Department of Electrical Engineering
Faculty of Technology
University of Delhi
Detailed Course Structure and Curriculum of B.Tech. (EE) Second Year

Department of Electrical Engineering
Faculty of Technology
University of Delhi

Course Structure of B. Tech. (EE) Second Year

Semester III						
S. No.	**Course Domain**	**Course Title**	**Credits***			**Total Credits**
			L	**T**	**P**	
1	DSC-7	Electrical Network Analysis	3	0	1	4
2	DSC-8	Electrical Machines I	3	0	1	4
3	DSC-9	Analog and Digital Electronic Circuits	3	0	1	4
4	DSE-1 or GE-3	Select a course from the specified list of DSE-1 or Select a course from the specified list of GE-3				4
5	AEC	Select a course from the specified list of AECs				2
6	SEC / IAPC	Choose one SEC or Internship / Apprenticeship / Project / Community Outreach (IAPC)				2
7	VAC	Select a course from the specified list of VACs				2
		Total Credits				**22**

Semester IV						
S. No.	**Course Domain**	**Course Title**	**Credits***			**Total Credits**
			L	**T**	**P**	
1	DSC-10	Electrical Machines II	3	0	1	4
2	DSC-11	Power Transmission and Distribution	3	0	1	4
3	DSC 12	Electrical and Electronic Measurements	3	0	1	4
4	DSE-2/ GE-4	Select a course from the specified list of DSE-2 or Select a course from the specified list of GE-4				4
5	AEC	Select a course from the specified list of AECs				2
6	SEC / IAPC	Choose one SEC or Internship / Apprenticeship / Project / Community Outreach (IAPC-2)				2
7	VAC	Select a course from the specified list of VACs				2
		Total Credits				**22**

**Credits*
L (01 Credit) is equivalent to 01 contact hour per week.
T (01 Credit) is equivalent to 01 contact hour per week.
P (01 Credit) is equivalent to 02 contact hours per week.

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Pool of DSEs offered by the Department of Electrical Engineering in Second Year

S. No.	Semester	DSE	Course Title
1.	III	DSE-1	Non-Conventional Energy Resources
2.			Signal and Systems
3.	IV	DSE-2	Electrical Machine Design
4.			Electrical Engineering Materials

List of SECs offered by the Department of Electrical Engineering in Second Year

S. No.	Semester	Course Title
1.	III	Advanced Electrical Workshop-I
2.	IV	Pspice Modelling for Electrical Circuits

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Specializations and Minor offered by the Department of Electrical Engineering

S. No.	Sem	DSE/ GE	Minor in EE (Open only for CSE/ ECE)	Specializations for EE / Minors for ECE and CSE		
				Robotics and Automation	Sustainable Energy Engineering	Electric and Hybrid Vehicle
1	III	DES-1/ GE-3	Fundamentals of Electrical Circuits	Fundamentals of Signal and Systems	Energy and Its Resources	Introduction to Electric and Hybrid Vehicles
2	IV	DSE-2/ GE-4	Electro-Mechanical Energy Conversion	Sensors and Transducers	Design and Evaluation of Photovoltaic Power Plants	Electric Vehicle Motor

Detailed Syllabus of Discipline Specific Core (DSC) Courses of B. Tech. (EE) – SEMESTER III

Electrical Network Analysis (DSC-7)

(Credit Distribution and Pre-Requisites of the Course)

Course title	Credits	Credit distribution of the course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Electrical Network Analysis	4	3	0	1	Introduction to Electrical and Electronics Engineering, Mathematics-I

Course Hours: L-03, T-00, P-02

Course Objectives:

1. To solve different complex circuits using various network reduction techniques such as Source Transformation, Network theorems etc.
2. To understand basic concepts of DC and AC circuit behavior.
3. To analyze the transient response of series and parallel A.C. circuits and to solve problems in time domain using Laplace Transform.
4. To analyze two port circuit behaviors.

Course Outcomes:

At the end of this course, students will demonstrate the ability to:

1. Acquire and demonstrate the knowledge of circuit elements, different laws and resonating behavior of circuits.
2. Apply the knowledge of basic circuit law to simplify the networks using network theorems.
3. Analyze the RL, RC and RLC circuits using Laplace transform and waveform Synthesis.
4. Analyze the transient, steady state of RL, RC and RLC circuits for AC and DC excitations.
5. Analysis of various two port networks with their connection, interrelationships and interconnection of two port networks (with respect to impedance, admittance, hybrid and transmission parameters).

UNIT-I

Introduction to AC circuits: Review of AC Circuits and Introduction to three phase circuits, Series and parallel resonance, frequency response of series and Parallel circuits, Q–Factor, Bandwidth.
Magnetically coupled circuits: Dot convention, Self and Mutual Inductance, Energy in a coupled circuit.

UNIT-II

Network Theorems for AC & DC circuits: Node and Mesh analysis, Thevenin's & Norton's Theorems, Superposition Theorem, Reciprocity, Compensation, Substitution, Maximum power transfer, Millman's and Tellegen's theorems. Examples with dependent & independent energy sources.
Network Topology: Concept of Network graph, Tree, Tree branch & link, Incidence matrix, cut set and tie set matrices.

UNIT-III

Laplace Transforms and properties: Initial conditions in networks and network solution with Laplace transformation, step, ramp and impulse functions, initial and final value theorem, waveform Synthesis

Transient behavior and initial conditions: Behavior of circuit elements under switching condition and their representation, evaluation of initial and final conditions in RL, RC and RLC circuits for AC and DC excitations.

UNIT-IV

Two port networks: Network & Transfer functions for one port & two ports, poles and zeros, Necessary condition for driving point & transfer function. Two port parameters – Z, Y, ABCD, Hybrid parameters, their inverse & image parameters, relationship between parameters, Interconnection of two ports networks, Terminated two port networks.

Filter circuits: Analysis and synthesis of Low pass, High pass, Band pass, Band reject, All pass filters (first and second order only) using operational amplifier. Solution of Problems.

Suggestive Readings:

1. Lawrence P. Huelsman, Basic Circuit Theory, Prentice Hall India Learning Private Limited; 3rd edition.
2. William H. Hayt, Jack Kemmerly, Steven M. Durbin, Engineering Circuit Analysis, McGraw Hill Education; Eighth edition (4 August 2013).
3. Raymond A. DeCarlo, Pen-Min Lin, Linear Circuit Analysis, OUP USA; 2nd edition.
4. M.E. Van Valkenburg, Network Analysis, PHI Learning, 3rd Edition, 2010.
5. William D Stanley: Network Analysis with Applications, Pearson Education, 4th Edition, 2013.

List of Experiments:

1. To verify the Thevenin's/Norton's Theorem.
2. To verify the Superposition Theorem.
3. To verify the Maximum Power Transfer Theorem.
4. To verify Reciprocity Theorem.
5. To verify the Millman's Theorem.
6. To verify the Tellegan’s Theorem.
7. To construct RL & RC transient circuits and to draw the transient curves.
8. To obtain the resonance frequency of the given RLC series electrical network.
9. To determine open circuit parameters and short circuit parameter of the given two-port network.
10. To calculate and verify 'ABCD' parameters of a two-port network.
11. To calculate and verify Hybrid parameters of two-port network.
12. Frequency response of first order low pass and high pass filters.
13. Frequency response of first order band pass and band reject filters.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercise.)

Electrical Machines I (DSC-8)

(Credit Distribution and Pre-Requisites of the Course)

Course title	Credits	Credit distribution of the course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Electrical Machines I	4	3	0	1	Introduction to Electrical and Electronics Engineering, Mathematics-I

Course Hours: L-03, T-00, P-02

Course Objectives:

To make the students familiar with the fundamentals of various type of DC machines and transformers both of which are important entities in the field of Electrical Engineering.

Course Outcomes:

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

1. Analyse the series and parallel magnetic circuits from the point of view of electrical machines and transformers. Students will also learn the concept of field energy and co - energy helpful in design of machines at a later stage.
2. Understand the intricate details of the construction of DC machines, needed in the design and fabrication of DC generators. Knowledge of the armature winding will enable the students to perform fault finding in the armature.
3. Gain complete knowledge of communication in DC machines to enable them to improve the performance of DC machines. The students will also learn the characteristics of DC Motors, a knowledge which will help them to select appropriate motor for a specific application.
4. Gain knowledge of various aspects of single and three-phase transformers, helping them to compute their performance in respect of voltage regulation efficiency, and also select proper type of three-phase connections for specific purpose.

