
Students should have knowledge of various classes of materials like solid, liquid, gaseous, conducting, insulating and resistive along with their basic characteristics.		

Course Objectives:	
1.	Explain classification,properties and characteristics of electrical engineering materials.
2.	Describe applications and measuring methods for parameters of dielectric, insulating, magnetic, conducting and resistive materials.
3.	Illustrate solving of simple problems based on dielectric, magnetic and conducting materials.
4.	Impart knowledge of Nano-technology to electrical engineering.5. Demonstrate testing methods of dielectric, insulating, magnetic, conducting and resistive materials as per IS.
5.	Demonstrate testing methods of dielectric, insulating, magnetic, conducting and resistive materials as per IS.
6.	Enable students to create self learning resource material through active learning based on practical /case study/assignments.

Course Outcomes: **At the end of the course, a graduate will be able to –**	
CO1.	Discuss classification,properties and characteristics of different electrical engineering materials.
CO2.	State various applicationsmeasuring methods for parameters of different classes of electrical engineering materials.
CO3.	Solve simple problems based on dielectric, magnetic and conducting materials.
CO4.	Apply knowledge of Nano-technology to electrical engineering.
CO5.	Execute tests ondielectric, insulating, magnetic, conducting, resistive materials as per IS to decide the quality of thematerials.
CO6.	Create learning resource material ethically to demonstrate **self learning leading to** lifelong learning skills and usage of ICT/ online technology through collaborative/active learning activities.

Course Contents :		
Unit 1 :	**Dielectric Properties of Insulating Materials**	**[6 Hrs]**

Static Field, Parameters of Dielectric material [Dielectric constant, Dipole moment, Polarization, Polarizability], Introduction to Polar and Non- Polar dielectric materials. Mechanisms of Polarizations- Electronic, Ionic and Orientation Polarization (descriptive treatment only), Clausius Mossotti Equation, Piezo-Electric, Pyro-Electric & Ferro-Electric Materials, Dielectric loss and loss tangent, Concept of negative tan delta.		
PR – Part A:	**1.** To measure Insulation Resistance and kVAr capacity of power capacitor.	
Unit 2A :	**Dielectric Breakdown**	**[2 Hrs]**
Introduction, Concept of Primary and Secondary Ionization of Gases (descriptive treatment only), Breakdown Voltage, Breakdown Strength, Factors affecting Breakdown Strengths of Solid, Liquid and Gaseous dielectric materials.		
Unit 2B :	**Testing of Materials**	**[4 Hrs]**
Explanation of following with objectives, equipment required, circuit diagrams and observations to be taken. 1. Measurement of dielectric loss tangent (tan δ) by Schering Bridge-IS 13585-1994. 2. Measurement of dielectric strength of solid insulating material-IS 2584. 3. Measurement of dielectric strength of liquid insulating material -IS 6798. 4. Measurement of dielectric strength of gaseous insulating material as per IS.		
PR – Part A:	**1.** To measure dielectric strength of solid insulating materials. **2.** To measure dielectric strength of liquid insulating materials. **3.** To measure dielectric strength of gaseous insulating materials using Sphere Gap-Unit.	
Unit 3 :	**Insulating Materials, Properties & Applications**	**[6 Hrs]**
Introduction, Characteristics of Good Insulating Material, Classification, Solid Insulating Materials- Paper, Press Board, Fibrous Materials, Ceramics, Mica, Asbestos, Resins, Amorphous materials Polymers, Ceramics, Enamels. Liquid Insulating Materials such as Transformer Oil, Varnish, Askarel. Insulating Gases like Air, SF_6. Insulating Materials for Power & Distribution Transformers, Rotating Machines, Capacitors, Cables, Line Insulators and Switchgears.		
PR – Part A:	**1.** To observe development of tracks due to ageing on different insulating materials e.g. Bakelite, Perspex, polyesters, Mica, Fiberglass etc.	
PR – Part B:	**1.** Review of research/on line literature from latest journal papers /transactions related to different **insulating materials**, advanced insulating material developments and their applications. Draft of paper, presentation among students, in conference /publishing it. **2.** Detailed case study of **complete insulation system** in transformer, comparison of various types of solid, liquid materials and study of recent advances related with major and minor insulating materials. **3.** Detailed study of patents on **caster oil** used in transformer, its properties and comparison with other liquid insulating material. **4.** Mini project on development of prototype of various electrical gadgets right from draft of specifications,design, selection of conducting, magnetic and insulating material. **5.** Testing and diagnosis of induction motor, cable, transformer **insulation** by measurement of Polarization index, Dielectric Absorption Ratio, Step Voltage, dielectric discharge and ramp testing using 5/10KV IR Tester.	

Unit 4 :	**Magnetic Materials**	**[6 Hrs]**
Introduction, Parameters of Magnetic material [Permeability, Magnetic Susceptibility, Magnetization], Classification of Magnetic Materials, Diamagnetism, Paramagnetism, Ferromagnetism, Ferri-magnetism, Ferro-magnetic behavior below Critical Temperature, Spontaneous Magnetization, Anti-ferromagnetism, Ferrites, Applications of Ferro magnetic Materials, Magnetic materials for Electric Devices such as Transformer Core, Core of Rotating Machines, Soft Magnetic Materials, Hard Magnetic Materials.		
PR – Part A:	**1.**To obtain hysteresis loop of the ferromagnetic material.	
PR – Part B:	**1.** Review of research/on line literature from latest journal papers /transactions related to different magnetic materials, advanced magnetic material developments and their applications. Draft of paper, presentation among students, in conference /publishing it.	
Unit 5 :	**Conducting Materials**	**[6 Hrs]**
General Properties of Conductor, Electrical Conducting Materials - Copper, Aluminum and its applications, Materials of High and Low Resistivity-Constantan, Nickel-Chromium Alloy, Tungsten, Kanthal, Silver and Silver alloys, Characteristics of Copper Alloys (Brass & Bronze), Electrical Carbon Materials. Materials used for Lamp Filaments, Solders, Metals and Alloys for different types of Thermal Bimetal and Thermocouples.		
PR– Part A:	**1.** To measure Resistivity of High Resistive Alloys. **2.** To understand the principle of thermocouple & to obtain characteristics of different thermocouples.	
PR – Part B:	**1.** Review of research/on line literature from latest journal papers /transactions related to different conducting materials, advanced conducting material developments and their applications. Draft of paper, presentation among students, in conference /publishing it.	
Unit 6 :	**Nanotechnology**	**[6 Hrs]**
Introduction, Concepts of Energy bands & various Conducting Mechanism in Nano-structures, Carbon Nano-structures, Carbon Molecules, Carbon Clusters, Carbon Nano-tubes and applications. Special Topics in Nano Technology such as Single Electron Transistor, Molecular Machines, BN Nanotubes, Nano wires.		
PR– Part A:	----	
PR– Part A:	**1.**Write report on visit to an industry related to manufacturing of batteries, capacitors, cables, transformers (Any one industry).	
PR – Part B:	**1.** Laboratory visits/survey/role play/games/debates/any activity focusing collaborative, student centrist, active learning on Industrial/ Social/ Sustainability/ Public Health/ Safety/Ethical/Cultural/ Societal and Environmental aspects related to advanced materials Presentations of industrial case studies related with material science.	

	2. Any activity using advanced ICT tool like **Virtual Labs/animations/simulations/advanced software/on line** certificate course like NPTEL/on line quiz etc related to curriculum.
Text Books:	
[T1]	S. P. Seth, "A Course in Electrical Engineering Materials", Dhanpat Rai and Sons publication.
[T2]	A Textbook of "Electrical Engineering Materials" by R.K.Rajput, Laxmi Publications (P) Ltd.
[T3]	"Electrical Engineering Materials", T.T.T.I, Madras.
[T4]	K. B. Raina & S. K. Bhattacharya, "Electrical Engineering Materials", S. K. Kataria & Sons.
[T5]	P.K. Palanisamy, "Material Science for Electrical Engineering", SciTech Pub. (India) Pvt. Ltd., Chennai.
[T6]	Charles P. Poole, Jr. Frank & J. Ownes, "Introduction to Nanotechnology", Wiley Student Edition.
Reference Books:	
[R1]	"Electrical Power Capacitors-Design & Manufacture", by D. M. Tagare, Tata McGraw Hill Publication.
[R2]	"Electrical Engineering Materials", by S. P. Chalotra and B. K. Bhattacharya, Khanna Publishers, Nath Market.
[R3]	"Electrical Engineering Materials", by C. S. Indulkar and S. Thiruvengadam, S. Chand and Company Ltd.
[R4]	"High Voltage Engineering" by Kamraju and Naidu, Tata McGraw Hill Publication.
[R5]	"Introduction to Material Science for Engineering", Sixth Edition by James F. Shackelford & M. K. Muralidhara, Pearson Education.
[R6]	"Insulation Technology Course Material of IEEMA Ratner", Pearson Education.
[R7]	"Materials Science for Engineering Students", by Traugott Fischer, Elsevier Publications.
[R8]	"Energy Conversion Systems", by Rakosh Das Begamudre, New Age International Publishers.
[R9]	"Advanced Nanomaterials and Their Applications in Renewable Energy", by Jingbo Louise Liu, Sajid Bashir, ELSEVIER Publications.
Self-Learning Topics :	
• Schering Bridge for measurement of Dielectric Loss Tangent	
Contents beyond Syllabus :	
• Cable, its types and different protective layers for it. • Use of SWG (Standard Wire Gauge)	
Extra Experiments :	
• Effect of Uniform and Non- Uniform Electric Field on Breakdown of Insulating Materials. • To make a chart / poster containing samples of different electrical materials, such as Conducting, Insulating and Magnetic etc. • Study of various magnetic materials along with their properties and applications.	

