Curriculum Components

Component	Courses	Credits
1. University Core (4 Courses)	1. UC 23.101 : Human Values & Professional Ethics (2) 2. UC 23.102 : Pragmatic English Communication (2) 3. UC 23.201 : Introduction to Management & Leadership (2) 4. UC 23.202 : Entrepreneurship Development (2)	8
2. University Elective (2 Courses)	1. University Elective-I (3) 2. University Elective-II (3)	6
3. Basic Science (9 Courses)	1. MA 23.101 : Mathematics I (4) 2. CY 23.101 : Engineering Chemistry (3) 3. CY 23.111 : Chemistry Laboratory (1) 4. CY 23.102 : Environmental Sciences (2) 5. MA 23.102 : Mathematics II (4) 6. PY 23.101 : Engineering Physics (3) 7. PY 23.111 : Physics Laboratory (1) 8. MA 23.201 : Mathematics-III (4) 9. EE 23.308 : Electrical and Electronics Engineering Materials (3)	25
4. Engineering Science (11 Courses)	1. ME 23.101 : Applied Mechanics (4) 2. EC 23.101 : Basics of Electronics Engineering (4) 3. ME 23.111 : Computer Aided Engineering Drawing (2) 4. EC 23.111 : Electronics Laboratory (1) 5. EE 23.101 : Basics of Electrical Engineering (4) 6. CS 23.101 : Programming for Problem Solving I (3) 7. EE 23.111 : Electrical Laboratory (1) 8. CS 23.111 : Programming Laboratory I (2) 9. ME 23.112 : Mechanical Workshop (1) 10. CS 23.205 : General Purpose Programming (3) 11. CS 23.255 : General Purpose Programming laboratory (1)	26
5. Program Core (28 Courses)	1. EE 23.201 : Electrical Machines-I (3) 2. EE 23.203 : Network Analysis and Synthesis (3) 3. EC 23.201 : Electronic Devices and Circuits (3) 4. EE 23.221 : Electrical Machines-I Laboratory (1) 5. EE 23.223 : Network Analysis and Synthesis Laboratory (1) 6. EC 23.221 : Electronic Devices and Circuits Laboratory (1) 7. EE 23.202 : Electrical Machines-II (4) 8. EE 23.204 : Electrical Measurement and Instrumentation (3) 9. EE 23.206 : Electromagnetic Fields (3) 10. EC 23.202 : Digital Electronics (3) 11. EE 23.222 : Electrical Machines-II Laboratory (1) 12. EE 23.224 : Electrical Measurement and Instrumentation Laboratory (1) 13. EE 23.226 : Electrical Simulation Laboratory (2) 14. EE 23.228 : Electrical Estimation and Costing Laboratory (1) 15. EE 23.301 : Transmission and Distribution (3) 16. EE 23.303 : Control System Engineering (3) 17. EE 23.305 : Power Plant Engineering (3) 18. EE 23.307 : Renewable Energy Technology (3) 19. EC 23.301 : Microprocessor and Microcontroller (3) 20. EE 23.321 : Power System-I Laboratory (1) 21. EE 23.323 : Control System Laboratory (1) 22. EE 23.302 : Power System Analysis and Design (3)	64

	23. EE 23.304 : Power Electronics (3) 24. EE 23.306 : Power System Protection (3) 25. EE 23.310 : Utilization of Electrical Energy and Traction System (3) 26. EE 23.316 : Electrical Machine Design (3) 27. EE 23.32 2: Power System-II Laboratory (1) 28. EE 23.324: Power Electronics Laboratory (1)	
6. Program Elective / MOOCs (5 Courses)	1. EE 23.401: Electric Drives and Control (3) 2. EE 23.403: Nonlinear Control system (3) 3. EE 23.405: Robotic Engineering (3) 4. EE 23.407: High Voltage Engineering (3) 5. EE 23.409: Smart Grid (3) 6. EE 23.411: Industrial Automation and Control (3) 7. EE 23.402: Solar PV Technology (3) 8. EE 23.404: Power Electronics in Renewable Energy Technology (3) 9. EE 23.406: PLC and Automation (3) 10. EE 23.408: Wind Energy System (3) 11. EE 23.410: Energy Storage Systems (3) 12. EE 23.412: Advanced Electric Drives (3)	15
7. Project / Summer Internship Project / Colloquium (7 Courses)	1. EE 23.331 : Summer Internship Project-1 (2) 2. EE 23.333: Project-1 (2) 3. EE 23.332 : Project-2 (2) 4. EE 23.334 : Colloquium (1) 5. EE 23. 431 : Summer Internship Project-2 (2) 6. EE 23. 433 : Capstone Project-1(2) 7. EE 23. 432 : Capstone Project-2 (6)	17
8. Proficiency (Non-Credit / Non-Graded) *	1. SF 101: Personal Grooming and Fine Dinning 2. SF 102: Social Grooming, Home Décor and Business Communication 3. SF 201: Personal Grooming Fine Dining and Home Safety 4. SF 202: Social Grooming and Professional Skills 5. SF 301: Civility and Ethics Business and Professional Grooming, Corporate Dinning Etiquettes 6. SF 302: Soft Skills and Interview Skills	
Total		**161**