UNIT-I

Electromechanical Energy Conversion: Law of conservation of Energy, Series and Parallel Magnetic Circuits, analogy with electric circuits. Energy stored in magnetic field, concept of co-energy. Energy conversion in singly excited and doubly excited systems. Production of Torque in Electromagnetic systems. Reluctance Torque.

UNIT-II

DC Machines: Constructional features of DC Machines. Types of field coils and their placement on stator. Lap and Wave Windings on armature. Concept of parallel paths.

DC Generators: EMF equation of a DC generator. Methods of excitation; shunt, series and compound generators and their characteristics.

UNIT-III

Commutation in DC Machines: Interaction between fields produced by field and Armature circuits. Phenomenon of commutation, Causes, effect and remedy for bad commutation.

DC Motors: Torque Equation of D.C. Motor, Concept of Back EMF. Methods of excitation of dc motors. Characteristics of shunt, series and Compound Motors. Starting & speed control of DC Motors, Testing of DC Machines.

UNIT-IV

Single phase transformers: Construction of Transformers. No load and load operation. Equivalent circuits and phasor diagrams, Voltage regulation, losses and efficiency. All day Efficiency of a transformer.

Testing of transformer: OC/SC Tests, Sumpner's test.

Three phase transformers: Three phase bank of single-phase transformers. Conditions of parallel operation of single phase & 3 phase transformers various types of winding connections of three phase transformers. Auto transformers: Construction operation , comparison with two winding transformers

Suggestive Readings:

1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery", McGraw Hill Education, 2013.
2. M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.
3. P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
4. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.
5. A. S. Langsdorf, "Alternating current machines", McGraw Hill Education, 1984.
6. P. S. Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers, 2011.

List of Experiments:

1. Magnetising characteristic of DC machines.
2. Load characteristic of DC shunt generator.
3. Load characteristic of DC compound generator.
4. Speed control of DC shunt motor.
5. Swinburn's test on a DC shunt motor.
6. Load Test on a DC shunt motor.
7. OC and SC test on a single-phase transformer.
8. Load test on a single-phase transformer.
9. Parallel operation of two single phase transformers.
10. Study of three phase connections of transformers.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercise.)

Analog and Digital Electronic Circuits (DSC-9)

(Credit Distribution and Pre-Requisites of the Course)

Course title	Credits	Credit distribution of the course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Analog and Digital Electronic Circuits	4	3	0	1	Introduction to Electrical and Electronics Engineering, Physics, Mathematics-I

Course Hours: L-03, T-00, P-02

Course Objectives:

This course is intended to develop an understanding of small signal amplifier design using linear transistor models; and its analysis at low and high frequencies, including different feedback topologies and oscillators. The course also indulges power amplifiers, tuned amplifiers and behavior of noise in an amplifier.

Course Outcomes:

At the end of this course, students will demonstrate the ability to:

1. Explain the basic concepts of BJT, MOSFET with their h parameter modelling.
2. Analyze the working principles of wave shapers and negative amplifiers.
3. Describe and compare the Bi-stable, Mono-stable and Astable circuits and its applications.
4. Explain the ideal and practical Op-Amp characteristics and perform the various Op-Amp circuits in different applications.

UNIT-I

Introduction to OP-Amp: Introduction, Block Diagram Representation of a Typical OP-Amp, Operational amplifier characteristics, slew rate, bandwidth, offset voltage, basic applications inverting, non-inverting amplifier and its application summing amplifier, differentiator, integrator, differential amplifier, instrumentation amplifier, log and antilog amplifier, voltage to current and current to voltage converters, comparators Schmitt trigger.

UNIT-II

Voltage Controlled Oscillator, precision rectifiers, sample and hold circuit, basic op-amp comparator circuit, zero crossing detector, function generator, peak detectors, analog and digital converters and digital to analog converters, 555 timer and its applications, phase locked ICs (PLL).

UNIT-III

Combinational circuits: Review of number systems and mutual conversion, Boolean algebra, Minterms and maxterms, Truth table and Karnaugh mapping, reduction of Boolean expression with SOP, POS and mixed terms.
Encoder/Decoder and Codes Encoders, Decoders, Multiplexers, Demultiplexers, code convertors, Half adder and full adder, parity checker/ generator, programming logic Array (PLA).

UNIT-IV

Sequential circuits: State tables and diagrams, flip flop and its various types- JK, RS, T, D, pulse and edge triggered flip flops transition and excitation tables, timing diagrams.

Shift registers: Series and parallel data transfer, asynchronous and synchronous counters, ripple counter, Modulo N counter design, up down counters, Ring counter, DAC and ADC.

Suggestive Readings:

1. Behzad Razavi, "Fundamentals of Microelectronics", Wiley India Pvt. Ltd. 2009.
2. S. Sedra and K. C. Smith, "Microelectronic Circuits", Oxford university Press, 6th Edition 2013.
3. Robert L Boylestad and Louis Nashelsky, "Electronic Devices & Circuit Theory", PHI 2001.
4. B. G. Streetman and S. Banerjee, "Solid State Electronic Devices", 7th ed., Pearson Ed, 2014.
5. Digital Logic and Computer Design, M. Morris Mano, Pearson Education.
6. Digital Fundamentals, T. L. Floyd, Pearson Education.

List of Experiments:

1. To study operational amplifier as inverting & non inverting amplifier & calculate gain.
2. To study and observe operational amplifier as a differentiator and integrator.
3. To study and observe operational amplifiers as summing amplifier & difference amplifiers.
4. To study operational amplifiers as comparator & Schmitt trigger.
5. To design an operational amplifier circuit for scaling and averaging.
6. Implementation of adder and subtractor circuits on breadboard.
7. Implementation of 4×1 Multiplexer on breadboard.
8. Implementation of 3-bit Binary to gray code converter circuit on breadboard.
9. Analysis of flip-flop using kit.
10. Implementation of 7-segment display using up counter.
11. Analysis of up and down synchronous/ asynchronous counter using kit.
12. To Study and perform the conversion using the A/D and D/A converter.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercise.)

Detailed Syllabus of Discipline Specific Elective (DSE) courses for B.Tech. (EE) – SEMESTER III

Non-Conventional Energy Resources (DSE-1)

(Credit Distribution and Pre-Requisites of the Course)

Course title	Credits	Credit distribution of the course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Non-Conventional Energy Resources	4	3	1	0	Nil

Course Hours: L-03, T-01, P-00

Course Objectives:
Examine diverse energy sources and their environmental impact. Analyze energy conversion processes. Foster critical thinking for sustainable energy resources.

Course Outcomes:
At the end of this course, students will demonstrate the ability to:

1. Identify renewable energy sources and their utilization.
2. Understand the basic concepts of solar radiation and analyze the working of solar and thermal systems.
3. Understand principles of energy conversion from alternate sources including wind, geothermal, ocean, biomass, biogas and hydrogen.
4. Identify methods of energy storage for specific applications.

UNIT-I
Principles of Solar Radiation: Role and potential of new and renewable source, the solar energy option, Environmental impact of solar power - Physics of the sun, the solar constant, extra-terrestrial and terrestrial solar radiation, Solar radiation on titled surface, Instruments for measuring solar radiation and sun shine, solar radiation data.
Solar Energy Collection: Flat plate and concentrating collectors, classification of concentrating collectors, orientation and thermal analysis, advanced collectors.

UNIT-II
Solar Energy Storage and Applications: Different methods, sensible, latent heat and stratified storage, solar ponds. Solar applications - solar heating/cooling techniques, solar distillation and drying, photovoltaic energy conversion.
Wind Energy: Sources and potentials, horizontal and vertical axis windmills, performance characteristics, Betz criteria

UNIT-III
Bio-Mass: Principles of Bio-Conversion, Anaerobic /aerobic digestion, types of Bio-gas digesters, gas yield, combustion characteristics of biogas, utilization for cooking, I.C. Engine operation, and economic aspects.

UNIT-IV

Geothermal Energy: Resources, types of wells, methods of harnessing the energy, potential in India. Ocean Energy – OTEC, Principles, utilization, setting of OTEC plants, thermodynamic cycles. Tidal and Wave energy: Potential and conversion techniques, mini-hydel power plants, their economics.