Industrial Visit :
An Industrial Visit is arranged to manufacturing and testing unit of related to capacitors, cables, Transformers, Machines (Any one industry).
Bridging Courses :
• Different types of capacitors. • Different types of cables. • Nano materials developed for Solar Cell.
Assignment Topics :
• Types of Polarization • Testing of Solid, Liquid and Gaseous insulating materials as per IS • Properties of insulating materials used in Capacitors, Cables, Transformers, Rotating Machines, Switchgears (Circuit Breakers), Insulators • Magnetic Parameters with their definitions and their units • Thermocouple and Thermal Bimetal • Carbon nano structures , carbon clusters, carbon nanotubes
Presentations :
• Nano Materials and their Applications

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Analog and Digital Electronics

Course Name : Analog And Digital Electronics **Course Number : 203143**		
Teaching Scheme Lecture: 03 Hrs/ Week **Practical**: 02 Hrs/ Week	**Credits** **Th/Tut**: 03 **PR**:01	**Examination Scheme** [Marks] **In Sem** : 30 Marks **End Sem**: 70 Marks **Practical**: 50 Marks

Designation of the Course : Professional-Core / Elective / Humanities

Prerequisites :

Basic Electronics Engineering, Basics of Numbering system, Logic gates & Diodes.

Course Objectives :

1.	To demonstrate the concept of numbering system & Boolean's algebra reduction using K map.
2.	To design and analyze sequential and combinational circuits.
3.	To introduce digital memories and logic families.
4.	To develop the concept of basics of Operational Amplifier and its applications.
5.	To introduce and design uncontrolled diode rectifier

Course Outcomes :At the end of the course, a graduate will be able to –

CO1.	Perform conversion of number system, perform binary arithmetic and reduce Boolean expressions by K- Map.
CO2.	Demonstrate basics of various types of Flip flops, design registers and counter.
CO3.	Apply and demonstrate the concept of digital memories and logic families.
CO4.	Analyze parameter of Op-amp and its applications.
CO5.	Apply the knowledge of Op-amp as wave form generators & filters.
CO6.	Analyze of uncontrolled rectifier.

Course Contents :

Unit 1 :	**Design of combinational circuit:**	**[6 Hrs]**
Booleans algebra, De-Morgan theory etc, Karnaugh map: structure for two, three and four Variables, SOP and POS form reduction of Boolean expressions by K-map. Design of combinational circuits using Boolean expression and K-map, encoder, decoder, half and full adder.		
PR/Tut :	1) Design of logical circuit for display of decimal number on seven segment display. **(Hardware)** 2) Deign 3:8 decoder for binary to octal decoding. **(Hardware)** 3) Design four bit full adder using any open source software. **(Software)** 4) Design logical circuit to convert binary to octal number system. **(Hardware)**	
Unit 2 :	**Design of sequential circuit:**	**[6 Hrs]**
Introduction to sequential circuit. Design of synchronous (K-map) and asynchronous counters. Up down counters, N modulo counters, Shift registers, ring and twisted ring counters		
PR/Tut :	Design digital clock or stop watch using decade counter. (IC74192) **(Hardware)**	
Unit 3 :	**Digital memories and logic families:**	**[6 Hrs]**
A) **Digital memories:** SRAM, DRAM, ROM, EPROM B) **Digital logic families:** PAL, PLA, CPLD, FPGA		

PR/Tut :	NIL	
Unit 4 :	**Operational Amplifier Applications:**	**[6 Hrs]**
Open loop and close loop configuration of Op-Amp. Applications of Op- Amp- zero crossing detectors, Comparator, Schmitt trigger, V-I and I-V converters, Instrumentation amplifier, peak detector, Waveform generation using Op-amp - sine, square, saw tooth and triangular generator.		
PR/Tut :	1) Find phase angle difference between same frequency signal using ZCD and AND gate. **(Hardware)** 2) Design of comparator and schmitt trigger. **(Hardware)** 3) Study of Instrumentation amplifier using three Op-amp, CMRR measurement **(Hardware)** 4) Design sine, and triangular wave generator. **(Hardware)**	
Unit 5 :	**Other Analog circuits:**	**[6 Hrs]**
Active filters-Its configuration with frequency response, Analysis of first order low pass and high pass filters using OPAMP, IC 555 –construction, working and modes of operation- astable and monostable multi vibrators, Sequence generator, voltage regulators using ICs 78xx, 79xx, LM 317		
PR/Tut :	1) Design first order high pass and low pass filter using OPAMP in any open source software. (For this provide one statement to each of four students to perform with desired cut-off frequency. Each group will demonstrate their result and prepare documentation) **(Software)** 2) Design of monostable mutivibrator using IC555 and digital circuit to count number of pulses. **(Hardware)** 3) Design astable multivibrator using IC-555. **(Hardware)**	
Unit 6 :	**Diode Rectifiers:**	**[6 Hrs]**
Single phase half wave rectifier with R, RL loads. Single phase full wave rectifier-Center tap and bridge rectifier supplying R and RL load and performance parameters. Three phase full wave bridge rectifier with R load.		
PR/Tut :	Design of single phase bridge rectifier with output voltage and specified ripple. (this practical should be design by each students, perform in simulation and demonstrate with hardware in laboratory with design documents) **(Software and Hardware)**	

Text Books :	
[T1]	Floyd and Jain, "Digital Fundamentals", Pearson Education.
[T2]	R. P. Jain, "Digital Electronics", Tata McGraw Hill, New Delhi.
[T3]	Malvino, "Digital Computer Electronics- An Introduction to Microcomputers," Tata McGraw Hill.
[T4]	Gaikwad R., "Operational Amplifier", PHI New Delhi.
[T5]	Floyd, "Electronics Devices", Pearson Education.
[T6]	Mottershed, "Electronics Devices & Circuits", PHI New Delhi
[T7]	Muhammad H. Rashid, "Power Electronics: Circuits, Devices and Applications", 3rd edition, Pearsons Education.
[T8]	Fundamental of digital circuits, 4th Edition, by A Anand Kumar, PHI learning private limited publication
Reference Books :	
[R1]	Tokheim, "Digital Electronics-Principles and Application", 6th edition, Tata McGraw Hill, New Delhi.
[R2]	A Jaico and Charles H. Roth, "Fundamentals of Logic Design" Jr. Fourth Edition.

[R3]	K. R. Botkar, "Integrated Circuits", Khanna Publication, New Delhi.
[R4]	James, "Operational Amplifier and Linear Integrated Circuits Theory and Application."
[R5]	P John Paul, "Electronics Devices and circuits", New Age international Publications.
[R6]	P. S. Bimbhra, "Power Electronics", Khanna Publications.
[R7]	NPTEL course on Digital Electronics Circuit, IIT, Kharagpur. https://nptel.ac.in/courses/108105132/
[R8]	NPTEL course on Integrated circuit, MOSFET, OPAMP and there applications IISC Banglore. https://nptel.ac.in/courses/108/108/108108111/
[R9]	NPTEL course on power electronics by IIT Kharagpur. https://nptel.ac.in/courses/108/105/108105066/

Self-Learning Topics :

- Op-Amp: Block diagrams of 741, ideal and practical parameters.
- Op-Amp: open loop and close loop configuration of Op-Amp.

Contents beyond Syllabus :

i. Octal and Hexadecimal arithmetic: - addition and subtraction.
ii. Study of various types of Op-Amp.
iii. Brief introduction of passive filter and bistable multivibrators.

Extra Experiments :

i. Study of Op-Amp as inverting, non-inverting, summer, voltage follower and differential.
ii. Study of IC-555 applications as sequential timer.
iii. Study of half wave and full wave precision rectifier using Op-Amp.

Presentations :

- **Digital memories:** SRAM, DRAM, ROM, EPROM
- **Digital logic families:** PAL, PLA, CPLD, FPGA

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Electrical Measurements and Instrumentation

Course Name : Electrical Measurements and Instrumentation **Course Number : 203144**		
Teaching Scheme **Theory : 3 Hrs. / week** **Practical : 2 Hrs. / week**	**Credits** **Th / Tut : 03** **PR : 02**	**Examination Scheme [Marks]** **In Sem : 30 Marks** **End Sem : 70 Marks** **Practical : 50 Marks** **Term Work : 25 Marks**
Designation of the Course : Professional-Core		
Prerequisites : AC Fundamentals, single phase ac circuits and poly phase ac circuits		

Course Objectives:

1.	To understand the necessity and importance of measurement and instrumentation.
2.	To know about various types of measurement techniques, instruments and sensors.
3.	To learn to apply proper methods of measurement and use of sensors in instrumentation.

Course Outcomes:
At the end of the course, a graduate will be able to –

CO1.	Define various characteristic and classify measuring instruments along with range extension techniques.
CO2.	Apply measurement techniques for measurement of resistance, inductance
CO3.	Demonstrate construction, working principle of electrodynamo type instrument for measurement of power
CO4.	Demonstrate use of 1-phase and 3-phase induction and static energy meter
CO5.	Make use of CRO for measurement of voltage, current and frequency.
CO6.	Classify transducer and apply it for measurement of physical parameters in real time.

Course Contents :

Unit 1 :	**Classification of Measuring Instruments**	**[6 Hrs]**

Classification of Measuring Instruments: Characteristics of measuring instruments: static and dynamic, accuracy, linearity, speed of response, dead zone, repeatability, resolution, span, reproducibility, drifts. Necessity of calibration, standards and their classification, absolute and secondary instruments, types of secondary instruments: indicating, integrating, and recording, analog / digital. Ammeter and Voltmeter Theory: Essentials of indicating instruments deflecting, controlling and damping systems. Construction, working principle, torque equation, advantages and disadvantages of Moving Iron (MI) instruments (attraction and repulsion). block diagram and operation of digital ammeter & voltmeter.