First Year - Autumn Semester										
Course Code	Course Title	Contact Hours Per Week			Credits	ETE Duration (Hours)	Weightage			
		L	T	P			CW	MTE	PBL	ETE
UC 23.101	Human Values & Professional Ethics	2	0	0	2	3	10	40		50
MA 23.101	Mathematics I	3	1	0	4	3	10	40		50
CY 23.101	Engineering Chemistry	3	0	0	3	3	10	40		50
ME 23.101	Applied Mechanics	3	1	0	4	3	10	40		50
EC 23.101	Basics of Electronics Engineering	3	1	0	4	3	10	40		50
ME 23.111	Computer Aided Engineering Drawing	0	0	4	2	2	20	20	20	40
CY 23.111	Chemistry Laboratory	0	0	2	1	2	20	20	20	40
EC 23.111	Electronics Laboratory	0	0	2	1	2	20	20	20	40
CY 23.102	Environmental Sciences	2	0	0	2	3	10	40		50
SF 101	Personal Grooming and Fine Dinning (Non Grade)	0	0	2	1	2	50			50
	Total	16	3	10	**23**					

First Year -Spring Semester										
Course Code	Course Title	Contact Hours Per Week			Credits	ETE Duration (Hours)	Weightage			
		L	T	P			CW	MTE	PBL	ETE
UC 23.102	Pragmatic English Communication	2	0	0	2	3	10	40		50
MA 23.102	Mathematics II	3	1	0	4	3	10	40		50
PY 23.101	Engineering Physics	3	0	0	3	3	10	40		50
EE 23.101	Basics of Electrical Engineering	3	1	0	4	3	10	40		50
CS 23.101	Programming for Problem Solving	3	0	0	3	3	10	40		50
PY 23.111	Physics Laboratory	0	0	2	1	2	20	20	20	40
EE 23.111	Electrical Laboratory	0	0	2	1	2	20	20	20	40
CS 23.111	Programming Laboratory	0	0	4	2	2	20	20	20	40
ME 23.112	Mechanical Workshop	0	0	2	1	2	20	20	20	40
SF 102	Social Grooming, Home Décor and Business Communication (Non Grade)	0	0	2	1	2	50			50
	Total	14	2	10	**21**					

Second Year - Autumn Semester										
Course Code	Course Title	Contact Hours Per Week			Credits	ETE Duration (Hours)	Weightage			
		L	T	P			CW	MTE	PBL	ETE
UC 23.201	Introduction to Management & Leadership	2	0	0	2	3	10	40		50
MA 23.201	Mathematics-III	3	1	0	4	3	10	40		50
EE 23.201	Electrical Machines-I	3	0	0	3	3	10	40		50
EE 23.203	Network Analysis and Synthesis	3	0	0	3	3	10	40		50
EC 23.201	Electronic Devices and Circuits	3	0	0	3	3	10	40		50
CS 23.205	General Purpose Programming	3	0	0	3	3	10	40		50
EE 23.221	Electrical Machines-I Laboratory	0	0	2	1	2	20	20	20	40
EE 23.223	Network Analysis and Synthesis Laboratory	0	0	2	1	2	20	20	20	40
EC 23.221	Electronic Devices and Circuits Laboratory	0	0	2	1	2	20	20	20	40
CS 23.255	General Purpose Programming laboratory	0	0	2	1	2	20	20	20	40
SF 201	Personal Grooming Fine Dining and Home Safety (Non Grade)	0	0	2	1	2	50			50
	Total	17	1	10	**22**					

Second Year -Spring Semester										
Course Code	Course Title	Contact Hours Per Week			Credits	ETE Duration (Hours)	Weightage			
		L	T	P			CW	MTE	PBL	ETE
UC 23.202	Entrepreneurship Development	2	0	0	2	3	10	40		50
UE	University Elective-I	3	0	0	3	3	10	40		50
EE 23.202	Electrical Machines-II	3	1	0	4	3	10	40		50
EE 23.204	Electrical Measurement and Instrumentation	3	0	0	3	3	10	40		50
EE 23.206	Electromagnetic Fields	3	0	0	3	3	10	40		50
EC 23.202	Digital Electronics	3	0	0	3	3	10	40		50
EE 23.222	Electrical Machines-II Laboratory	0	0	2	1	2	20	20	20	40
EE 23.224	Electrical Measurement and Instrumentation Laboratory	0	0	2	1	2	20	20	20	40
EE 23.226	Electrical Simulation Laboratory	0	0	4	2	2	20	20	20	40
EE 23.228	Electrical Estimation and Costing Laboratory	0	0	2	1	2	20	20	20	40
SF 202	Social Grooming and Professional Skills (Non Grade)	0	0	2	1	2	50			50
	Total	17	1	12	**23**					