Suggestive Readings:

1. Renewable Energy Resources / Tiwari and Ghosal / Narosa
2. Non- conventional Energy Sources / G.D. Rai/ Khanna Publishers
3. Biological Energy Resources/ Malcolm Fleischer & Chris Lawis/ E&FN Spon.
4. Renewable Energy Sources / Twidell & Weir
5. Solar Power Engineering / B.S. Magal Frank Kreith & J.F. Kreith
6. Principles of Solar Energy / Frank Krieth & John F Kreider
7. Non-Conventional Energy / Ashok V Desai / Wiley Eastern
8. Non-Conventional Energy Systems / K Mittal / Wheeler
9. Renewable Energy Technologies / Ramesh & Kumar / Narosa

Signal and Systems (DSE-1)

(Credit Distribution and Pre-Requisites of the Course)

Course title	Credits	Credit distribution of the course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Signal and Systems	4	3	1	0	Introduction to Electrical and Electronics Engineering, Mathematics-I

Course Hours: L-03, T-01, P-00

Course Objectives:

1. To understand the classification of signals, systems, impulse response, convolution, LTI systems, Fourier series and Fourier transform.
2. To learn the concepts of Laplace transforms, z-transforms, sampling, and its applications.
3. To understand the sampling and its applications.

Course Outcomes:

At the end of this course, students will demonstrate the ability to:

1. Acquire and demonstrate the knowledge of knowledge of various signals, systems, convolution and LTI systems.
2. Apply the knowledge of analyze the spectral characteristics of signals using Fourier series, Fourier transforms, Laplace transforms and z-transforms.
3. Understand sampling which will also help understand other introductory courses.

UNIT-I

Types of Signals and Systems and Their Representation

Continuous-time and discrete-time signals, energy and power of signals, periodic-aperiodic signals, even-odd signals, standard signals: unit impulse, unit step, ramp, exponential and sinusoids. Transformations of the independent variable, continuous and discrete time systems, system properties.

UNIT-II

LTI Systems

Impulse response, convolution integral and convolution sum, LTI systems' properties, LTI system characterization by linear constant coefficient difference equation.

Fourier Series and Fourier Transform of Signals

Fourier series representation of continuous and discrete time periodic signals, convergence, properties of Fourier series, Fourier series and LTI systems, Application of Fourier series in filtering, Fourier transform representation of continuous and discrete time signals, Fourier transform properties, Hilbert transform and its properties, system characterization by linear constant coefficient difference equation.

UNIT-III

Laplace and Z-Transform

The Laplace transform, region of convergence, properties of Laplace transform, initial and final value theorem, inverse Laplace transform, system functions, poles and zeros of system functions, analysis and characterization of LTI systems using Laplace transform, z-transform, region of convergence and pole-zero plot for z-transform, properties of z-transform, analysis and characterization of LTI systems using z-transform, stability criterion.

UNIT-IV

Sampling and Reconstruction

Sampling Theorem, classification of sampling, aliasing, anti-aliasing filter, analog to digital conversion, signal reconstruction.

Suggestive Readings:

1. Alan V. Oppenheim, Alan S. Willsky, S. Hamid Nawab, "Signals and Systems", Prentice Hall, 2nd Edition.
2. S. Haykin and B. Van Been, "Signals and Systems", John Wiley & Sons, 2nd Edition, 2003.
3. B. P. Lathi, "Linear Systems and Signals", Oxford University Press, 2nd edition, 2006.

Detailed Syllabus of Discipline Specific Core (DSC) courses for B.Tech. (EE) – SEMESTER IV

Electrical Machines II (DSC-10)

(Credit Distribution and Pre-Requisites of the Course)

Course title	Credits	Credit distribution of the course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Electrical Machines II	4	3	0	1	Electrical Machine I

Course Hours: L-03, T-00, P-02

Course Objectives:
To make the students familiar with the fundamentals of various type of Induction machines both three phase and single phase and synchronous machines both of which are important entities in the field of Electrical Engineering.

Course Outcomes:
At the end of this course, students will demonstrate the ability to:
1. Understand AC machine windings.
2. Concept of rotating magnetic fields.
3. Understand the operation of AC machines.
4. Analyze performance characteristics of AC machines.

UNIT-I
Constructional features of squirrel cage and slip ring induction motors. Poly-phase AC windings. Production of rotating magnetic field and operation-of 3 phase Induction Motors. Concept of slip. Power flow stages in an induction motor. Equivalent circuit. Phasor diagram. Power, torque and slip relations. Torque slip characteristics Generator action. Line connected and self-excited induction generators.
Various methods of Starting, speed control and braking of Induction motors. No load and blocked rotor tests on Induction motors. Computation of Equivalent circuit parameters. Deep bar and Double cage rotors. Clogging and crawling of Induction motors.

UNIT-II
SYNCHRONOUS GENERATORS (Alternators)
Constructional features. Armature winding (extension of what was discussed in Unit-I) Generations of EMF. Pitch and distribution coefficients.
Harmonics in induced emf. Armature Reaction and its effects. Open Circuit and short circuit tests. Various methods of determining Voltage regulation. Parallel operation and operation on an infinite bus. Two reaction theory. Power expressions for salient pole and cylindrical rotor machines. Performance characteristics.

UNIT-III
SYNCHRONOUS MOTORS

Construction and principle of operation. Starting methods. Phasor diagram. Torque- angle characteristic. V-curves, hunting and damping. Synchronous motor as a condenser. Single phase synchronous motors: Reluctance and Hysteresis motors.

UNIT-IV

SINGLE PHASE INDUCTION MOTORS AND OTHER FRACTIONAL-HORSEPOWER (FHP) MOTORS

Single Phase Induction motors: Nature of field produced by one single phase winding on stator. Double revolving field theory, Equivalent circuit, Torque speed characteristics.

No load and blocked rotor tests. Split phase starting, various types of capacitor motors.

Other motors; -

Shaded pole motor, Universal motor, AC servo motor, Stepper motor, Switched reluctance motor, Hysteresis motor, BLDC motor.

Suggestive Readings:

1. E. Fitzgerald and C. Kingsley, "Electric Machinery", McGraw Hill Education, 2013.
2. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.
3. P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
4. M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.
5. A.S. Langsdorf, "Theory of AC Machines," Tata McGraw-Hill Publishing Company Limited
6. Cyril G. Veinott. And Joseph E. Martin, "Fractional and Sub fractional horse power Electric Motors," Tata McGraw-Hill.
7. S. J. Chapman, "Electrical Machinery Fundamentals," Tata McGraw-Hill, 2005.
8. A. S. Langsdorf, "Alternating current machines", McGraw Hill Education, 1984.
9. P. S. Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers, 2011.

List of Experiments:

1. To Study Open Circuit & Short Circuit Tests on Three Phase Alternator, and determine its voltage Regulation by synchronous impedance method.
2. To perform Load Test on Three Phase Alternator.
3. To Study the reactance, Xd & Xq of Three Phase Alternator.
4. To perform Load Test on Three Phase Induction Motor (through Electrical Loading) and obtain Torque speed curve.
5. To perform No Load & Blocked Rotor Tests on Three Phase Induction Motor (Mechanical Loading) and get equivalent circuit parameters.
6. To perform speed control of a Three Phase Induction Motor by (a) keeping v/f ratio constant (b) By changing frequency at the rated voltage.
7. Make connection of DOL Starter, Star-Delta Starter & through VFD for three phase induction motor.
8. To perform Load Test on Three Phase Slip-ring Induction Motor and get speed Torque characteristics.
9. To perform No Load & Blocked Rotor Test on Three Phase slip ring Induction Motor and get equivalent circuit parameters.
10. To control the Speed of a three Phase Slip ring Induction Motor by varying resistance in the rotor circuit.
11. To perform Load Test on Single Phase Induction Motor.
12. To perform No Load & Blocked Rotor Tests on Single Phase Induction Motor
13. To Study the effect of Capacitor on the performance of the Motor and to change the direction of rotation.

14. To test the performance of a synchronous motor at different load conditions and to see the effect of variation of excitation and power factor (V curve & Inverted V Curve).

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercise.)

Power Transmission and Distribution (DSC-11)

(Credit Distribution and Pre-Requisites of the Course)

Course title	Credits	Credit distribution of the course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Power Transmission and Distribution	4	3	0	1	Introduction to Electrical and Electronics Engineering, Electrical Network Analysis

Course Hours: L-03, T-00, P-02

Course Objectives:
To make students familiarize with the structure of a power system network, its different components like transmission lines, underground cables, insulators and the performance evaluation of the transmission lines.