B. Range Extension: Instrument Transformers : Construction, connection of CT & PT in the circuit, advantages of CT / PT for range extension of MI Instruments, transformation ratio, turns ratio, nominal ratio, burden, ratio and phase angle error.(descriptive treatment only)

PR/Tut :	**Part A:** 1. Extension of instrument range: ammeter, voltmeter, watt meter using CT & PT. **Part B:** 1. Study of various standards (IS/IEC) related to calibration process of various instruments and NABL accredited Test Laboratory visit. 2. Determination of polarities and ratio, phase angle and ratio error of various CTs and PTs.

Unit 2 :	**Measurement of Resistance & Inductance**	**[6 Hrs]**

A. Measurement of Resistance: Measurement of low, medium and high resistance. Wheatstone bridge, Kelvin's double bridge, ammeter-voltmeter method, megger, loss of charge method. Earth tester for earth resistance measurement.

B. Measurement of Inductance: Introduction, sources and detectors for A.C. bridge, general equation for bridge at balance. Measurement of inductance: Maxwell's inductance & Maxwell's inductance – Capacitance Bridge, Anderson's bridge.

PR/Tut :	**Part A:** 1. Measurement of resistance by ammeter voltmeter method. 2. Measurement of low resistance using Kelvin's double bridge. 3. Measurement of inductance using Maxwell's Inductance and Inductance – Capacitance bridge. **Part B:** 1. Measurement of soil resistivity using four pin wenner method.

Unit 3 :	**Measurement of Power**	**[6 Hrs]**

Measurement of Power: Construction, working principle, torque equation, errors and their compensation, advantages and disadvantages of dynamometer type wattmeter, low power factor wattmeter, poly-phase wattmeter. Active & reactive power measurement in three phase system for balanced and unbalanced load using three wattmeter method, two wattmeter method & one wattmeter method.

PR/Tut :	**Part A:** 1. Measurement of active & reactive power in three phase circuit using two wattmeter methods (balanced & unbalanced loads). 2. Measurement of active & reactive power in three phase balanced circuit using one wattmeter method with two way switch. 3. Measurement of reactive power by one wattmeter with all possible connections of current coil and pressure coil. 4. Measurement of power in three phase, four wire system using three CTs & two wattmeter. 5. Calibration of single phase wattmeter at different power factors. **Part B:** 1. Demonstration of Power analyser and multifunction meter for measurement of various electrical quantities.

Unit 4 :	**Measurement of Energy**	**[6 Hrs]**
Measurement of Energy: Construction, working principle, torque equation of single phase conventional (induction type) energy meter. Block diagram and operation of single phase and three phase static energy meter. Calibration of static energy meter. TOD meter.		
PR/Tut :	**Part A:** 1. Calibration of single phase static energy meter at different power factors. Part B: 1. Study and demonstration of net meter and four quadrant TOD Meter.	
Unit 5 :	**Oscilloscope & Transducers**	**[6 Hrs]**
A. Oscilloscope: Introduction, various parts, front panel controls, use of CRO for measurement of voltage, current, period, frequency. Phase angle & frequency by lissajous pattern & numerical. Introduction to DSO. B. **Transducers:** Introduction, classification, types: resistive, inductive, capacitive, basic requirements for transducers. C. **Pressure Measurement:** Introduction, classification of pressure as low, medium & high, absolute, gauge, vacuum, static, dynamic & head pressure. High pressure measurement using electric methods, low pressure measurement by McLeod gauge and pirani gauge, capacitive pressure transducer.		
PR/Tut :	**Part A:** 1. Measurement of voltage, current, time period, frequency using CRO. **Part B:** 1. Detailed study of various temperature transducers, their selection procedure, specifications, characteristics and comparison, calibration process of temperature transducer.	
Unit 6 :	**Level & Displacement**	**[6 Hrs]**
Level Measurement: Introduction and importance of level measurement, level measurement methods: mechanical, hydraulic, pneumatic, electrical, nucleonic and ultrasonic. **B. Displacement Measurement:** LVDT & RVDT – construction, working, application, null voltage, specifications, advantages & disadvantages, effect of frequency on performance. **C. Strain Gauge**: Introduction, definition of strain, types of strain gauge: Wire strain gauge, foil strain gauge, semiconductor strain gauge etc.; their construction, working, advantages and disadvantages.		
PR/Tut :	**Part A:** 1. Displacement measurement by LVDT. **Part B:** 1. Virtual instrument modeling using software like LABVIEW.	

Text Books:

[T1]	A. K. Sawhney, "A Course in Electrical and Electronic Measurements & Instrumentation" DhanpatRai& Co.
[T2]	J. B. Gupta, "A Course in Electronics and Electrical Measurements and Instrumentation" S. K. Kataria& Sons,
[T3]	R. K. Jain, "Mechanical and Industrial Measurements" Khanna Publishers.
[T4]	B. C. Nakra& K. K. Chaudhari, "Instrumentation Measurement and Analysis", Tata McGraw Hill.

Reference Books:	
[R1]	E. W. Golding & F. C. Widdies, "Electrical Measurements & Measuring Instruments" reem Publications.
[R2]	Dr. Rajendra Prasad, Electronic Measurements & Instrumentation, Khanna Publishers
[R3]	Arun K. Ghosh, "Introduction to Measurements and Instrumentation, PHI Publication
[R4]	] M. M. S. Anand "Electronics Instruments and Instrumentation Technology" by, PHI Publication.
Self-Learning Topics :	
Block diagram & Operation of Digital ammeters & Voltmeters, strain gauge	
Contents beyond Syllabus :	
Digital power factor meter, digital frequency meter, Adjustments in Induction type energy meter	
Bridging Courses :	
Construction & operation of galvanometers and PMMC instruments, mechanical methods of pressure measurement.	
Assignment Topics :	
1. Characteristics of measuring instruments, Instrument transformers 2. Measurement of resistance & Inductance 3. Measurement of Power and Energy 4. Oscilloscope & Transducers	
Presentations :	
Oscilloscope, DSO,LVDT, Level measurement methods,Strain Gauge	

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Applications of Mathematics in Electrical Engineering

Course Name : Applications of Mathematics in Electrical Engineering **Course Name : 203150**		
Teaching Scheme **Practical** : 02 Hrs/ Week	**Credits** **PR : 01**	**Examination Scheme** [Marks] **Term Work**: 25 Marks
Designation of the Course :		
Prerequisite: Basic mathematics, Engineering Mathematics-I, II		
Course Objectives: **At the end of this course, student will be able to**		
1.	To relate mathematics and electrical problems.	
2.	To introduce software solution	
3.	To develop mathematical and complex problem solving skill	
CO1	Apply fundamentals of mathematics in solving electrical engineering problem	
CO2	Analyze complex electrical engineering problem using mathematical techniques.	
CO3	Implement program and simulation for problems in electrical engineering.	
CO4	Demonstrate self-lifelong learning skills with applications of mathematics in electrical engineering through software.	
Course Contents		
PR 1	To solve ordinary differential equations in electrical circuits or DC motors.	
PR 2	To apply Laplace Transform for solving ordinary differential equations in electrical circuits or DC motors.	
PR 3	To analyze the waveform generated using Fourier series.	
PR 4	To solve difference equations using z-Transform	
PR 5	To solve linear simultaneous equations from electrical network (KVL/KCL) using software programming.	
PR 6	To perform mathematical addition, subtraction, multiplication and division of electrical signals.	
PR 7	To calculate rms and average values of given waveform using software programming.	

PR 8	To calculate electrical power under sinusoidal and non-sinusoidal voltage and current.
PR 9	To determine maxima and minima of single/two variable problem.
PR 10	To calculate poles and zeros in complex electrical network.

Text Books :

[T1]	Higher Engineering Mathematics by B. S. Grewal (Khanna Publication, Delhi).
[T2]	B.L. Theraja, A text book on electrical technology Vol-I, S Chand Publications

References :

[R1]	Advanced Engineering Mathematics, 10e, by Erwin Kreyszig
[R2]	Advanced Engineering Mathematics, 2e, by M. D. Greenberg

Guidelines for Student's Lab Journal :

The student's Lab Journal should contain following related to every experiment:

- There should be continuous assessment
- Assessment must be based on understanding of theory, attentiveness during practical session, how efficiently the student is able to do programming
- Timely submission of journal

Guidelines for Instructor's Manual :

The Instructor Manual should contain following related to every program

- Theory related to the method
- Algorithm
- Solve numerical using appropriate method
- Expected Output

Guidelines for Lab /TW Assessment :

Each experiment will be evaluated out of 10 marks. The evaluation will be based on
1. Involvement of the student in performing the experiment.
2. His/her understanding about the concept involved.
3. His sincerity in the submission of the experiment manual.

Guidelines for Laboratory Conduction :

- Detail theory and numerical related to the method should be taken prior to the lab session
- Algorithm should be discussed in detail in the lab session
- Students are expected to do the program based on the discussed algorithm individually

• Printout of the program and output should be taken on the day when the program is performed
Self-Learning Topics : Differential equations in Electrical Circuits
Contents beyond Syllabus : Nil
Extra Experiments: Nil
Assignment Topics : Each experiment manual will have assignment problem to be solved and submitted during submission of the lab journal.