Third Year - Autumn Semester									
Course Code	Course Title	Contact Hours Per Week			Credits	ETE Duration	Weightage		
		L	T	P			CW	MTE	ETE
EE 23.301	Transmission and Distribution	3	0	0	3	3	10	40	50
EE 23.303	Control System Engineering	3	0	0	3	3	10	40	50
EE 23.305	Power Plant Engineering	3	0	0	3	3	10	40	50
EE 23.307	Renewable Energy Technology	3	0	0	3	3	10	40	50
EC 23.301	Microprocessor and Microcontroller	3	0	0	3	3	10	40	50
	Program Elective-1 *	0	0	0	3	-	Based on MOOC Exam Score		
EE 23.321	Power System-I Laboratory	0	0	2	1	2	20	40	40
EE 23.323	Control System Laboratory	0	0	2	1	2	20	40	40
EE 23.331	Summer Internship Project-1**	0	0	0	2	-	100		
EE 23.333	Project-1	0	0	4	2	-	50	-	50
SF 301	Civility and Ethics Business and Professional Grooming, Corporate Dinning Etiquettes (Non Grade)	0	0	2	**1**	2	50	-	50
	Total	15	0	10	**24**				

Third Year -Spring Semester									
Course Code	Course Title	Contact Hours Per Week			Credits	ETE Duration (Hours)	Weightage		
		L	T	P			CW	MTE	ETE
EE 23.302	Power System Analysis and Design	3	0	0	3	3	10	40	50
EE 23.304	Power Electronics	3	0	0	3	3	10	40	50
EE 23.306	Power System Protection	3	0	0	3	3	10	40	50
EE 23.308	Electrical and Electronics Engineering Materials	3	0	0	3	3	10	40	50
EE 23.310	Utilization of Electrical Energy and Traction System	3	0	0	3	3	10	40	50
EE 23.316	Electrical Machine Design	3	0	0	3	3	10	40	50
EE 23. 334	Colloquium	0	0	2	1		100		
EE 23.322	Power System-II Laboratory	0	0	2	1	2	20	40	40
EE 23.324	Power Electronics Laboratory	0	0	2	1	2	20	40	40
EE 23. 332	Project-2	0	0	4	2		50	-	50
SF 302	Soft Skills and Interview Skills (Non Grade)	0	0	2	**1**	2	50	-	50
	Total	18	0	12	**23**				

*The course may be taken through MOOC. NPTEL/SWAYAM/COURSERA will be the authorized platform for MOOC course. A minimum 8 week duration is required to earn 3 credits. After successful completion of this MOOC course, the student shall provide the successful completion status/certificate to the University (COE) through HOD/NPTEL/Coursera coordinator.

Fourth Year - Autumn Semester									
Course Code	Course Title	Contact Hours Per Week			Credits	ETE Duration	Weightage		
		L	T	P			CW	MTE	ETE
UE	University Elective-II	3	0	0	3	3	10	40	50
	Program Elective-2	3	0	0	3	3	10	40	50
	Program Elective-3	3	0	0	3	3	10	40	50
EE 23. 431	Summer Internship Project-2**	0	0	0	2	-	100		
EE 23. 433	Capstone Project-1	0	0	4	2	-	100		
	Total	9	0	4	**13**				

Fourth Year -Spring Semester									
Course Code	Course Title	Contact Hours Per Week			Credits	ETE Duration	Weightage		
		L	T	P			CW	MTE	ETE
	Program elective-4	3	0	0	3	3	10	40	50
	Program elective-5	3	0	0	3	3	10	40	50
EE 23.432	Capstone Project-2	0	0	4	6	-	100		
	Total	6	0	4	**12**				