Course Outcomes:
At the end of this course, students will demonstrate the ability to:

1. To get introduced with the basics of power transmission systems.
2. To be familiar with the distribution systems.
3. To analyze performance of transmission systems through modeling.
4. To know design and physical construction of overhead lines and underground cables.
5. To be aware of phenomena of surges and travelling waves in high voltage transmission systems.

UNIT-I
Introduction to Transmission and Distribution Systems: Structure of a power system, equipment for substations, general layout; radial, ring mains, sub-transmission, primary and secondary distribution systems; calculation of line resistance (skin and proximity effect), inductance and capacitance of single-phase and three-phase, single circuit and double circuit transmission lines.

UNIT-II
Performance of Transmission Lines: Models of short, medium and long transmission lines including A, B, C, D constants; Ferranti effect, regulation and efficiency, tuned power lines, power flow through a transmission line, power circle diagrams, and transmission loss; transposition of conductors, surge impedance loading, formation of corona, critical voltage, methods of reduction – bundle conductor, effect online performance and interference.

UNIT-III
Overhead Lines and Underground Cables: Overhead line supports (towers), conductors, insulating materials and insulators - voltage distribution over suspension insulator string, equalizer ring, string efficiency, testing of insulators; conductor sag-tension calculations, effects of wind and ice loading, vibration dampers. Types of LV and HV underground cables and insulation – solid, liquid, gaseous, dielectric stress, dielectric loss, heating of cables, grading of cables, measuring insulation resistance, and capacitances of single-phase and three-phase cables, charging current in a cable and rating, failure due to tree formation.

UNIT-IV
Surge Performance and Protection: Switching surges, origin and mechanism of lightning strokes, direct and induced strokes, protection from surges - lightning arrestors (rod gap, horn gap, multi-gap and expulsion type) and surge diverters, evaluation of surge impedance, energy and power associated with a surge.

Traveling Waves: Theory of traveling waves, wave equation, role of characteristic impedance of a line, incident and reflected waves, transmission and refraction of waves, Bewley Lattice Diagram, velocity of traveling waves, behavior of traveling waves for different terminations - inductor, capacitor, open-end, short-end, cable while approaching substation and over the junction of dissimilar lines, attenuation of traveling waves.

Suggestive Readings:

1. Hadi Saddat, "Electric power systems", Tata McGraw Hill. 2014.
2. Abhijit Chakraborty, and Sunita halder, "Power System Analysis, Operation and Control", PHI, New Delhi, 2011.
3. W. H. Stevension, "Elements of Power System Analysis", McGraw Hill, 1982.
4. C. L. Wadhava, "Electrical Power Systems", New Age International, 2004.

List of Experiments:

1. To study and testing of typical Radial DC Distribution system supplied from one as well as both ends.
2. To study and testing of typical Ring main DC Distribution system.
3. Study of Short Transmission Line for calculation of various parameters.
4. Ferranti Effect of Single-Phase Transmission Line.
5. P-V Characteristics of Single-Phase Transmission Line.
6. Simulation of String of Insulators with and without Guard Ring and evaluating its efficiency.
7. Measurement of Capacitance of Three-Core Cable.
8. Determination of Voltage Drop in a Cable.
9. To determine the dielectric strength of the given transformer oil using Oil testing Kit.
10. Calculate the corona loss of transmission line and show the effect of different factors affecting corona losses.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercise.)

Electrical and Electronic Measurements (DSC-12)

(Credit Distribution and Pre-Requisites of the Course)

Course title	Credits	Credit distribution of the course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Electrical and Electronic Measurements	4	3	0	1	Introduction to Electrical and Electronics Engineering

Course Hours: L-03, T-00, P-02

Course Objectives:
To make students familiarize with different types of error in measurements, analog type measuring instruments, different ways of power, energy, resistance, inductance and capacitance measurement.

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

1. Classify various measuring instruments used to measure electrical quantities.
2. Apply methods for the measurement of resistance, capacitance and inductance.
3. Choose the suitable current and potential transformers.
4. Measure and analyze the error free currents and voltages.

UNIT-I
Preliminaries: Concepts of Measurements & Measurement Systems: Introduction to measurement and instrumentation, S. I. system, methods of measurement, static and dynamic characteristics of instruments, definitions – true value, accuracy, error, precision, sensitivity, resolution etc.
Analog Electromechanical Instruments: Classification of analog instruments, principle of operation, operating forces, errors in ammeters and voltmeters. Permanent magnet moving coil, moving iron, dynamometer type, induction type, electrostatic type instruments.

UNIT-II
Potentiometers: Principle of D. C. potentiometer, direct reading potentiometers, accurate forms of potentiometers, A. C. potentiometer principle, polar and Co - ordinate type A. C. potentiometer, applications of A. C. and D. C. potentiometers.
Measurement of Power and Energy: Electrodynamometer type wattmeter, measurement of power in three phase circuits, three phase wattmeter, measurement of reactive power, energy meter for A.C. circuits, induction type energy meter.

UNIT-III
Measurement of Resistance: Measurement of low, medium & high resistances, insulation resistance measurement, localization of cable fault, Loop tests.
Measurement of Inductance and Capacitance: A. C. bridges for inductance measurement – Maxwell, Hays, Anderson and Owen bridges, capacitance measurement – De Sauty and Schering Bridge. Measurement of frequency by Wien's bridge.

UNIT-IV

Magnetic Measurements: Magnetic measurement using Ballistic Galvanometer, Grassot Flux meter, BH curve of magnetic material, separation of losses.
Instrument Transformers: Current and Potential transformers, ratio and phase angle errors, design considerations, numerical problem.
Electronic Measurements: Electronic voltmeter, multi meter, wattmeter and energy meter. Time, Frequency and Phase Angle meters; CRO, Storage oscilloscope, Spectrum and Wave analyzer.

Suggestive Readings:

1. Introduction to Modern Electronic Instrumentation and Measurement Techniques: Helfrick and Cooper, Prentice Hall of India, 1997.
2. Instrumentation Measurement and Feedback: Jones, B. E., Tata McGraw-Hill, 1995.
3. Electrical Measurement and Measuring Instruments: Golding, E. W., Sir Issac Pitman & Sons., 3rd Edition.
4. A course in Electrical and Electronic Measurement and Instrumentation: A. K. Sawhney, Dhanpat Rai Publication.

List of Experiments:

1. Calibration of voltmeter and Ammeter.
2. Calibration of single phase A.C. Energy meter.
3. Three phase power measurement by two wattmeter method.
4. Measurement of reactive power using single wattmeter in three-phase circuit.
5. Measurement of percentage ratio error and phase angle of given C.T. by Silsbee's method.
6. Extension of instrument ranges using C.T. and P.T.
7. Measurement of resistance using Kelvin's Double Bridge.
8. Measurement of earth resistance using Meggar.
9. Measurement of self-inductance and Quality factor using Anderson Bridge.
10. Measurement of capacitance using Schering Bridge.
11. Measurement of voltage, current and resistance using DC potentiometer.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercise.)

Detailed Syllabus of Discipline Specific Elective (DSE) courses for B.Tech. (EE) – SEMESTER-IV

Electrical Engineering Materials (DSE-2)

(Credit Distribution and Pre-Requisites of the Course)

Course title	Credits	Credit distribution of the course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Electrical Engineering Materials	4	3	1	0	Introduction to Electrical and Electronics Engineering, Physics

Course Hours: L-03, T-01, P-00

Course Objectives:
1. To know about different materials used in Electrical Engineering and their properties.
2. To understand conductive nature of a metal and its principle.
3. To analyze the magnetic and dielectric properties of different materials.
4. To know about the behaviors of different semiconductor materials.

Course Outcomes:
At the end of this course, students will demonstrate the ability to:
1. Acquire and demonstrate the knowledge of different materials used in electrical equipment.
2. Analyze different materials based on their conductive, dielectric and magnetic properties.
3. Uses the knowledge of semiconductor materials in design and fabrication of chips.
4. Analyze the electric equipment and do proper deign of that with exact material.

UNIT-I
Conductivity of Metal: Introduction, factors affecting the resistivity of electrical materials, motion of an electron in an electric field, Equation of motion of an electron, current carried by electrons, mobility, energy levels of a molecule, emission of electrons from metals, thermionic emission, photo electric emission, field emission, effect of temperature on electrical conductivity of metals, electrical conducting materials, thermal properties, thermal conductivity of metals, thermoelectric effects.