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Soft Skill

Course Name : Soft Skills **Course Number : 203151**		
Teaching Scheme **Practical : 2 Hrs. / week**	**Credits** **PR : 01**	**Examination Scheme [Marks]** **Term Work : 25 Marks**
Designation of the Course : Humanities		
Prerequisites :nil		
Course Objectives:		
1.	To possess knowledge of the concept of Self-awareness and Self Development	
2.	To Understand the importance of Speaking Skills, listening skills, Presentation Skills and leadership skills.	
3.	To gain the knowledge of corporate grooming & dressing, Email & telephone etiquettes, etiquettes in social & office setting	
4.	To get conversant with Team work, Team effectiveness, Group discussion, Decision making.	
5.	To recognize the importance of time management and stress management.	
Course Outcomes: **At the end of the course, a graduate will be able to –**		
CO1.	Set their personal Goals and SWOT analysis.	
CO2.	Write a formal letter and write proper resume	
CO3.	Develop presentation and take part in group discussion.	
CO4.	Follow and Implement etiquettes in workplace and in society at large.	
CO5.	Work in team with team spirit and develop leadership qualities.	
CO6.	Utilize the techniques for time management and stress management	
Course Contents :		
Unit1	**Self Assesment:**	**[4Hrs]**
A) Self-Assessment , Self-Appraisal, SWOT, Goal setting - Personal & career - Self-Assessment, Self-Awareness, Perceptions and Attitudes, Positive Attitude, Values and Belief Systems, Self-Esteem, Self-appraisal, Personal Goal setting, B) Career Planning, Personal success factors, Handling failure, Depression and Habit, relating SWOT analysis & goal setting and prioritization.		
PR/Tut :	1. SWOT analysis 2. Personal & Career Goal setting – Short term & Long term	
Unit 2 :	**Communication Skill:**	**[6Hrs]**
A) Importance of communication, types, barriers of communication, effective communication. B) **Speaking Skills:** Public Speaking, Presentation skills, Group discussion- Importance of speaking effectively, speech process, message, audience, speech style, feedback, conversation and oral skills, fluency and self-expression, body language phonetics and spoken English, speaking techniques, word stress, correct stress patterns, voice quality, correct tone, types of tones, positive image projection techniques.		

C) **Listening Skills:** Law of nature- you have 2 ears and 1 tongue so listen twice and speak once is the best policy, Empathic listening, Avoid selective listening.
D) **Group Discussion:** Characteristics, subject knowledge, oral and leadership skills, team management, strategies and individual contribution and consistency.
E) **Presentation skills:** Planning, preparation, organization, delivery.
F) **Written Skills:** Formal & Informal letter writing, Report writing, Resume writing - Sentence structure, sentence coherence, emphasis. Paragraph writing. Letter writing skills – form and structure, style and tone. Inquiry letters, Instruction letters, complaint letters, Routine business letters, Sales Letters etc.

PR/Tut :	1.Presentation Skill 2.Letter/Application writing 3.Report writing 4.Presentation 5.Listening skills

Unit 3 :	**Corporate / Business Etiquettes:**	**[2Hrs]**

Corporate grooming & dressing, Email & telephone etiquettes, etiquettes in social & office setting: Understand the importance of professional behavior at the work place, Understand and Implement etiquettes in workplace, presenting oneself with finesse and making others comfortable in a business setting. Importance of first impression, Grooming, Wardrobe, Body language, Meeting etiquettes (targeted at young professionals who are just entering business environment), Introduction to Ethics in engineering and ethical reasoning, rights and responsibilities.

Unit 4 :	**Interpersonal relationship:**	**[4Hrs]**

A) **Team work, Team effectiveness, Group discussion, Decision making –** Team Communication. Team, Conflict Resolution, Team Goal Setting, Team Motivation Understanding Team Development, Team Problem Solving, Building the team dynamics. Multicultural team activity.
B) **Group Discussion**- Preparation for a GD, Introduction and definitions of a GD, Purpose ofGD,Types of GD, Strategies in a GD, Conflict management, Do's and Don'ts in GD.

PR/Tut :	Group discussion

Unit 5 :	**Leadership skills:**	**[2Hrs]**

Leaders' role, responsibilities and skill required - Understanding good Leadership behaviors, Learning the difference between Leadership and Management, Gaining insight into your Patterns, Beliefs and Rules, Defining Qualities and Strengths of leadership, Determining how well you perceive what's going on around you, interpersonal Skills and Communication Skills, Learning about Commitment and How to Move Things Forward, Making Key Decisions, Handling Your and Other People's Stress, Empowering, Motivating and Inspiring Others, Leading by example, effective feedback.

Unit 6 :	**Other skills:**	**[2Hrs]**

A) **Time management**- The Time management matrix, apply the Pareto Principle (80/20 Rule) to time management issues, to priorities using decision matrices, to beat the most common time wasters, how to plan ahead, how to handle interruptions , to maximize your personal effectiveness, how to say "no" to time wasters, develop your own individualized plan of action.
B) **Stress management**- understanding the stress & its impact, techniques of handling stress.Problem solving skill, Confidence building Problem solving skill, Confidence building

PR/Tut :	Stress management
Text Books:	
[T1]	Sanjay Kumar and PushpaLata, "Communication Skills", Oxford University Press.
[T2]	Krishna Mohan, MeeraBanerji, "Developing Communication Skill", McMillan India Ltd.
[T3]	Simon Sweeney, "English for Business Communication", Cambridge University Press
Reference Books:	
[R1]	Accenture, Convergys, Dell et.al, "NASSCOM-Global Business Foundation Skills, Foundation Books, Cambridge University Press.
[R2]	E. H. McGrath, "Basic Managerial Skills for all", Eastern Economy Edition, Prentice hall India.
[R3]	Barun K. Mitra, "Personality Development and Group Discussions", Oxford University Press.
[R4]	PriyadarshiPatnaik, "Group Discussions and Interview Skills: Foundation Books", Cambridge University Press.
[R5]	Napoleon Hill, "Think and Grow Rich", Ebury Publishing, ISBN 9781407029252.
[R6]	Tony Robbins, "Awaken the Giant Within", Harper Collins Publishers, ISBN-139780743409384.
[R7]	Wayne Dyer, "Change Your Thoughts, Change Your Life", Hay House India, ISBN-139788189988050.
[R8]	Stephen Covey, "Habits of Highly Effective People", Pocket Books, ISBN-139781416502494.
[R9]	Dr. Joseph Murphy, "The Power of Your Subconscious Mind", MaanuGraphics, ISBN-13 9789381529560.
[R10]	Daniel Coleman, "The new Leaders", Sphere Books Ltd, ISBN-139780751533811.
[R11]	Richard Koch, "The 80/20 Principal", Nicholas Brealey Publishing , ISBN-13 9781857883992.
[R12]	Julie Morgenstern, "Time management from inside out", Owl Books (NY),ISBN-13 9780805075908.
[R13]	SharuRanganekar, "Wonderland of Indian Manageress", Vikas Publishing Houses, ISBN-13 9788125942603.
[R14]	Shiv Khera, "You can win", Macmillan, ISBN-139789350591932.
[R15]	Gopalaswamy Ramesh, Mahadevan Ramesh, "The Ace of Soft Skills: Attitude, Communication and Etiquette for Success".
Self-Learning Topics :	
Learning about Commitment and How to Move Things Forward, Making Key Decisions, Handling Your and Other People's Stress, Empowering, Motivating and Inspiring Others, Leading by example, effective feedback.	
Contents beyond Syllabus :	
1. How to appear for an interview 2. Interview skills	

Extra Experiments :
1. Discussion about positive thinking 2. Extempo 3. Mock interviews
Assignment Topics :
Term Work/Assignments: Term work will consist the record of any 8 assignments of following exercises 1. SWOT analysis 2. Personal & Career Goal setting – Short term & Long term 3. Presentation Skill 4. Report writing 5. Letter/Application writing 6. Listening skills 7. Group discussion 8. Resume writing 9. Public Speaking 10. Stress management 11. Team Activity-- Use of Language laboratory
Presentations :
1. Self Awareness 2. Self esteem 3. SWOT analysis 4. Listening skills 5. Letter writing 6. Public speaking 7. Presentation skills 8. Resume writing 9. Group discussion 10. Team work 11. Time management 12. Stress management 13. One presentation by student on any topic of his choice

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Audit Course III

Course Name: Audit Course III : Solar Thermal System **Course Number : 203152 (A)**		
Teaching Scheme **Theory : 2 Hrs/week** **Practical : NA** **Tutorial : NA**	**Credits** **Th / Tut : NA** **PR : NA** **GRADE : PP/NP**	**Examination Scheme [Marks]** **ISE : 00** ESE: 00 OR-PR-TW : 00

Designation of the Course : Audit Course III

Course Objectives :

1.	**To understand basics and types of solar thermal systems.**
2.	**To get knowledge of various types of concentrators.**
3.	**To make students aware of different Standards and certification for Concentrator Solar Power.**

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

CO1.	Differentiate between types of solar Concentrators.
CO2.	Apply software tool for solar concentrators.
CO3.	Design different types of Solar collectors and balance of plant.

Course Contents :

Sun, Earth and seasons
• Solar Radiation
• Basics of heat transfer
• Absorption, reflection and transmission of radiation
• Types of Solar thermal systems
• Basic design of different types of systems
• Applications of solar thermal systems and their economics
• Need for solar concentration
• Various types of solar concentrators
• Movement of Sun and tracking
• Control systems for solar tracking
• Concentrating solar thermal (CSP)
• Concentrating solar PV (CPV)
• Balance of plant for CSP
• Critical points in concentrating solar system installation
• Operation and maintenance of CSP
• Typical financial analysis of CSP
• Software tools for concentrating solar power
• Environmental impact assessment
• Standards and certification for CSP
• Basics of solar thermal (STH) systems

• Elements of various STH systems • Design, materials and manufacturing of ➢ Flat plate solar collector ➢ Evacuated tube solar collector ➢ Parabolic trough collector ➢ Dish type solar concentrators ➢ Concentrating PV systems ➢ Balance of plant • Manufacturing standards • Quality assurance and standards • Certification • Special purpose machines and Automation in manufacturing • Site assembly and fabrication • Typical shop layouts • Inventory management • Economics of manufacturing

Assignment :

Design of solar thermal system for residential/ commercial building.

Reference Books:	
[R1]	Trainers Textbook Solar Thermal Systems Module, Ministry of New and Renewable Energy, Government of India
[R2]	Students Workbook for Solar Thermal Systems Module, Ministry of New and Renewable Energy, Government of India

Power System I

Course Name : Power Systems I Course Number : 203145		
Teaching Scheme **Theory : 3 Hrs. / week**	**Credits** **Th: 03**	**Examination Scheme [Marks]** **In Sem: 30 Marks** **End Sem : 70 Marks**
Designation of the Course : Professional-Core		
Prerequisites :		
Power Generation, Various insulating materials and properties, knowledge of fundamental of electrical circuit components.		