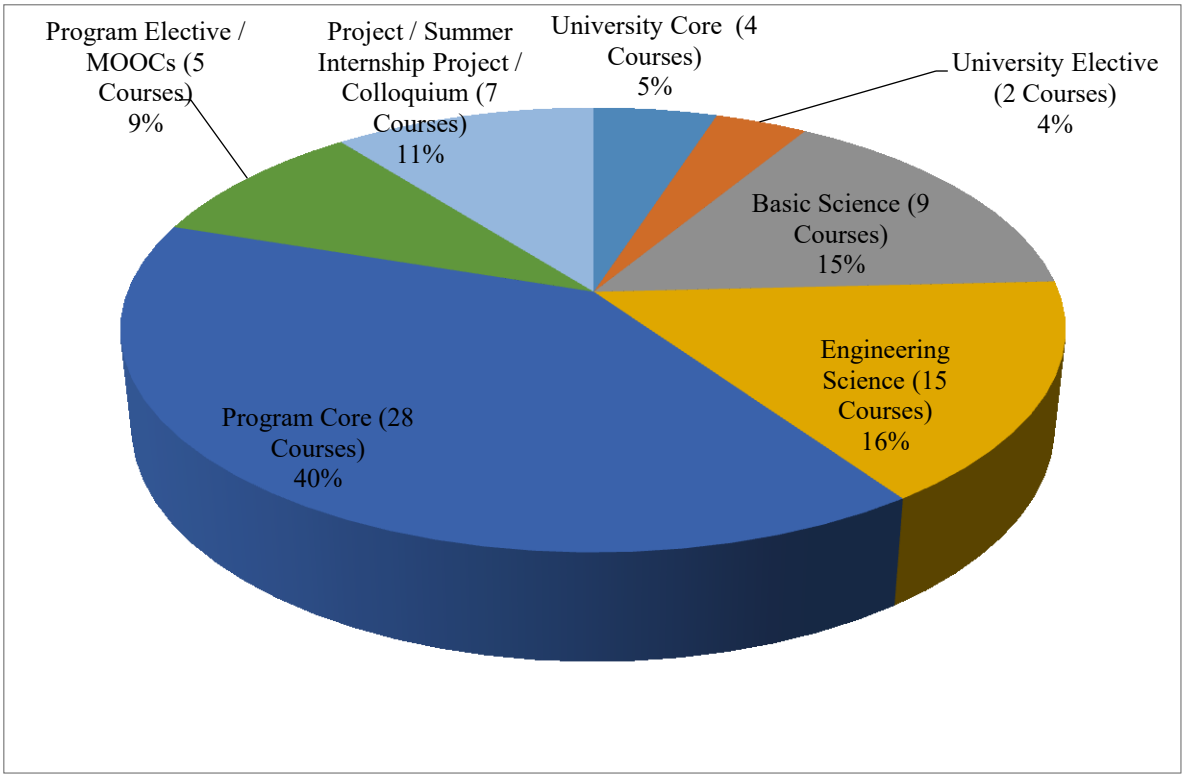
**Summer Internship-1 & 2 must be performed in an industry between summer vacation of end of second year and start of fourth year.

List of Program Elective Options

Code	Program Elective-1
	MOOC
Code	**Program Elective-2**
EE 23.401	Electric Drives and Control
EE 23.403	Nonlinear Control system
EE 23.405	Robotic Engineering
Code	**Program Elective-3**
EE 23.407	High Voltage Engineering
EE 23.409	Smart Grid
EE 23.411	Industrial Automation and Control
Code	**Program Elective-4**
EE 23.402	Solar PV Technology
EE 23.404	Power Electronics in Renewable Energy Technology
EE 23.406	PLC and Automation
Code	**Program Elective-5**
EE 23.408	Wind Energy System
EE 23.410	Energy Storage Systems
EE 23.412	Advanced Electric Drives

Credit Distribution across all Components								
Semester	UC	UE	BS	ES	PC	PE	PR	Total
First	2	0	10	11	0	0	0	23
Second	2	0	8	11	0	0	0	21
Third	2	0	4	4	12	0	0	22
Fourth	2	3	0	0	18	0	0	23
Fifth	0	0	0	0	17	3	4	24
Sixth	0	0	3	0	17	0	3	23
Seventh	0	3	0	0	0	6	4	13
Eight	0	0	0	0	0	6	6	12
Total	8	6	25	26	64	15	17	161

Acronym	
UC	University Core
UE	University Elective
BS	Basic Science
ES	Engineering Science
PC	Program Core
PE	Program Elective / MOOCs
PR	Project/Summer Internship



UC 23.101 **Human Values and Professional Ethics** **Total Lectures: 26**

2-0-0-2

Objective: To create an awareness on professional ethics and human values, To instill moral and social values and loyalty and to appreciate the rights of others.

Pre-requisite:

1. **Introduction to Human Values:** Morals, Values and Ethics – Happiness & Prosperity Truth, Rights Conduct (Righteousness), Love, non-violence and peace, Humility and character. Core areas of ethics: Social ethics, Personal ethics Integrity and Trustworthiness, Honesty, Loyalty, Courage, Prudence, Confidence, Confidentiality. **[5]**
2. **Understand the Harmony:** Understanding the harmony as co-existing of self and body. Understanding myself, harmony in the family and society harmony in nature. **[4]**
3. **Professional Ethics:** Introduction, meaning of work ethics, professional ethics for Journalists, Physicians, Lawyers, Engineers and Accountants. Intellectual property Rights, scope of ethics, code of conduct, business values and inner consciousness, Ethics at the workplace cybercrime, plagiarism, misconduct, fraudulent use of institutional resources, etc. **[7]**
4. **Corporate Social Responsibility:** Evolution of Corporate Social Responsibility (CSR) in India, CSR models, CSR to different stakeholders, Corporate Social Responsibility Initiatives of Major Companies of India, Promoting value based governance in organization. Whistle blower policy. **[6]**
5. **Ethics and Environment:** Introduction to environmental Issues- Industry and Environmental Pollution, Ethics of Controlling environmental pollution – Impact of environmental pollution on human health – Rights, Duties and care in environmental protection - Sustainable development. **[4]**

Outcome: The students will understand the basic perception of profession, professional ethics, various moral issues and uses of ethical theories.