UNIT-II
Dielectric Properties of Materials: Introduction, effect of a dielectric on the behavior of a capacitor, polarization, the dielectric constant of monatomic gases, frequency dependence of permittivity, dielectric losses, significance of the loss tangent, dipolar relaxation, frequency and temperature dependence of the dielectric constant, dielectric properties of polymeric system, ionic conductivity in insulators, insulating materials, ferroelectricity, piezoelectricity.

UNIT-III
Magnetic properties of Materials: Introduction, Classification of magnetic materials, diamagnetism, paramagnetism, ferromagnetism, magnetization curve, the hysteresis loop, factors affecting permeability and hysteresis loss, common magnetic materials, magnetic resonance.

UNIT-IV

Semiconductor Materials: energy band in solids, conductors, semiconductors and insulators, types of semiconductors, Intrinsic semiconductors, impurity type semiconductor, diffusion, the Einstein relation, hall effect, thermal conductivity of semiconductors, electrical conductivity of doped materials.

Suggestive Readings:

1. C. S. Indulkar and S. Thiruvengadam, "An Introduction to Electrical Engineering Materials," S. Chand Publication
2. Kenneth G. Budinski, Michael K. Budinski, "Engineering Materials: Propertise and Selection," Prentice Hall of India, New Delhi
3. S. P. Seth, "A Course in Electrical Engineering Materials," Dhanpat Rai Publication

Electrical Machine Design (DSE-2)

(Credit Distribution and Pre-Requisites of the Course)

Course title	Credits	Credit distribution of the course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Electrical Machine Design	4	3	1	0	Electrical Machines I

Course Hours: L-03, T-01, P-00

Course Objectives:
1. To understand the design concepts of transformers and know about how to design the parts.
2. To understand the design of various parts of DC machines and solve the problems of design.
3. To analyze the design concepts of induction motors and solve the problems related to design.
4. To know importance of design of machines based on their applications using computer tools.

Course Outcomes:
At the end of this course, students will demonstrate the ability to:
1. Classify the materials used for construction of electrical machines.
2. Assess and examine the design, performance of transformer.
3. Develop the overall dimensions of a rotating machine.
4. Analyze the design and performance of rotating machines.

UNIT-I
Fundamental Aspects of Electrical Machine Design: Design of machines, design factors, limitation in design, modern trends in electrical machine design, types of magnetic, electric and insulating materials, modes of heat dissipation, cooling of rotating machines Computer Aided Design (CAD) of Electrical Machines Limitations and assumptions in traditional designs, need of CAD.

UNIT-II
Design of Transformers: Transformer windings, output equation, design of main dimensions, design of core, choice of flux density, determination of number of turns and length of mean term, resistance and leakage reactance, no load current calculation, cooling of transformers, calculation of number of tubes.

UNIT-III
Design of DC Machines: Output equation, selection of specific magnetic and electric loadings, separation of D and L, estimation of number of conductors, armature slots and conduct dimensions, choice of number of poles and calculation of length of airgap, design of field systems, interpoles and brushes.

UNIT-IV
Design of Induction Motors: Output equation, main dimensions, choice of average flux density and ampere conduction for meter, design of stator slots and rotor slots, design of rotor bars end rings, design of wound rotor, design of no-load current.

Suggestive Readings:

1. M. Ramamoorty, Computer Aided Design of Electrical Equipment, Eastern Press Private Limited (1989).
2. AK. Sawhney, a Course in Electrical Machine Design, Dhanpat Rai & CO. (2013).
3. M. G. Say, Design and Performance of Machines, CBS Publications (1981).
4. E. S. Hamdi, Design of Small Electrical Machine, John Wiley and Sons (1994).

Department of Electrical Engineering
Faculty of Technology
University of Delhi

List of Discipline Specific Elective (DSE)/ Generic Elective (GE) courses offered for Minors / Specializations by the Department of Electrical Engineering in Second Year

1. **Minor in EE (Offered to ECE and CSE)**
    a. DSE-1/ GE-3: Fundamentals of Electrical Circuits
    b. DSE-2/ GE-4: Electro-Mechanical Energy Conversion
2. **Minor/Specialization in Robotics and Automation (Offered to EE, ECE, and CSE)**
    a. DSE-1/ GE-3: Fundamentals of Signal and Systems
    b. DSE-2/ GE-4: Sensors & Transducers
3. **Minor/Specialization in Sustainable Energy Engineering (Offered to EE, ECE, and CSE)**
    a. DSE-1/ GE-3: Energy and Its Resources
    b. DSE-2/ GE-4: Design and Evaluation of Photovoltaic Power Plants
4. **Minor/Specialization in Electric and Hybrid Vehicle (Offered to EE, ECE, and CSE)**
    a. DSE-1/ GE-3: Introduction to Electric and Hybrid Vehicles
    b. DSE-2/ GE-4: Electric Vehicle Motor

Detailed Syllabus of Generic Elective (GE) courses offered for Minors / Specializations by Department of Electrical Engineering in SEMESTER III

Fundamentals of Electrical Circuits (DSE-1/ GE-3)

(Credit Distribution and Pre-Requisites of the Course)

Course title	Credits	Credit distribution of the course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Fundamentals of Electrical Circuits	4	3	0	1	Introduction to Electrical and Electronics Engineering, Mathematics I.

Course Hours: L-03, T-00, P-02

Course Objectives:

1. To solve different complex circuits using various network reduction techniques such as Source Transformation, Network theorems etc.
2. To understand basic concepts of DC and AC circuit behavior.
3. To analyze the transient response of series and parallel A.C. circuits and to solve problems in time domain using Laplace Transform.
4. To analyze two port circuit behaviors.

Course Outcomes:

1. At the end of this course, students will demonstrate the ability to:
2. Acquire and demonstrate the knowledge of circuit elements, different laws and resonating behavior of circuits.
3. Apply the knowledge of basic circuit law to simplify the networks using network theorems.
4. Analyze the RL, RC and RLC circuits using Laplace transform.
5. Analyze the transient, steady state of RL, RC and RLC circuits for AC and DC excitations.
6. Analysis of various two port networks with their connection, interrelationships and interconnection of two port networks (with respect to impedance, admittance, hybrid and transmission parameters).

UNIT-I

Introduction to AC circuits: Review of AC Circuits and Introduction to three phase circuits, Series and parallel resonance, frequency response of series and Parallel circuits, Q–Factor, Bandwidth.
Magnetically coupled circuits: Dot convention, Self and Mutual Inductance, Energy in a coupled circuit.

UNIT-II

Network Theorems for AC & DC circuits: Node and Mesh analysis, Thevenin's & Norton's Theorems, Superposition Theorem, Reciprocity, Compensation, Substitution, Maximum power transfer, Millman's and Tellegen's theorems. Examples with independent energy sources.

UNIT-III

Laplace Transforms and properties: Initial conditions in networks and network solution with Laplace transformation, step, ramp and impulse functions, initial and final value theorem.

Transient behavior and initial conditions: Behavior of circuit elements under switching condition and their representation, evaluation of initial and final conditions in RL, RC and RLC circuits for AC and DC excitations.

UNIT-IV

Two port networks: Network & Transfer functions for one port & two ports, poles and zeros, Necessary condition for driving point & transfer function. Two port parameters – Z, Y, ABCD, Hybrid parameters, their inverse & image parameters, relationship between parameters, Interconnection of two ports networks, Terminated two port networks.

Suggestive Readings:

1. Lawrence P. Huelsman, Basic Circuit Theory, Prentice Hall India Learning Private Limited; 3rd edition.
2. William H. Hayt, Jack Kemmerly, Steven M. Durbin, Engineering Circuit Analysis, McGraw Hill Education; Eighth edition (4 August 2013).
3. Raymond A. DeCarlo, Pen-Min Lin , Linear Circuit Analysis, OUP USA; 2nd edition.
4. M.E. Van Valkenburg, Network Analysis, Phi Learning, 3rd Edition, 2010.
5. William D Stanley: Network Analysis with Applications, Pearson Education, 4th Edition, 2013.

List of Experiments:

1. To verify the Thevenin's Theorem.
2. To verify the Superposition Theorem.
3. To verify the Maximum Power Transfer Theorem.
4. To verify Reciprocity Theorem.
5. To verify the Millman's Theorem.
6. To verify the Tellegan's Theorem.
7. To construct RL & RC transient circuits and to draw the transient curves.
8. To obtain the resonance frequency of the given RLC series electrical network.
9. To determine open circuit parameters and short circuit parameter of the given two-port network.
10. To calculate and verify 'ABCD' parameters of a two-port network.
11. To calculate and verify Hybrid parameters of two-port network.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercise.)