Course Objectives:	
1.	To learn the basic structure of electrical power systems, various electrical terms related with power system and understand various types of tariff
2.	To understand the specifications and applications of various major electrical equipment present in power plant.
3.	To get the knowledge of mechanical and electrical design of overhead and underground transmission system.
4.	To learn representation of transmission lines for performance evaluation

Course Outcomes: **At the end of the course, a graduate will be able to –**	
CO1.	Recognize different patterns of load curve and calculate associated different factors with it and tariff.
CO2.	Draft specifications of electrical equipment in power station.
CO3.	Design electrical and mechanical aspects in overhead transmission and underground cables.
CO4.	Evaluate the inductance and capacitance of different transmission line configurations.
CO5.	Analyse the performance of short and medium transmission lines

Course Contents :

Unit 1 :	**Structure of Electrical Power Systems and tariff**	**[6Hrs]**

Structure of Electrical Power Systems: Structure of Electrical Power System**,** Different factors associated with generating stations such as Connected load, Maximum Demand, Demand Factor, average load, load factor, diversity factor, plant capacity factor, reserve capacity, plant use factor, Load curve, load duration curve, concept of base load and peak load stations, Interconnected grid system. Fitting of available generating stations into the area load duration curve.

B) Tariff : Introduction of Tariff, Tariff setting principles, desirable characteristics of tariff, various consumer categories and implemented tariff such as two part tariff, three part tariff(Numerical on two part and three part tariff), Time of day tariff for H.T and L.T industrial and commercial consumers, Introduction to Availability based tariff (ABT), kVAh tariff(Descriptive treatment only)

Unit 2 :	**Major Electrical Equipment's in Power Stations and Overhead line insulators**	**[6 Hrs]**

A) Major Electrical Equipment's in Power Stations : Descriptive treatment of ratings of various equipment used in power station, Special features, field of use of equipment like alternators, necessity of exciters, various excitation systems such as dc excitation, ac excitation and static excitation systems, transformers, voltage regulators, bus-bars, current limiting reactors, circuit breakers, protective relays, current transformers, Potential transformers, Lightning arresters, Earthing switches, isolators, carrier current equipment (P.L.C.C.), Control panels, battery rooms,

B) Underground Cables: Construction of Cables, Classification of cables, XLPE cables, Capacitance of single core and three core cable, Dielectric stresses in single core cable, Grading of cables, inter sheath grading, capacitance grading.

Unit 3 :	**Mechanical Design of Overhead Lines and Underground Cables**	**[8Hrs]**

Mechanical Design of Overhead Lines: Main components of overhead lines, Line supports, conductor spacing, length of span, calculation of sag for equal and unequal supports and effect of ice and wind loadings.

B) Overhead Line Insulators: Types of insulators, its construction and their applications such as Pin type, Suspension type, Strain type, Shackle type, Post insulators, bushing. Potential distribution over suspension insulators, String efficiency, (Numerical on string efficiency and up to four discs only), Methods of improving string efficiency (Descriptive treatment only).

Unit 4 :	**Resistance and Inductance of Transmission Line**	**[9Hrs]**

Resistance of transmission line, skin effect and its effects, proximity effect, internal & external flux linkages of single conductor, inductance of single phase two wire line, inductance of three phase line with symmetrical and unsymmetrical spacing, concept of G.M.R. and G.M.D, necessity of transposition, inductance of three phase double circuit line with symmetrical and unsymmetrical spacing, inductance of bundled conductors.

Unit 5 :	**Capacitance of Transmission Line**	**[7Hrs]**

Electric potential at single charged conductor, potential at conductor in a group of charged conductors, capacitance of single phase line, Capacitance of single phase line with effect of earth's surface on electric field, Concept of G.M.R. and G.M.D for capacitance calculations, capacitance of three phase line with symmetrical and unsymmetrical spacing, capacitance of double circuit three phase line with symmetrical and unsymmetrical spacing.

Unit 6 :	**Performance of Transmission Lines**	**[8 Hrs]**

Classification of lines based on length and voltage levels such as short, medium and long lines. Performance of short transmission line with voltage current relationship and phasor diagram, Representation of medium lines as 'Nominal Pi' and 'Nominal Tee' circuits using R, L and C parameters. Ferranti effect, Representation of 'Tee' and 'Pi' models of lines as two port networks, evaluation and estimation of generalized circuit constants (ABCD) for short and medium lines, Estimation of Efficiency & regulation of short & medium lines.

Text Books:

[T1]	J. B. Gupta, "Transmission and Distribution", S. K. Kataria& Sons, New Delhi.
[T2]	V. K. Mehta, Rohit Mehta, "Principles of Power System", S. Chand Publication
[T3]	J. B. Gupta, "Generation and Economic Considerations", S. K. Kataria& Sons, New Delhi.
[T4]	Dr. B. R. Gupta, "Generation of Electrical Energy", S. Chand Publication

[T5]	A Chakraborty, M. L. Soni, P. V. Gupta, U.S. Bhatnagar, "A text book on Power System Engineering", Dhanpatrai& Co., Delhi.
[T6]	S. N. Singh, "Electric Power Generation, Transmission and Distribution", Prentice Hall of India.
Reference Books:	
[R1]	Nagrath& Kothari, "Power System Engineering", Tata McGraw Hill Publications.
[R2]	D. Das, "Electrical Power System", New Age Publication.
[R3]	W.D. Stevenson, "Power System Analysis", Tata McGraw Hill Publications.
[R4]	"Know your Power – citizen's primer" – Prayas energy group
[R5]	www.mahadiscom.in
[R6]	www.mercindia.org.in
Self-Learning Topics :	
End condenser method of medium transmission line	
Contents beyond Syllabus :	
How to read electricity bill, Incentives and Penalties in tariff	
Industrial Visit :	
An Industrial Visit to HV or EHV Substation.	
Assignment Topics :	
1. Factors associated with generating station, Tariff 2. Major electrical equipment's in power plants & overhead line insulators 3. Inductance and capacitance calculations of transmission lines 4. Performance of transmission lines	
Presentations :	
overhead line insulators, underground cables	

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Electrical Machines I

Course Name : Electrical Machines I		**Course Number : 203146**
Teaching Scheme **Theory : 3Hrs. / week** **Practical : 2 Hrs. / week**	**Credits** **Th / Tut : 03** **PR : 01**	**Examination Scheme [Marks]** **In Sem : 30 Marks** **End Sem : 70 Marks** **Practical : 50 Marks**

Designation of the Course : Professional-Core / Elective / Humanities

Prerequisites :

Magnetic circuit, mutual induced EMF, dynamically induced EMF, Direction of magnetic field in current carrying conductor, Flemings LHR & RHR, Electromechanical energy conversion.

Course Objectives :

1.	To understand energy conversion process.
2.	To understand selection of machines for specific applications.
3.	To understand the construction, principle of operation of transformers, DC Machine & Induction Machine.
4.	To test & analyze the performance of machine.

Course Outcomes :At the end of the course, a graduate will be able to –

CO1.	Evaluate performance parameters of transformer with experimentation and demonstrate construction along with specifications as per standards.
CO2.	Distinguish between various types of transformer connections as per vector groups with application and to perform parallel operation of single/three phase transformers.
CO3.	Select and draft specifications of DC machines and Induction motors for various applications along with speed control methods.
CO4.	Justify the need of starters in electrical machines with merits and demerits.
CO5.	Test and evaluate performance of DC machines and Induction motors as per IS standard.

Course Contents :

Unit 1 :	**Transformers:**	**[6 Hrs]**

Single phase Transformer: Concept of ideal transformer. Corrugated core transformer. Toroidal core Transformer, Useful and leakage flux, its effects. Resistance, leakage reactance and leakage impedance of transformer windings & their effects on voltage regulation and efficiency. Exact and approximate equivalent circuits referred to L.V. and H. V. side of the transformer. Phasor diagrams for no-load and on load conditions. Transformer ratings. Losses in a transformer, their variation with load, voltage & Frequency on no load losses Efficiency and condition for maximum efficiency. All day Efficiency. Auto transformers, their ratings and applications. Comparison with two winding transformers with respect to saving of copper and size.

PR/Tut :

1. O.C. and S.C. test on single phase Transformer a. Determination of equivalent circuit parameters from the test data b. Determination of voltage regulation and efficiency.
2. Measurements of non-sinusoidal current waveform of transformer at no load.
3. Determination of sequence impedance of the transformer.