Text Books:

1. B.N Ghosh “Business Ethics and Corporate Governance”, McGraw Hill Education, Chennai, 2016.
2. John R Boatright, “Ethics And The Conduct Of Business”, Pearson Education, New Delhi, 2013.

Reference Books:

1. Raju Ramachandran, “Professional Ethics: Changing Profession and Changing Ethics”, LexisNexis, Butterworths, 2nd Edition 2014.
2. Andrew Crane and Dirk Matten, “Business Ethics”, Oxford University Press, 2nd Edition, 2015.
3. S.K Mandal “Ethics in Business and Corporate Governance” McGraw Hill Education, New Delhi, 2013.
4. R. Subramanian “Professional Ethics”, Oxford University Press, 2015.

MA 23.101 **Mathematics I** **Total Lectures: 40**

3-1-0-4

Objective: To acquire fundamental knowledge of Mathematics and apply in engineering disciplines.

Pre-requisite: (10+2) Higher Secondary Mathematics

1. **Differential Calculus I:** Review of basic concepts, partial differentiation, different chain rules, second and higher order partial derivatives, Euler's theorem (with proof) on homogeneous functions and applications, Jacobians, properties of Jacobians. [07]

2. **Differential Calculus II:** Maxima and minima of functions of two variables, asymptotes (parallel and oblique), Tracing of simple Cartesian curves and standard polar curves. [07]

3. **Integral Calculus:** Basics of Beta and Gamma functions, Length of plane curves (Cartesian and polar), area bounded by the curves (Cartesian and polar), multiple integrals (double and triple), change of order of integration, physical interpretations and applications. [10]

4. **Matrix Theory**: Rank of matrix(elementary row transformations), linear dependence and independence of vectors, Solution of system of simultaneous linear equations, Eigen values, Eigen vectors of a matrix, Cayley-Hamilton theorem (without proof) and applications, diagonal and quadratic form of matrix.. [08]

5. **Three-dimensional Geometry:** Direction cosines and direction ratios of a straight line, equation of a plane, plane passing through intersections of two planes, equations of straight line, shortest distance between two skew lines, equation of a sphere, intersection of plane and sphere. [08]

Outcome: After completion of the course, students would be able to apply mathematical knowledge in engineering and solve curriculum problems.

Text Books:

1. Ramana B.V., Higher Engineering Mathematics, McGraw Hill Education, July, 2017.
2. Bali N. P. and Goyal Manish , A Text Book of Engineering Mathematics, Ninth Edition, Laxmi Publication, January 2016..

Reference Books:

1. Erwin Kreyszig Advanced Engineering Mathematics, 9th Edition, Reprint 2011.
2. Pal and Bhunia, Engineering Mathematics, Oxford University Press, 2015.
3. Dass and Verma, Higher Engineering Mathematics, S.Chand, 2019.

CY 23.101 **Engineering Chemistry** **Total Lectures: 39**

3-0-0-3

Prerequisite(s): NIL

Objective(s):
- To purify the most valuable natural resource of the future-water.
- To understand one of the most versatile Engineering Materials: Polymers their preparation, properties and uses.
- To develop the basics of protecting engineering materials from the natural forces.
- To understand the present day up-to-date knowledge of the contemporary energy sources.
- To build up the basis of the future Engineering materials like superconductors, conducting organic polymers, Nano materials etc.

1. **Water treatment:** Hardness, types of hardness, degree of hardness and its estimation (EDTA methods). Numerical problems on degree of hardness. Boiler troubles: sludge and scale formation, Prevention of sludge and scale formation in boilers. Softening of hard water (Lime-Soda, Permutit, Ion Exchange and calgon methods). Numerical problems based on water treatment (Lime-Soda process). [8]

2. **Polymers and Phase Rule:** Industrial applications of Inorganic and organic polymers. Phase Rule and its application to water and Sulfur system. [8]

3. **Electrochemistry and Corrosion:** Electrochemical Changes, Electrochemical cell and its classifications (Galvanic cell, electrolytic cell). Types of electrodes. Origin of electrode potential, Electrochemical Series. Electromotive force, Nernst equation of electrode potential. [8]
Corrosion: Definition and its significance, Theories of corrosion, Mechanism of corrosion, types of corrosion, Corrosion control (Corrosion inhibitors, Cathodic protection - sacrificial anodic and impressed current cathodic protection).