Fundamentals of Signal and Systems (DSE-1/ GE-3)

(Credit Distribution and Pre-Requisites of the Course)

Course title	Credits	Credit distribution of the course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Fundamentals of Signal and Systems	4	3	1	0	Introduction to Electrical and Electronics Engineering, Mathematics-I

Course Hours: L-03, T-01, P-00

Course Objectives:

1. To understand the categories of signals and systems.
2. To learn the different applications of transforms in signals.
3. To understand the sampling and its applications.

Course Outcomes:

At the end of this course, students will demonstrate the ability to:

1. Apply the various mathematical operations on different signals and systems.
2. Apply the various transforms such as Fourier series, Fourier transforms, Laplace transforms and z-transforms in signals.
3. Understand sampling which will also help understand other introductory courses.

UNIT-I

Introduction to various types of signals and systems

Types of signals, energy and power of signals, periodic-aperiodic signals, even-odd signals and standard signals. Mathematical operations on signals, different systems and its properties.

UNIT-II

System response and Fourier Transforms

Convolution integral and convolution sum, Impulse response, difference equation. Fourier series representation of continuous and discrete time periodic signals, convergence, properties of Fourier series, Application of Fourier series in filtering, Fourier transform representation of continuous and discrete time signals, Fourier transform properties.

UNIT-III

Properties of Laplace and Z-Transform

The Laplace transform, region of convergence, properties of Laplace transform, inverse Laplace transform, system functions, poles and zeros of system functions, analysis and characterization of LTI systems using Laplace transform, z-transform, region of convergence and pole-zero plot for z-transform, properties of z-transform.

UNIT-IV

Sampling Theorem and A/D conversion

Sampling Theorem, classification of sampling, aliasing, anti-aliasing filter, analog to digital conversion, signal reconstruction.

Suggestive Readings:

1. Alan V. Oppenheim, Alan S. Willsky, S. Hamid Nawab, “Signals and Systems”, Prentice Hall, 2nd Edition.
2. S. Haykin and B. Van Been, “Signals and Systems”, John Wiley & Sons, 2nd Edition, 2003.
3. B. P. Lathi, “Linear Systems and Signals”, Oxford University Press, 2nd edition, 2006.

Energy and Its Resources (DSE-1/ GE-3)

(Credit Distribution and Pre-Requisites of the Course)

Course title	Credits	Credit distribution of the course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Energy and Its Resources	4	3	0	1	Nil

Course Hours: L-03, T-00, P-02

Course Objectives:
Examine diverse energy sources and their environmental impact. Analyze energy conversion processes. Understand policy frameworks and global trends. Foster critical thinking for sustainable energy use and resource management.

Course Outcomes:
1. Understanding of energy units, unit conversion, unit magnitudes
2. Understanding energy needs of self, institution, country and world, energy consumption by sector
3. Wind, biomass and solar energy resources
4. Per capita energy consumption and impact on social and economic parameters 5. Future scenarios of energy requirements.

UNIT-I
Energy and its units: discussion on role of energy in our lives, various sources of energy that we use, units of energy, small and large units of energy, magnitude of energy units, units for energy consumption of individual, institution and country.
Renewable and Non-renewable energy: difference, characteristics of resources, advantages and disadvantages, discussion in class on which type of resources to be used by individual, by a country, reason out why?

UNIT-II
Energy requirements of a country: evolution of energy consumption, population of country, number of demands for energy, per demand energy, estimating energy consumption of country, discussion on possible growth on energy demand, should it grow or not?
World energy scenario- consumption: energy consumption of world, by resources, by sector, per capita electricity and total energy consumption, comparison among countries and between continents, relationship between Human Development Index (HDI) and energy consumption, discussion in the class on disparity in energy consumption.

UNIT-III
India's energy scenario: India's energy consumption from all resources, consumption of oil, coal, gas, import of fossil resources, foreign exchange requirements, discussion on energy security of country and imports dependency. Renewable energy sources: what are renewable energy sources? Why they are renewable? summary of all RE resources, global scenario of these resources.

UNIT-IV
Wind and Biomass resources in India: discussion on origin of these resources, potential of these resources in India, how these resources are converted into useful energy.

Solar energy resources: Sun as source of energy, solar energy reaching the Earth's surface, solar spectrum, photons of different energy, solar irradiation and solar radiation/insolation, extra-terrestrial solar radiation, global, direct and diffuse solar radiation.

Suggestive Readings:

1. S. P. Sukhatme and J. K. Nayak, Solar Energy – Principles of Thermal Collection and Storage, Tata McGraw Hill, 2008.
2. Solar Photovoltaics – Fundamentals, Technologies and Applications, 3rd Ed. Prentice Hall of India, 2016.
3. John Twidell, Tony Weir, Renewable Energy Resources, Taylor & Francis, 2005
4. Andrew L. Simon, Energy Resources, Elsevier Science, 2013.
5. World Energy report (https://www.iea.org/reports/)
6. Knowledge Centre, Ministry of New & Renewable Energy - Government of India (https://mnre.gov.in/)

List of Experiments:

1. Measure instantaneous solar irradiation (W/m^2) inside a classroom and under a clear sunny sky and compare.
2. Measure the short circuit current of solar panel under various orientation of solar panel with respect to the Sun. Note down reading, compare the variation in measured current values and compare and comment on variation in the values.
3. Measure energy consumption of a light and a fan (or any other appliance) in your lab using power meter / energy meter over the duration of experiment. Also do the theoretical estimation of possible energy consumption by the appliances over the same time. Compare both and comments.
4. Figure out from which point electricity is entering your campus/building, how it is being measured, check if you can take any reading, discuss the electrical supervisor on daily, monthly electricity consumption of the campus, discuss the variation of electricity consumption with season and reason behind it.
5. Debate on which energy sources to be promoted, students are to be divided in 4 or 5 groups, each group representing different source, each group presents their idea why that particular source should be promoted, the task of the whole class is to come to a conclusion on use of a particular source.
6. Estimate the monthly energy consumption of your own family, include energy consumption from electricity, petrol, diesel, LPG, public transportation, etc. Make a brief report on it.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercise.)

Introduction to Electric and Hybrid Vehicles (DSE-1/ GE-3)

(Credit Distribution and Pre-Requisites of the Course)

Course title	Credits	Credit distribution of the course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Introduction to Electric and Hybrid Vehicles	4	3	1	0	Introduction to Electrical and Electronics Engineering, Physics

Course Hours: L-03, T-01, P-00

Course Objectives:
1. To understand the concept of electric vehicles.
2. To study about the motors & drives for electric vehicles.
3. To understand the concept of hybrid vehicles.

Course Outcomes:
At the end of this course, students will be able to:
1. Describe about working principle of electric vehicles.
2. Explain the construction and working principle of various motors used in electric vehicles.
3. Understand about working principle of electronics and sensor less control in electric vehicles.
4. Describe the different types and working principle of hybrid vehicles.

UNIT-I
Introduction to Electric Vehicles
Electric Vehicle – Need - Types – Cost and Emissions – End of life. Electric Vehicle Technology – layouts, cables, components, Controls. Batteries – overview and its types. Battery plug-in and life. Ultra-capacitor,
Charging – Methods and Standards. Alternate charging sources – Wireless & Solar.

UNIT-II
Electronics and Sensor-less control in EV
Basic Electronics Devices – Diodes, Thyristors, BJTs, MOSFETs, IGBTs, Convertors, Inverters. Safety – Risks and Guidance, Precautions, High Voltage safety, Hazard management. Sensors - Autonomous EV cars, Selfdrive Cars, Hacking; Sensor less – Control methods- Phase Flux Linkage-Based Method, Phase Inductance- Based, Modulated Signal Injection, Mutually Induced VoltageBased, Observer-Based.

UNIT-III
Hybrid Vehicles
Hybrid Electric vehicles – Classification – Micro, Mild, Full, Plug-in, EV. Layout and Architecture – Series,Parallel and Series-Parallel Hybrid, Propulsion systems and components. Regenerative Braking, Economy,
Vibration and Noise reduction. Hybrid Electric Vehicles System – Analysis and its Types, Controls.

UNIT-IV
Advancement in E-vehicles

Integration of IoT in e-vehicle, Wireless sensor networks need for IoT, Intelligent Transport Systems, Degradation and disposal of batteries, modes of fast and efficient charging, and availability of charging stations as per Indian road conditions. Types of standards. Safety rules and regulations.