Unit 2 :	**Transformers:**	**[6 Hrs]**

Polarity test. Parallel operation of single-phase transformers, conditions to be satisfied, load sharing under various conditions. & Welding Transformer **Three Phase Transformers:** Standard connections of three phase transformers and their suitability for various applications, voltage Phasor diagrams and vector groups. Descriptive treatment of Parallel operation of three phase transformers Scott connection and V connections. Three winding (tertiary windings) transformers.		
PR/Tut :	**1.** Polarity test on single phase and three phase transformer. **2.** Parallel operation of two single phase transformers and study of their load sharing under various conditions of voltage ratios and leakage impedance.	
Unit 3 :	**D.C. Machines (Part-1):**	**[6 Hrs]**
Construction, main parts, magnetic circuits, poles, yoke, field winding, armature core, Armature windings: Simple lap and wave winding, commutator and brush assembly. Generating action, E.M.F equation, magnetization curve, Flashing of Generator. Motoring action. Types of DC motors, significance of back E.M.F, torque equation, working at no-load and on-load. Losses, power flow diagram and efficiency. Descriptive treatment of armature reaction.		
PR/Tut :	NIL	
Unit 4 :	**D.C. Machines(Part-2):**	**[6 Hrs]**
Characteristics and applications of D.C. Shunt and Series Motors, Starting of DC motors, study of starters for series and shunt motor, solid state starters, speed control of various types of DC motors. Commutation: Process of commutation, time of commutation, reactance voltage, different form of commutations, causes of bad commutation and its remedies (Descriptive treatment only).		
PR/Tut :	1. Speed control of D.C. Shunt motor and study of starters. 2. Brake test on D.C. Shunt motor. 3. Load characteristics of D.C. series motor. 4. Hopkinson's test on D.C. shunts machines. 5. To study Sumpner's test. 6. Swinburne Test on DC shunt Motor.	
Unit 5 :	**Three Phase Induction Motor:**	**[6 Hrs]**
Construction: Stator, Squirrel cage & wound rotors. Production of rotating mmf. Principle of working, simplified theory with constant air gap flux; slip, frequency of rotor emf and rotor currents, mmf produced by rotor currents, its speed w.r.t. rotor and stator mmf. Production of torque, torque-slip relation, condition for maximum torque, torque-slip Characteristics, effect of rotor resistance on torque-slip characteristics. Relation between starting torque, full load torque and maximum torque. Losses in three phase induction motor, power-flow diagram, Relation between rotor input power, rotor copper loss & gross mechanical power developed, efficiency.		
PR/Tut :	Load test on 3-phase induction motor.	
Unit 6 :	**Three Phase Induction Motor:**	**[6 Hrs]**
Induction motor as a generalized transformer; phasor diagram. Exact & approximate equivalent circuit. No load and blocked rotor tests to determine the equivalent circuit parameters and plotting the circle diagram. Computation of performance characteristics from the equivalent circuit and circle diagram. Performance curves. Necessity of starter for 3-phase induction motors. Starters for slip-ring and cage rotor induction motors, comparison of various starters. Testing of three phase induction motor as per IS 325 & IS 4029.		
PR/Tut :	1. No load & blocked-rotor test on 3-phase induction motor : a) Determination of parameters of equivalent circuit.	

	b) Plotting of circle diagram. 2. Calculation of motor performance from (a) & (b) above.
Text Books :	
[T1]	Edward Hughes "Electrical Technology", ELBS, Pearson Education.
[T2]	Ashfaq Husain, "Electrical Machines", Dhanpat Rai& Sons.
[T3]	S. K. Bhattacharya, "Electrical Machine", Tata McGraw Hill publishing Co. Ltd, 2nd Edition.
[T4]	Nagrath & Kothari, "Electrical Machines", Tata McGraw Hill.
[T5]	Bhag S Guru, Husein R. Hiziroglu, "Electrical Machines", Oxford University Press.
[T6]	K Krishna Reddy, "Electrical Machines- I and II", SCITECH Publications (India) Pvt. Ltd. Chennai.
Reference Books :	
[R1]	A.E. Clayton and N. N. Hancock, "Performance and Design of Direct Current Machines", CBS Publishers, Third Edition.
[R2]	A.E. Fitzgerald, Charles Kingsley, Stephen D. Umans, "Electrical Machines", Tata McGraw Hill Publication Ltd., Fifth Edition.
[R3]	A.S. Langsdorf, "Theory and performance of DC machines", Tata McGraw Hill.
[R4]	M.G. Say, "Performance and Design of AC. Machines", CBS Publishers and Distributors.
[R5]	Smarajit Ghosh, "Electrical Machines", Pearson Education, New Delhi.
[R6]	Charles I Hubert, "Electrical Machines Theory, Application, & Control", Pearson Education, New Delhi, Second Edition.
Self-Learning Topics :	
1. Toroidal core 2. Welding Transformer	
Contents beyond Syllabus :	
• Winding for DC machines.	
Extra Experiments : NIL	
Bridging Courses :	
• Actual winding of transformer /induction motor.	
Assignment Topics :	
Unit-I 1) Draw equivalent circuit of transformer referred to primary side. Explain all the parameters involved in the equivalent circuit. 2) A transformer rated 150 kVA has full load copper loss of 2.25 kW and iron loss of 2.25 kW. It is loaded as follows : No of hrs in day loading Power factor 3 100% Unity 4 50% Unity 17 0% — Determine all day efficiency. **Unit-II** 1) Draw circuit diagram and phasor diagram of 3-phase star-star connected transformer. Explain it in brief.	

2) With suitable phasor diagram explain wye/delta connection and delta/wye connection for 3-phase transformer. Clearly mark the angular displacement in respective phasor diagram.

Unit-III

1) Derive torque equation of DC motor with usual notations.
2) Compare Lap winding with wave winding (Minimum six points of comparison expected).

Presentations : NIl

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Network Analysis

Course Name : Fundamental of Microcontroller and Applications (2019 PAT) **Course Number : 203149**		
Teaching Scheme **Lecture : 03 Hrs/ Week** **Practical : 04 Hrs/ Week**	**Credits** **Th: 03** **PR:02**	**Examination Scheme [Marks]** **In Sem : 30 Marks** **End Sem : 70 Marks** **Term Work: 25 Marks** **Oral : 25 Marks**

Designation of the Course : Professional-Core

Prerequisites :

Knowledge of numbering systems and Boolean algebra and combinational and sequential logic circuits.

Course Objectives:

- Explain the microcontroller architecture & describe the features of a typical microcontroller.
- To use the 8051 addressing modes and instruction set and apply this knowledge to develop programs in assembly language and C language.
- To define the protocol for serial communication and understand the microcontroller development systems.
- Explain the interrupt structure of the microcontroller and to develop programs related to interrupt handling
- To introduce students to Global System for Mobile Communication (GSM)
- To provide students with interfacing concepts and develop interfacing circuits for simple devices.

Course Outcomes:

At the end of the course, a graduate will be able to –

CO1.	Describe the architecture and features of 8051 microcontroller
CO2.	Illustrate various addressing modes and write and execute programs in assembly language for 8051 microcontroller
CO3.	Write programs in C language for i/o ports and timers in 8051 microcontroller.
CO4.	Describe interrupt structure of 8051 and write program in C to handle interrupt and ADC0809
CO5.	Describe UART protocol for serial communication in 8051 and write AT commands for GSM
CO6.	Interface input output devices and measure electrical parameters with 8051 in real time

Course Contents :

Unit 1 :		**[6 Hrs]**

Introduction to concept of microcontroller, Intel 8051 Functional block diagram, Functions of pins of 8051, Memory organization of 8051, PSW and Flag Bits, Stack and Stack pointer. Overview of special function registers, Data transfer instructions and programs in assembly language.		
Practical :	• Study and use of 8051 Microcontroller trainer kit.	
Unit 2 :		**[6 Hrs]**
Arithmetic and logical instructions and programs in assembly language. Boolean and Program Branching instructions and programs in assembly language. Addressing modes of 8051.		
Practical :	• Assembly Language Program for the arithmetic operation of 8-bit numbers. • Assembly Language Program for finding the largest number and smallest number from a given an array of 8-bit numbers. • Assembly Language program to arrange 8-bit numbers stored in an array in ascending order and descending order.	
Unit 3 :		**[6 Hrs]**
8051 Programming in C , Data types in C . Ports of 8051, their use, and programming in C (Byte Level and Bit-level). Time delay programming in C. Timers and counters in 8051, Timer modes 0,1,2 and its programming in C and counterprogramming.		
Practical :	• The blinking display of LED's interfaced with 8051. • Interfacing of 7 segment display with 8051.	
Unit 4 :		**[6 Hrs]**
Interrupt structure of 8051 and SFR associated with interrupts. Programming of External hardware interrupts in C.Interfacing of ADC 0809 with 8051.		
Practical :	• Measurement of physical parameters - Temperature using 8051 and LM35 and displaying the value on the LCD at certain intervals. (PART B) • Interfacing of LCD with 8051 (Demo)	
Unit 5 :		**[6 Hrs]**
Serial port Structure in 8051. Programming of Serial port for transferring and receiving data in C in mode 1. Introduction to GSM module, AT commands, Programming to send and read SMS.		
Practical :	• Implementation of Serial Communication by using 8051 serial ports. • Study of GSM Module SIM800C and AT Commands (PART B) • Develop a program in C to read and send SMS from the GSM module. (PART B) • Interfacing GSM with 8051 trainer kit and develop a program to send AT commands. (PART B)	
Unit 6 :		**[6 Hrs]**
Measurement of electrical parameters such as voltage, current (Theoretical Treatment only). Interfacing of Stepper motor with 8051 and its programming in C. Interfacing and programming of single Key, LED, and Relay with 8051 in C.		
Practical :	• Stepper motor control by 8051 Microcontroller. • Study of IoT system (PART B)	
Text Books:		

[T1]	Muhammad Ali Mazidi, J.G. Mazidi, "The 8051 Microcontroller and Embedded Systems", Pearsons Publishers.
[T2]	V Udayashankara and M S MallikarjunaSwamy, "8051 Microcontroller, Hardware, software and applications", TATA McGraw Hill.
[T3]	Ajay Deshmukh, "Microcontroller 8051" –TATA McGraw Hill.
[T4]	Theagrajan," Microprocessor and Microcontroller", BS Publication.
[T5]	K. J. Ayala, "The 8051 Microcontrollers- Architecture, Programming and Applications", Peram International Publications.
[T6]	SubrataGhoshal, "8051 microcontroller", Pearsons Publishers.
[T7]	Han-Way Huang," Embedded System Design with C8051", Cengage Learning
Reference Books:	
[R1]	Scott Mackenzie, "8051 Microcontroller", Pearson Education.
[R2]	Intel Microcontroller data book.
[R3]	Intel Corporation 1990- 8 bit embedded controller handbook.

Bridging Course :

Gap :

- C programming language is not included in FE or Diploma level Electrical Curriculum.
- More than 60% practical on 8051 involve C programming at SE level

Efforts to bridge the gap :

- A bridging course in Basics of C Programming is taken for students at the beginning of the semester.
- Spoken Tutorial in C Programming is planned at the mid of the semester.