4. **Fuels and Lubricants:** Introduction - Importance of fuels in Industries. Classifications of fuels, Comparison of solid, liquid & solid fuels, Calorific value of a fuel. Determination of calorific value by Bomb calorimeter. Refining and cracking of petroleum, knocking. Octane Number and Cetane Number. L.P.G., Coal gas and Producer gas. [9]
Lubricants: Introduction and Classification of Lubricants. Properties of Lubricants, Lubricant Oil, Grease, Emulsions.

5. **New Engineering Materials:** Introduction: Superconductors, high and low temperature superconductors, organic electronic materials, Fullerenes and Nano materials, Industrial applications of fullerenes and Nano materials. [6]

Outcome(s): The student will be able to understand the basis of the future Engineering materials like of lubricants, superconductors, conducting polymers, Nano materials etc and purification of the most valuable natural resource of the future-water.

Text Books:
1. Jain and Jain, "Engineering Chemistry," 16th Edition, Dhanpat Rai Publishing Company, 2015.
2. S.S. Dara, "A Text Book of Engineering Chemistry," 12th Edition, S. Chand & Company Limited, 2014.

Reference Books:
1. Peter Atkins, Julio de Paula, and James Keeler, "Atkins' Physical Chemistry" Eleventh Edition, Oxford University Press, 2017.
2. William D. Callister, "Materials Science and Engineering: An Introduction, Eighth Edition, John Wiley & Sons, Inc., 2010.

ME 23.101 **Applied Mechanics** **Total Lectures: 40**

3-1-0-4

Objectives:

- This course will help the student to acquire knowledge of basic engineering mechanics concepts and enhance their ability to solve open ended engineering problems.
- To provide the student with a clear and thorough understanding of the theory and applications of engineering mechanics, covering both statics and dynamics.

Prerequisite Basic Mathematics and Physics

1. **Introduction:** Idealization of Mechanics, concept of Rigid Body, External Forces, Laws of Mechanics. **[12]**

   Force Systems and Equilibrium: Force systems, Moment of force, Moment of a couple, Equivalent system, Free Body Diagram, Equations of equilibrium and their applications to various systems of forces.

2. **Distributed Forces and Moment Of Inertia:** Centroid of Composite figures, Area Moment of Inertia, Mass Moment of Inertia, Principle axes and Principle Moment of Inertia. **[7]**

3. **Friction:** Introduction of friction, Laws of friction, wedge, screw, belt, rolling friction. **[7]**

4. **Tension, Compression and Shear:** Normal stress and strain, Linear elasticity, Hooke's Law and Poisson's Ratio, Shear stress and shear strain, **[8]**

   Beams: Different support & load conditions, SFD, BMD

5. **Kinematics of Particles:** Introduction, Rectilinear motion, Plane curvilinear motion**,** Rectangular coordinates, Tangential and normal coordinates, Relative motion **Kinetics of Particles:** Introduction, Force, Mass and acceleration, Newton's second law of motion, Equation of motion and solution of problems, Work and Energy, Impulse and Momentum. **[6]**

Outcome: The students shall develop the ability to identify, formulate, and solve engineering problems related to forces and motion.

Text Books:

1. Hibbeler, Gupta R. C., "Engineering Mechanics," 11th ed., Pearson India, 2010.
2. Merian, J.L, Kraige, L.G., "Engineering Mechanics Vol I & II," 5th edition, Wiley India 2010.

Reference Books:

1. Timoshenko, S, Young, D.H, Rao, J.V, "Engineering Mechanics," 4th edition TMH, 2010.
2. Irving. H. Shames, "Engineering Mechanics," Prentice Hall Book Company, 1966.

EC 23.101 **Basics of Electronics Engineering** **Total Lectures: 40**

3-1-0-4

Prerequisite Basic Knowledge of Engineering and Applied Physics

Objective: To learn the fundamental principle and applications of electronics and communication engineering and devices.

1. **Introduction:** Brief history of major inventions in ECE, Electronic test and measurement equipment's, Specifications for electronic components. **[3]**
2. **Semiconductors**: Material and its properties, Formation of energy band diagram, Currents in semiconductors, Fermi-Dirac energy distribution, Types of semiconductors – Intrinsic and Extrinsic, Mass action law, Hall effect. **[7]**
3. **Diodes**: Introduction, Characteristic of ideal and real diode, Current components in diode, load characteristics, Breakdown in diode, Zener diode, Varactor diode, Tunnel diode, Clippers and Clampers, Rectifiers – Half and Full-wave rectifiers. **[10]**
4. **Transistors:** Introduction to pnp and npn transistors, current components, active, cutoff and saturation regions, CC, CB and CE configuration, Operating point, Biasing circuits, Bias Stability, Thermal runway and thermal stability. **[10]**
5. **Introduction to Signals and Communication Systems**: Definition, Classification of signals – Analog and Digital, Deterministic and Random signals, Power and Energy of signals, Bandwidth, Bit and Baud rate. Block representation of communication system, Modulation – Definition, Need of modulation, Types of modulation. **[10]**

Outcome: After completion of this course, students would be able to :

1. Distinguish between conductors, semiconductors and insulators based on energy band theory and classify different types of semiconductors.