Suggestive Readings:

1. Jack Erjavec and Jeff Arias, “Hybrid, Electric and Fuel Cell Vehicles”, Cengage Learning, 2012.
2. Jack Erjavec and Jeff Arias, “Alternative Fuel Technology – Electric, Hybrid and Fuel Cell Vehicles”, Cengage Learning Pvt. Ltd., New Delhi, 2007
3. Mehrdad Ehsani, Yimin Gao, sebastien E. Gay and Ali Emadi, “Modern Electric, Hybrid
4. Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, CRC Press, 2009.
5. Hybrid Electric Vehicle System Modeling and Control - Wei Liu, General Motors, USA, John Wiley & Sons, Inc., 2017.
6. Hybrid Electric Vehicles – Teresa Donateo, Published by ExLi4EvA, 2017.
7. Electric and Hybrid Vehicles Power Sources, Models, Sustainability, Infrastructure and the Market Gianfranco Pistoia Consultant, Rome, Italy, Elsevier Publications, 2017.
8. Hybrid, Electric & Fuel-Cell Vehicles Jack Erjavec, Delmar, Cengage Learning.
9. Electric and Hybrid Vehicles, Tom Denton, Taylor & Francis, 2018.

Detailed Syllabus of Generic Elective (GE) courses offered for Minors / Specializations by Department of Electrical Engineering in SEMESTER IV

Electro-Mechanical Energy Conversion (DSE-2/ GE-4)

(Credit Distribution and Pre-Requisites of the Course)

Course title	Credits	Credit distribution of the course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Electro-Mechanical Energy Conversion	4	3	1	0	Introduction to Electrical and Electronics Engineering, Fundamentals of Electrical Circuits

Course Hours: L-03, T-01, P-00

Course Objectives:
To make the students familiar with the fundamentals of various type of transformers, DC machines, Induction Machines and Synchronous Machines which are important entities in the field of Electrical Engineering.

Course Outcomes:

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

1. Understand the constructional features and operating principles of transformers, both single phase and three-phase and to determine the voltage regulation and performance characteristics of transformers.
2. Understand the intricate details of the construction of DC machines, needed in the design and fabrication of DC generators. Knowledge of the armature winding will enable the students to perform fault finding in the armature.
3. Review the constructional details of three-phase induction motors and understand their working principles, analyze the equivalent circuit, interpret the power flow diagram, phasor diagram and evaluate the characteristics.
4. Analyze the constructional features of polyphase synchronous machines and explain their operating principles, excitation systems. Derive the EMF equation, equivalent circuit model, and phasor diagram for cylindrical rotor and salient pole of synchronous machines and apply the two-reaction theory of salient pole synchronous machines.

UNIT-I

Transformers: Constructional review of single-phase transformer, Equivalent circuits, voltage regulation, short circuit and open circuit tests, Autotransformers, All day efficiency.

UNIT-II

D.C. Machines: Review of constructional features, Methods of excitation, Voltage and torque equations, Operation as generator, characteristics, Armature reaction, Commutation. Operation as a Motor, characteristics. Starter, speed control, Losses and Efficiency.

UNIT-III

Three Phase Induction Machines: Construction, Types (squirrel cage and slip-ring), Torque Slip Characteristics, Starting and Maximum Torque, Equivalent circuit, Phasor Diagram, Losses and

Efficiency, Effect of parameter variation on torque speed characteristics (variation of rotor and stator resistances, stator voltage, frequency).

UNIT-IV

Synchronous Machines: Constructional features, cylindrical rotor synchronous machine - generated EMF, equivalent circuit and phasor diagram, armature reaction, synchronous impedance, voltage regulation, Operating characteristics of synchronous machines, V-curves.

Suggestive Readings:

1. E. Fitzgerald and C. Kingsley, "Electric Machinery”, McGraw Hill Education, 2013.
2. M. G. Say, “Performance and design of AC machines”, CBS Publishers, 2002.
3. P. S. Bimbhra, “Electrical Machinery”, Khanna Publishers, 2011.
4. I. J. Nagrath and D. P. Kothari, “Electric Machines”, McGraw Hill Education, 2010.
5. A. S. Langsdorf, “Alternating current machines”, McGraw Hill Education, 1984.
6. P. S. Bimbhra, “Generalized Theory of Electrical Machines”, Khanna Publishers, 2011.

Sensors and Transducers (DSE-2/ GE-4)

(Credit Distribution and Pre-Requisites of the Course)

Course title	Credits	Credit distribution of the course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Sensors and Transducers	4	3	0	1	Fundamentals of Signal and Systems

Course Hours: L-03, T-00, P-02

Course Objectives:
To provide students the fundamentals of sensor and transducers used for different sensing system systems. In depth knowledge of different types of sensors with their applications and data acquisition and signal processing.

Course Outcomes:
At the end of this course, students will demonstrate the ability to:

1. Use concepts in common methods for converting a physical parameter into an electrical quantity
2. Classify and explain with examples of transducers, including those for measurement of temperature, strain, motion, position and light.
3. Choose proper sensor comparing different standards and guidelines to make sensitive measurements of physical parameters like pressure, flow, acceleration, etc
4. Predict correctly the expected performance of various sensors
5. Locate different type of sensors used in real life applications and paraphrase their importance.
6. Set up testing strategies to evaluate performance characteristics of different types of sensors and transducers and develop professional skills in acquiring and applying the knowledge outside the classroom through design of a real-life instrumentation system.

UNIT-I
Mechanical and Electromechanical sensor: Definition, principle of sensing & transduction, classification. Resistive (potentiometric type): Forms, material, resolution, accuracy, sensitivity. Strain gauge: Theory, type, materials, design consideration, sensitivity, gauge factor, variation with temperature, adhesive, rosettes. Proximity Sensors.

Inductive sensor: Common types- Reluctance change type, Mutual inductance change type, transformer action type, Magnetostrictive type, brief discussion with respect to material, construction and input output variable, Ferromagnetic plunger type, short analysis.

UNIT-II
Capacitive sensors: Variable distance-parallel plate type, variable area- parallel plate, serrated plate/teeth type and cylindrical type, variable dielectric constant type, calculation of sensitivity. Stretched diaphragm type: microphone, response characteristics. Piezoelectric element: piezoelectric effect, charge and voltage co-efficient, crystal model, materials, natural & synthetic type, their comparison, force & stress sensing, ultrasonic sensors.
Magnetic sensors: Sensor based on Villari effect for assessment of force, torque, proximity, Wiedemann effect for yoke coil sensors, Thomson effect, Hall effect, and Hall drive, performance characteristics.
Radiation sensors: LDR, Photovoltaic cells, photodiodes, photo emissive cell types, materials, construction, response.
Geiger counters, Scintillation detectors, Introduction to smart sensors.

UNIT-III

Thermal sensors: Material expansion type: solid, liquid, gas & vapor Resistance change type: RTD materials, tip sensitive & stem sensitive type, Thermistor material, shape, ranges and accuracy specification.

Thermo emf sensor: types, thermoelectric power, general consideration, Junction semiconductor type IC and PTAT type.

Radiation sensors: types, characteristics and comparison.

Pyroelectric type.

Transducers: Classifications, Transducers for measurement of nonelectrical quantities: displacement, level, strain, pressure, force, torque, temperature, flow, velocity, acceleration, speed, etc.; seismic measurements. Transducers for measuring Electrical quantities.

LVDT: Construction, material, output input relationship, I/O curve, discussion.

UNIT-IV

Signal Conditioners: Level shifters, voltage to current, current to voltage converter; Peak detectors, Sample/Hold circuit, linearizers.

Signal Processors: Window Comparators, Absolute value circuits, Precision rectifiers; Log- and Antilog- amplifiers – multiplier, divider, squarer, square rooter, RMS converter and True RMS circuits. F to V and V to F converters.

Data Acquisition System and Central monitoring: Single and multichannel data acquisition; Analog and digital display devices, Data loggers, Recorders, Plotters, Application of microprocessors in Instrumentation System.

Suggestive Readings:

1. Sensor & Transducers, D. Patranabis, 2nd edition, PHI Learning.
2. Instrument Transducers, H.K.P. Neubert, Oxford University press.
3. Measurement Systems: application & design, E.A.Doebelin, Mc Graw Hill.