Self-Learning Topics :

- Measurement of electrical current (Theoretical Treatment only).
- Interfacing and programming Relay with 8051 in C.

Contents beyond Syllabus :

- Computation of Relative address in branching and looping instructions.
- Programming of Timer 0 interrupts in Assembly.
- Programming of External hardware interrupts in Assembly.

Extra Experiments :

-

Assignment Topics :

Assignment 1 on Architecture and memory organization of 8051 microcontroller.
Assignment 2 on Assembly language programs and addressing modes
Assignment 3 on Port programming and Timer / counter
Assignment 4 on Interrupt and ADC programming
Assignment 5 on Serial Communication

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Numerical Methods and Computer Programming

Course Name : Numerical Methods and Computer Programming **Course Number : 203148**		
Teaching Scheme **Theory : 3 Hrs. / week** **Practical : 2 Hrs. / week**	**Credits** **Th : 03** **PR : 01**	**Examination Scheme [Marks]** **In Sem : 30 Marks** **End Sem : 70 Marks** **Practical : 25 Marks**
Designation of the Course : Professional-Core		
Prerequisites : 1. Differentiation and integration of a single real variable, ordinary differential equations. 2. Programming and Problem solving. 3. Linear Algebra.		

Course Objectives :

1.	To emphasize the need of computational techniques and analyze errors involved in the computation.
2.	To provide sound knowledge of various numerical methods
3.	To apply various numerical methods to obtain solution of different types of equations such as transcendental, simultaneous, ODE etc. and also for interpolation, integration and differentiation.
4.	To impart skills to develop algorithms and programs for various numerical methods.

Course Outcomes :

At the end of the course, a graduate will be able to –

CO1.	Demonstrate types of errors in computation, their causes of occurrence and remedies to minimize them.
CO2.	Compare and apply various numerical methods for obtaining roots of transcendental equations and for solution of system of linear simultaneous equation.
CO3.	Compare and apply various numerical methods of interpolation, numerical integration and differentiation.
CO4.	Apply various numerical methods for obtaining solution of first and second order ordinary differential equations.
CO5.	Compare and apply various numerical methods for solution of system of linear simultaneous equation.
CO6.	Develop algorithms for various numerical methods and develop computer programs using 'Python' programming language.

Course Contents :

Unit 1 :	**Numerical Computations, Errors and Concept of root of equation :**	**[6 Hrs]**

A) Basic principle of numerical computation. Floating point algebra with normalized floating point technique, Significant digits. Errors: Different types of errors, causes of occurrence and remedies to minimize them, Generalized error formula (Derivation and Numerical) B) Concept of roots of an equation. Descartes' rule of signs, Intermediate value theorem, Roots of Polynomial Equations using Birge-Vieta method.		
Practical :	• Practice programs using Python • Solution of a polynomial equation using Birge-Vieta method.	
Unit 2 :	**Solution of Transcendental & polynomial equation and Curve Fitting:**	**[6 Hrs]**
A) Solution of Transcendental and polynomial equation using Bisection, Regula- Falsi, Newton-Raphson method for single variable and two variables. B) Curve fitting using least square approximation – First order and second order		
Practical :	• Solution of transcendental equation using Bisection method. • Program for fitting a straight line to given data using method of least squares.	
Unit 3 :	**Interpolation :**	**[6 Hrs]**
Forward, Backward, Central and Divided Difference operators, Introduction to interpolation. A) Interpolation with equal Intervals - Newton's forward, backward interpolation formula (Derivations and numerical), Stirling's and Bessel's central difference formula (Only numericals) B) Interpolation with unequal Intervals- Newton's divided difference formula and Lagrange's interpolation (Derivations and numerical).		
Practical :	• Program for interpolation using Newton's forward difference interpolation. • Program for interpolation using Lagrange's interpolation.	
Unit 4 :	**Numerical Differentiation and Integration :**	**[6 Hrs]**
A) Numerical Differentiation using Newton's forward and backward interpolation formula (Derivation and numerical). B) Numerical Integration: Trapezoidal and Simpson's rules as special cases of Newton-Cote's quadrature technique for single integral. Numerical on double integrals using Trapezoidal and Simpson's 1/3 rd rule.		
Practical :	• Solution of Numerical Integration using Simpson's $(1/3)^{rd}$ rule.	
Unit 5 :	**Solution of linear simultaneous equation :**	**[8 Hrs]**
A) Solution of linear simultaneous equation: Direct methods - Gauss elimination method, concept of pivoting – partial and complete. Gauss Jordan method, Iterative methods – Jacobi method and Gauss Seidel method. B) Matrix Inversion using Gauss Jordan method		
Practical :	• Solution of simultaneous equation using Gauss Elimination method. • Solution of simultaneous equation using Jacobi iterative method.	
Unit 6 :	**Solution of Ordinary Differential Equation(ODE) :**	**[8 Hrs]**
A) Solution of First order Ordinary Differential Equation (ODE) using Taylor's series method, Euler's method, Modified Euler's method (Derivation and numerical). Runge-Kutta fourth order method (Numerical). B) Solution of Second order ODE using 4th order Runge-Kutta method (Numerical)		
Practical :	• Solution of first order ODE using Modified Euler's method.	

Text Books :	
[T1]	M. K. Jain, S.R.K. Iyangar, R. K. Jain, "Numerical Methods for Scientific and Engineering Computations", New Age Publications.
[T2]	Dr. B. S. Grewal, "Numerical Methods in Engineering & Sciences", Khanna Publishers.
[T3]	T. Veerarajan and T. Ramchandran, "Numerical Methods with Programs in C and C++", Tata McGraw Hill Publication.
[T4]	P.P. Gupta & G.S Malik, "Calculus of Finite Difference and Numerical Analysis", Krishna Prakashan Media Ltd, Meerut**.**
[T5]	S Arumugam, "Numerical Methods" Scitech Publication
Reference Books :	
[R1]	J. B. Scarborough, "Numerical Mathematical Analysis", Oxford & IBH, New Delhi.
[R2]	Steven Chapra, Raymond P. Canale, "Numerical Methods for Engineers", Tata McGraw Hill Publication.
[R3]	S.S. Sastry, "Introductory methods of Numerical Analysis", PHI Learning Private Ltd.
[R4]	P. Thangaraj, "Computer oriented Numerical Methods", PHI Learning Private Ltd.
[R5]	Yashwant Kanetkar, "Let us Python", BPB Publications.
[R6]	NPTEL course on Numerical Analysis, IIT, Roorkee. https://nptel.ac.in/courses/111107062/
[R7]	NPTEL course on MATLAB Programming on Numerical Computation, IIT Madras https://nptel.ac.in/courses/103106118/
[R8]	NPTEL course on Python for Data Science, IIT Madras https://nptel.ac.in/courses/106106212/
[R9]	Jaan Kiusalaas, "Numerical methods in Engineering with Python", Cambridge University Press

Self-Learning Topics :

- Newton's Backward difference interpolation methods.
- Gauss Jordan method and Gauss Seidel method.
- Numerical integration using Simpson's 1/3 and 3/8 rule.

Extra Experiments :

Practice programs in Python language e.g. –

- To find roots of quadratic equation.
- To find mean, median and standard deviation from given data.
- Matrix multiplication.

Assignment Topics :

- Python programs
- one assignment each on all 6 units

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Fundamentals of Microcontroller and Applications

Course Name : Fundamental of Microcontroller and Applications (2019 PAT) **Course Number : 203149**		
Teaching Scheme **Lecture : 03 Hrs/ Week** **Practical : 04 Hrs/ Week**	**Credits** **Th: 03** **PR:02**	**Examination Scheme [Marks]** **In Sem : 30 Marks** **End Sem : 70 Marks** **Term Work: 25 Marks** **Oral : 25 Marks**
Designation of the Course : Professional-Core		
Prerequisites :		
Knowledge of numbering systems and Boolean algebra and combinational and sequential logic circuits.		

Course Objectives:

- Explain the microcontroller architecture & describe the features of a typical microcontroller.
- To use the 8051 addressing modes and instruction set and apply this knowledge to develop programs in assembly language and C language.
- To define the protocol for serial communication and understand the microcontroller development systems.
- Explain the interrupt structure of the microcontroller and to develop programs related to interrupt handling
- To introduce students to Global System for Mobile Communication (GSM)
- To provide students with interfacing concepts and develop interfacing circuits for simple devices.

Course Outcomes:

At the end of the course, a graduate will be able to –

CO1.	Describe the architecture and features of 8051 microcontroller
CO2.	Illustrate various addressing modes and write and execute programs in assembly language for 8051 microcontroller
CO3.	Write programs in C language for i/o ports and timers in 8051 microcontroller.
CO4.	Describe interrupt structure of 8051 and write program in C to handle interrupt and ADC0809
CO5.	Describe UART protocol for serial communication in 8051 and write AT commands for GSM
CO6.	Interface input output devices and measure electrical parameters with 8051 in real time

Course Contents :