2. Employ the concept of Energy Band Theory and Fermi Levels to explain the operating principle of semiconductors.

3. Demonstrate the operating principle and characteristics of p-n junction diodes, different diode circuits and Transistors.

4. Understand various types of communication signals and its characteristics parameters.

5. Understand the basic concepts of communication system and modulation techniques..

Text Books:

1. George Kennedy, Bernard Davis, "Electronics Communication Systems", Tata McGraw-Hill, 3rd Edition, 2007.

2. Behrouz Forouzan, "Data Communication and Networking", McGraw-Hill, 4th Edition, 2006.

Reference Books:

1. David A. Bell, "Electronics Devices and Circuits", PHI, 4th edition, 2008.

2. Wayne, Tomasi, "Advanced Electronic Communication Systems", PHI, 6th edition, 2013.

3. Robert L. Boylestad, Louis Nashelsky, "Electronics Devices and Circuits Theory", Prentice Hall, 10th Edition, 2009.

ME 23.111 **Computer Aided Engineering Drawing** **Total Hours: 26**

0-0-4-2

Objective:

- To improve the visualization skills.
- To enable the students with various concepts like dimensioning, conventions and standards related to working drawings, projections in order to become professionally efficient.
- To impart the knowledge on understanding and drawing of simple engineering products.

1. **Introduction to Computer Aided Sketching:** Introduction, Drawing Instruments and their uses, BIS conventions, Lettering, Dimensioning and free hand practice. Board Drawing vs. Computer- Aided Drawing. Introduction to Solid works Environments. Computer screen, layout of the software, standard tool bar/menus and description of most commonly used tool bars, navigational tools. Co-ordinate system and reference planes. Definitions of HP, VP, RPP &LPP. Creation of 2D/3D environment. Selection of drawing size and scale. Commands and creation of Lines, Co-ordinate points, axes, dimensioning, line conventions, material conventions and lettering. [8]
2. **Orthographic Projections** : Horizontal planes, Vertical planes, Front view, Top view, Side view, Projections, First and Third angle of projection, Projections of points, Principles of orthographic projections, Sketching of different views of given objects. Introduction to sketching in Solid works : 2-Dimenional Sketching, Sketching in Solid works, poly-lines, square, rectangle, polygons, splines, circles, ellipse, text, move, copy, off-set, mirror, rotate, trim, extend, break, chamfer, fillet, curves, constraints viz. tangency, parallelism, inclination and perpendicularity. [12]
3. **Projections of Lines, Planes and Solids:** Lines inclined to both the principal planes, projection of Lamina inclined to both principal planes, Projections of solids: Axis inclined to both the reference planes and Intersection of solids. Introduction to part module in Solid works: Extrude, Revolve, Sweep, Hole, Filleting, and Chamfering features. [12]
4. **Sections of solids and sectional orthographic views:** Sectional orthographic projections - Full, Half, Partial, revolved and removed surfaces. Introduction to drawing module in Solid works: Standard 3 views, Auxiliary view, Section View, Projected view. [12]
5. **Isometric Projection:** Terminology, Isometric scale, Box method, Coordinate or offset method, Four-center method, isometric projection of arcs. Solid models practice using Solidworks part module. [8]

Outcomes:

1. Students will be able to improve their visualization skills so that they can apply these skills in developing new products.
2. Students will be able to know and understand the conventions and the methods of engineering drawing using Solid works.
3. Students will be able to prepare simple drawings of engineering products.

Text Books:

1. N.D. Bhatt, "Engineering Drawing", Charotar Publishing House, 2013.
2. Prof. Sham Tickoo, Sandeep Prem Dass “Solid works 2013 for Engineers and Designers” Wiley Publication, 2013.

Reference Books:

1. Randy H. Shih, “Solid works 2013 and Engineering Graphics: An Integrated Approach”, SDC Publications. 2013

CY 23.111 **Chemistry Laboratory** **Total Hours:26**

0-0-2 - 1

Prerequisite(s): NIL

Objective(s):

- To introduce students to water chemistry and purify the most valuable natural resource of the future-water.
- To understand one of the most versatile Engineering Materials: Polymers, lubricants, fuel and their properties and uses.