List of Experiments:

1. Analysis of negative temperature co-efficient type thermistor sensor as a temperature sensor.
2. Experimentation on Load cell with signal conditioning.
3. Experiment on voltage and current measurement can be done in this Hall Effect transducer.
4. Experiments on different optical sensors like LDR/ photodiode/ photo transistor.
5. Experiment on the measurement of strain using Strain Gauge.
6. To study the characteristics of LVDT.
7. To study the characteristics of Crompton Potentiometer.
8. To study the characteristics of Piezo-electric transducer.
9. Measurement of displacement using inductive transducer.
10. Characteristics of capacitive displacement transducer.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercise.)

Design and Evaluation of Photovoltaic Power Plants (DSE-2/ GE-4)

(Credit Distribution and Pre-Requisites of the Course)

Course title	Credits	Credit distribution of the course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Design and Evaluation of Photovoltaic Power Plants	4	3	0	1	Energy and its resources

Course Hours: L-03, T-00, P-02

Course Objectives:
Develop expertise in designing photovoltaic power plants. Assess performance, economic viability, and environmental impact. Integrate technical and economic aspects. Foster skills for sustainable and efficient solar energy systems.

Course Outcomes:
1. Understand the solar power plant.
2. Able to model the Photovoltaic power plants.
3. Able to analyse the Photovoltaic power plants.
4. Able to design the Photovoltaic power plants.

UNIT-I
Introduction: Types of Solar Power Plant-Grid Connected solar Power Plant, Grid interactive solar power plant, Net Metering Solar Power Plant, Off-Grid /Hybrid solar power plant, Schemes of solar power plant. Selection of site and PV module technology.

UNIT-II
Modeling of Photovoltaic Power Plants, DC Side modeling (cells, modules, arrays, generation of module file), AC side modeling (inverters, transformers, grid connection).

UNIT-III
Algorithms for modeling solar irradiance, module temperature, shading, soiling, Structural aspects, contemporary issues, financial aspects.

UNIT-IV
Monitoring, Performance Assessment and Degradation, Real time monitoring and fault detection in large PV power plants, Performance Assessment of large PV Power Plants, Performance Degradation and Reliability of PV Power Plants

Suggestive Readings:

1. Sandia National Labs, PV Performance Modeling Collaborative, 2014 URL: https://pvpmc.sandia.gov/
2. Weidong Xiao, “Photovoltaic Power System: Modeling, Design, and Control”,Wiley, 2017.
3. Tamer Khatib, Wilfried Elmenreich, “Modeling of Photovoltaic Systems Using MATLAB: Simplified Green Codes”, Wiley, 2016
4. Luis Castaner, Santiago Silvestre, “Modelling Photovoltaic Systems Using PSpice”, Wiley, 2002.

List of Experiments:

1. Simulation study on Solar PV Energy system.
2. Obtain the VI-Characteristics of Solar PV system.
3. Effect Of Temperature Variation on Photovoltaic Array
4. Calculation of Efficiency of a stand-alone solar PV system.
5. Experiment on Shadowing effect & diode-based solution in Solar PV system.
6. Experiment on Performance assessment of Grid-connected and Standalone Solar Power System.
7. Simulation study on Hybrid (Solar-Wind) Power System.
8. Design of solar PV boost converter using P&O MPPT technique.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercise.)

Electric Vehicles Motors (DSE-2/ GE-4)

(Credit Distribution and Pre-Requisites of the Course)

Course title	Credits	Credit distribution of the course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Electric Vehicles Motors	4	3	1	0	Introduction to Electric and Hybrid Vehicles

Course Hours: L-03, T-01, P-00

Course Objectives:
Understand principles, design, and operation of electric vehicle motors, focusing on efficiency, performance, and integration into EV systems.

Course Outcomes:
1. To understand the concept of electric vehicles motors.
2. To understand about the configuration of motors used in electric vehicles.
3. To understand the special electrical motors.

UNIT-I
CLASSIFICATIONS OF MOTORS
Introduction to EV motors – requirements - challenges - comparisons of EV motors and industrial motors - Motors (DC, Induction, BLDC, PMSM) – Types, Principle, Construction, Control - Electric Drive Train and its types.

UNIT-II
CONFIGURATION OF MOTORS
Configuration and control of DC Motor drives - Configuration and control of Induction Motor drives - configuration and control of Permanent Magnet Motor drives.

UNIT-III
AC MOTOR OPERATION CHARACTERISTICS
AC Induction Motor and Control - Basic Principle of AC Induction Motor Operation - Controls of AC Induction Motor - Selection and sizing of Motor - RPM and Torque calculation of motor - Motor Controllers.

UNIT-IV
SPECIAL ELECTRICAL MOTORS
Switched Reluctance Motor: Basic Magnetic Structure, Torque Production - SRM Drive Converter - Modes of Operation - Generating Mode of Operation (Regenerative Braking) - Sensorless Control - Phase Flux Linkage based Method.

Suggestive Readings:

1. Jack Erjavec and Jeff Arias, “Hybrid, Electric and Fuel Cell Vehicles”, Cengage Learning, 2012.
2. Jack Erjavec and Jeff Arias, “Alternative Fuel Technology – Electric, Hybrid and Fuel Cell Vehicles”, Cengage Learning Pvt. Ltd., New Delhi, 2007

3. Mehrdad Ehsani, Yimin Gao, sebastien E. Gay and Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2009.
4. Hybrid Electric Vehicle System Modeling and Control - Wei Liu, General Motors, USA, John Wiley & Sons, Inc., 2017.
5. Hybrid Electric Vehicles – Teresa Donateo, Published by ExLi4EvA, 2017.
6. Electric and Hybrid Vehicles Power Sources, Models, Sustainability, Infrastructure and the Market Gianfranco Pistoia Consultant, Rome, Italy, Elsevier Publications, 2017.
7. Hybrid, Electric & Fuel-Cell Vehicles Jack Erjavec, Delmar, Cengage Learning.
8. Electric and Hybrid Vehicles, Tom Denton, Taylor & Francis, 2018.

SEMESTER III

Advance Electric Workshop-I (SEC)

(Credit Distribution and Pre-Requisites of the Course)

Course title	Credits	Credit distribution of the course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Advance Electric Workshop-I	2	0	0	2	Electric Workshop

Course Hours: L-00, T-00, P-04

List of Jobs:

1. Transformer design & fabrication.
2. Battery Charger/eliminator.
3. Overhauling dc motor.
4. Overhanding Induction Motor 3-phase.
5. Overhauling Inductor Motor 1-phase.
6. Control panel for forward reverse / inching of IM.
7. Fabrication of contactor-controlled Star Della Starter (automatic).
8. Winding of single-phase IM.
9. Operation through programmable timer.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercise.)

SEMESTER IV

Pspice Modelling for Electrical Circuits (SEC)

(Credit Distribution and Pre-Requisites of the Course)

Course title	Credits	Credit distribution of the course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Pspice Modelling for Electrical Circuits	2	0	0	2	Advanced Electrical Workshop-I

Course Hours: L-00, T-00, P-04

Practice of following:

Introduction to PSpice: Laying out a Schematic, Libraries, Moving Components, Display Properties, New Simulation, Main Operational Icons, Simulation Settings **Electric Circuit Analysis**: Basic Definitions and Terminology, Analysing methods, PSpice Examples, Transient Circuits and Laplace Transforms, Transfer Functions and System Parameters, PSpice Examples
AC Electric Circuit Analysis: AC Circuit Theory, Capacitors - Capacitive Reactance Plot, Capacitor Current and Voltage Waveforms Inductors - Inductor Signal Phase Measurement, AC Circuit Theorems, Thevenin's Theorem - Thevenin Impedance, Thevenin Voltage Norton Equivalent Circuit - The Output File, Exercises
Series and Parallel-tuned Resonance: Resonance, Series-Tuned Circuit, Current Response, Example, Parallel-Tuned LC R Circuit Universal Response Curue, Fourier series, Series-Tuned Circuit as a Low-Pass, Design Examples.
Semiconductor Devices and Characteristics: Semiconductor Devices, Diode Characteristics and Parameters, Zener Diode Characteristic, Silicon-Controlled Rectifier, Bipolar Transistor - Input and Output Characteristics, Junction Field-Effect Transistor - Input and Output Characteristics, D Operator, Exercises

Suggestive Readings:

1. Paul Tobin, PSpice for Circuit Theory and Electronic Devices, Morgan & Claypool Publishers, 2007.
2. Muhammad H. Rashid, Introduction to Pspice Using Orcad for Circuits and Electronics, Prentice-Hall of India h/t.Ltd, 2004.
3. Orcad Capture User's Guide, Cadence Design Systems, Second edition 2000.