Unit 1 :		**[6 Hrs]**

Introduction to concept of microcontroller, Intel 8051 Functional block diagram, Functions of pins of 8051, Memory organization of 8051, PSW and Flag Bits, Stack and Stack pointer. Overview of special function registers, Data transfer instructions and programs in assembly language.		
Practical :	• Study and use of 8051 Microcontroller trainer kit.	
Unit 2 :		**[6 Hrs]**
Arithmetic and logical instructions and programs in assembly language. Boolean and Program Branching instructions and programs in assembly language. Addressing modes of 8051.		
Practical :	• Assembly Language Program for the arithmetic operation of 8-bit numbers. • Assembly Language Program for finding the largest number and smallest number from a given an array of 8-bit numbers. • Assembly Language program to arrange 8-bit numbers stored in an array in ascending order and descending order.	
Unit 3 :		**[6 Hrs]**
8051 Programming in C , Data types in C . Ports of 8051, their use, and programming in C (Byte Level and Bit-level). Time delay programming in C. Timers and counters in 8051, Timer modes 0,1,2 and its programming in C and counterprogramming.		
Practical :	• The blinking display of LED's interfaced with 8051. • Interfacing of 7 segment display with 8051.	
Unit 4 :		**[6 Hrs]**
Interrupt structure of 8051 and SFR associated with interrupts. Programming of External hardware interrupts in C.Interfacing of ADC 0809 with 8051.		
Practical :	• Measurement of physical parameters - Temperature using 8051 and LM35 and displaying the value on the LCD at certain intervals. (PART B) • Interfacing of LCD with 8051 (Demo)	
Unit 5 :		**[6 Hrs]**
Serial port Structure in 8051. Programming of Serial port for transferring and receiving data in C in mode 1. Introduction to GSM module, AT commands, Programming to send and read SMS.		
Practical :	• Implementation of Serial Communication by using 8051 serial ports. • Study of GSM Module SIM800C and AT Commands (PART B) • Develop a program in C to read and send SMS from the GSM module. (PART B) • Interfacing GSM with 8051 trainer kit and develop a program to send AT commands. (PART B)	
Unit 6 :		**[6 Hrs]**
Measurement of electrical parameters such as voltage, current (Theoretical Treatment only). Interfacing of Stepper motor with 8051 and its programming in C. Interfacing and programming of single Key, LED, and Relay with 8051 in C.		
Practical :	• Stepper motor control by 8051 Microcontroller. • Study of IoT system (PART B)	
Text Books:		

[T1]	Muhammad Ali Mazidi, J.G. Mazidi, "The 8051 Microcontroller and Embedded Systems", Pearsons Publishers.
[T2]	V Udayashankara and M S MallikarjunaSwamy, "8051 Microcontroller, Hardware, software and applications", TATA McGraw Hill.
[T3]	Ajay Deshmukh, "Microcontroller 8051" –TATA McGraw Hill.
[T4]	Theagrajan," Microprocessor and Microcontroller", BS Publication.
[T5]	K. J. Ayala, "The 8051 Microcontrollers- Architecture, Programming and Applications", Peram International Publications.
[T6]	SubrataGhoshal, "8051 microcontroller", Pearsons Publishers.
[T7]	Han-Way Huang," Embedded System Design with C8051", Cengage Learning
Reference Books:	
[R1]	Scott Mackenzie, "8051 Microcontroller", Pearson Education.
[R2]	Intel Microcontroller data book.
[R3]	Intel Corporation 1990- 8 bit embedded controller handbook.

Bridging Course :

Gap :

- C programming language is not included in FE or Diploma level Electrical Curriculum.
- More than 60% practical on 8051 involve C programming at SE level

Efforts to bridge the gap :

- A bridging course in Basics of C Programming is taken for students at the beginning of the semester.
- Spoken Tutorial in C Programming is planned at the mid of the semester.

Self-Learning Topics :

- Measurement of electrical current (Theoretical Treatment only).
- Interfacing and programming Relay with 8051 in C.

Contents beyond Syllabus :

- Computation of Relative address in branching and looping instructions.
- Programming of Timer 0 interrupts in Assembly.
- Programming of External hardware interrupts in Assembly.

Extra Experiments :

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Assignment Topics :

Assignment 1 on Architecture and memory organization of 8051 microcontroller.
Assignment 2 on Assembly language programs and addressing modes
Assignment 3 on Port programming and Timer / counter
Assignment 4 on Interrupt and ADC programming
Assignment 5 on Serial Communication

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Project Based Learning

Course Name: Project Based Learning **Course Number : 203152**		
Teaching Scheme **Theory : NA** **Practical : 02** **Tutorial : NA**	**Credits** **Th / Tut : NA** **PR :02** **GRADE : NA**	**Examination Scheme [Marks]** **ISE : 00** **ESE: 00** **OR-PR-TW : 50**
Designation of the Course : Audit Course IV		

Course Objectives :

1.	To impart technical knowledge and skills, and develop deeper understanding to integrate knowledge and skills from various areas.
2.	To build critical thinking, problem-solving, communication, collaboration and creativity, and innovation amongst students
3.	To make students aware of their own academic, personal, and social developments.
4.	To develop habits of self-evaluation and self-criticism, against self-competency and trying to see beyond own ideas and knowledge

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

CO1.	Identify, formulate, and analyze the simple project problem.
CO2.	Apply knowledge of mathematics, basic sciences, and electrical engineering fundamentals to develop solutions for the project.
CO3.	Learn to work in teams, and to plan and carry out different tasks that are required during a project.
CO4.	Understand their own and their team-mate's strengths and skills.
CO5.	Draw information from a variety of sources and be able to filter and summarize the relevant points.
CO6.	Communicate to different audiences in oral, visual, and written forms.

Procedure: A group of 4-5 students will be assigned to a faculty member called a mentor. Based on the engineering knowledge of a group and societal and industry problems, the mentor has to guide a group to identify project problems and plan the work schedule. Here, the expected outcomes of the project must be noted. The complete work-plan should be divided in the form of the individual tasks to be accomplished with targets. Weekly review of the completed task should be taken and further guidelines are to be given to a group. The final activity will be presenting the work completed and submitting the report. A group should be promoted to participate in a competition or write a paper.
A problem needs to refer back to a particularly practical, scientific, social, and/or technical domain. The problem should stand as one specific example or manifestation of more general learning outcomes related to knowledge and/or modes of inquiry. There are no commonly shared criteria for what constitutes an acceptable project. Projects vary greatly in the depth of the questions explored, the clarity of the learning goals, the content, and the structure of the activity.

It may have

✓ A few hands-on activities that may or may not be multidisciplinary.

✓ Use of technology in meaningful ways to help them investigate, collaborate, analyze, synthesize, and present their learning.

✓ Activities on solving real-life problems, investigation /study, and writing reports of in-depth study, fieldwork.

Assessment: The department/mentor is committed to assess and evaluate both students' performance and course effectiveness. The progress of PBL is monitored regularly every week. During the process of monitoring, continuous assessment and evaluation the individual and team performances are to be measured by supervisor /mentor and authorities. Students must maintain an institutional culture of authentic collaboration, self-motivation, peerlearning, and personal responsibility. The institution/department should support students in this regard through guidance/orientation programs and the provision of appropriate resources and services. Supervisor/mentor and students must actively participate in the assessment and evaluation processes. Groups may demonstrate their knowledge and skills by developing a solution to the problem, public product, and/or report and/or presentation.

✓ Individual assessment for each student (Understanding individual capacity, role, and involvement in the project)

✓ Group assessment (roles defined, distribution of work, intra-team communication and togetherness)

✓ Documentation and presentation

Evaluation and Continuous Assessment: It is recommended that all activities are to be recorded in a PBL workbook regularly, regular assessment of work to be done and proper documents are to be maintained at the department level by both students as well as a mentor. Continuous Assessment Sheet (CAS) is to be maintained by all mentors/department. Recommended parameters for assessment, evaluation, and weightage are as follows.

✓ Idea Inception (5%)

✓ Outcomes of PBL/ Problem Solving Skills/ Solution provided/ Final product (50%) (Individual assessment and team assessment)

✓ Documentation (Gathering requirements, design and modeling, implementation/execution, use of technology and final report, other documents) (25%)

✓ Demonstration (Presentation, User Interface, Usability, etc.) (10%)

✓ Contest Participation/ publication (5%)

✓ Awareness /Consideration of -Environment/ Social /Ethics/ Safety measures/Legal aspects (5%)

✓ PBL workbook will serve the purpose and facilitate the job of students, mentors, and project coordinator. This workbook will reflect accountability, punctuality, technical writing ability and work flow of the work undertaken

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Audit Course IV

Course Name: Solar Photovoltaic Systems **Course Number : 203153(A)**		
Teaching Scheme **Theory : 2 Hrs/week** **Practical : NA** **Tutorial : NA**	**Credits** **Th / Tut : NA** **PR : NA** **GRADE : PP/NP**	**Examination Scheme** **[Marks]** **ISE : 00** **ESE: 00** **OR-PR-TW : 00**

Designation of the Course : Audit Course IV

Course Objectives :

1.	**To learn Solar PV system and its appliances.**
2.	**To get knowledge of balance of PV system, batteries, inverters etc.**
3.	**To understand grid tied SPV solar plants.**

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

CO1.	Design of Solar PV system for small and large installations.
CO2.	Handle software tools for Solar PV systems.

Course Contents :

- Physics of photovoltaic (PV) electricity
- Photodiode and solar cell
- Solar radiation spectrum for PV
- • Types of solar cell and comparison
- Introduction to various types of solar module manufacturing
- Basic system design and economics
- Types of systems
- Common applications of solar PV
- Introduction to solar PV (SPV) systems
- SPV appliances
- Small capacity SPV power plants
- Grid tied SPV power plants
- Large scale SPV power plants
- Balance of system
- Solar inverters
- Batteries
- Financial modelling of SPV
- Operation and maintenance of SPV
- Software tools for SPV
- Environmental impact assessment
- Standards and certification for SPV
- Basics of SPV systems
- Elements of SPV appliances and power plants Procurement versus production

• Bought-outs, assemblies, sub-assemblies
• Manufacturing and assembly
• Manufacturing standards
• Quality assurance and standards
• Certification
• Special purpose machines and Automation in manufacturing
• Site assembly and Fabrication
• Typical shop layouts
• Inventory management
• Economics of manufacturing Practical
• PV characterization
• Batteries and energy storage
• PV system design

Assignment :

• Design of solar PV system for department / college.

Reference Books:

[R1]	A.S.Kapur -A Practical Guide for Total Engineering of MW capacity Solar PV Power Project
[R2]	Solanki C.S- Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers- PHI
[R3]	Solanki C.S- SolarPhotovoltaics - Fundamentals, Technologies and Applications- PHI
[R4]	S. Sukhatme -Solar Energy : Principles of Thermal Collection and Storage- McGraw Hill