LIST OF EXPERIMENTS

Choice of 10-12 experiments from the following

1. To determine the temporary and permanent hardness in the given water sample by complexometric titration using EDTA as standard solution.
2. To determine the percentage of Available Chlorine in the given sample of Bleaching powder. Iodometrically.
3. To determine the alkalinity of water sample.
4. To prepare urea formaldehyde resin.
5. To determine the strength of given HCl solution by titrating it against NaOH solution using pH meter.
6. To determine the strength of given acid solution by titration it against sodium hydroxide solution using conductometer.
7. To determine molecular weight of a polymer using Ostwald viscometer.
8. Determination of viscosity of given lubricating oil by Redwood viscometer.
9. Determination of cloud and pour point of given lubricating oil.
10. Determination of the flash and fire point of given lubricating oil.
11. Determination of phase diagram of water system.
12. To determine the calorific value (HCV) of a sample of fuel.

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Outcomes The students will learn to:

- Estimate the Hardness of water, alkalinity of water.
- Familiar with the important practical applications of electrochemistry, lubricants, solids, their properties and applications, and the polymer materials.

EC 23.111 **Electronics Laboratory** **Total Hours: 26**

0-0-2-1

Objective:

- To gain practical knowledge by applying the experimental methods to correlate with the theory of Electronics Engineering.
- To apply the analytical techniques and graphical analysis to the experimental data.
- To enable the students to simulate and test the Electronics circuits using Multisim software.

Prerequisite: Basic Understanding of Engineering Physics and Electronics

Practical to be performed on Hardware:

1. Familiarity of Soldering/de-soldering process, Component identification, testing and their verification using multimeter.
2. To plot V-I characteristics of junction diode and Zener diode.
3. To design a half wave rectifier with and without filter circuit and find the ripple factor.
4. To design a full wave rectifier with and without filter circuit and find the ripple factor.
5. Study of clipper and clamper circuits and their implementation on breadboard.
6. To plot the characteristics of Transistor under Common Emitter configuration

Practical to be performed using Multi-Sim Software:

7. To verify Ohm's law and Kirchhoff's law
8. To Simulate half wave and full wave bridge rectifier.
9. To plot V-I characteristics of p-n junction diode.
10. To plot V-I characteristics of Zener diode.
11. Study of Clipper circuit and its implementation on Multisim.

Outcome: After performing the above experiments, Student will be able to :

1 Identify and describe basic electronic components used in circuits.
2 Build and configure basic electronic circuits using breadboards.
3. Analyze the voltage-current characteristics of p-n junction diodes , Zener diodes and Transistor.
4 Develop clipper and clamper circuits to achieve desired voltage waveforms.
5 Utilize Multisim software to simulate and validate circuit designs.

CY 23.102 **Environmental Sciences** **Total Lectures: 26**
2-0-0-2

Objective: • To teach the principal resources, renewable energy systems and biosphere.
• To explore the environmental impact of various energy sources and also the effects of different types of pollutants.

Pre-requisite: Nil

1. **Basic concepts of Environmental Studies:** Definition, scope and importance**,** Multidisciplinary nature of environmental studies, Need for public awareness. Role of an individual in conservation of natural resources. Equitable use of resources for sustainable lifestyles. [4]

2. **Natural Resources:** Renewable and non-renewable resources. **Mineral resources:** Use and exploitation, environmental effects of extracting and using mineral resources, case studies. **Forest resources:** Use and over exploitation, deforestation, case studies. **Land resources:** Land as a resource, land degradation, man induced landslides, soil erosion and desertification. **Food resources:** World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, [6]

3. **Ecosystems & Biodiversity:** Concept and Structure and function of an ecosystem. Producers, consumers and decomposers. Energy flow and nutrient cycling in the ecosystem. Food chains, food webs and ecological pyramids. [5]

   Biodiversity and its conservation: Introduction – Definition, genetic, species and ecosystem diversity. Threats to biodiversity: habitat loss, illicit poaching, man-wildlife conflicts.

4. **Environmental Pollution :** Definition, cause, effects and control measures of: Air pollution, Water pollution, Soil pollution, Noise pollution, Thermal pollution, Nuclear Radiation. [6]
   Solid waste Management: Causes, effects and control measures of urban and industrial wastes. Pollution case studies. Disaster management: floods, earthquake, cyclone and landslides.

5. **Social Issues, Population and impacts of Environmental impacts:**Urban problems related to energy, Resettlement and rehabilitation of people, Global Climate Change, global warming, acid rain, ozone layer depletion. Wasteland reclamation. Population growth, variation among nations. Population explosion, Environment and human health. Human Rights. Value Education. Women and Child Welfare. Role of Information Technology in Environment and human health. Case Studies. Environment Protection Acts. [5]

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

- Evaluate local, regional and global environmental topics related to resource use and management
- Propose solutions to environmental problems related to resource use and management.
- Describe threats to global biodiversity, their implications and potential solutions.

Text Books:

1. Erach Bharucha “Environmental Studies”, University Grants Commission, 2004.
2. Anubha Kaushik, C P Kaushik “ Perspectives In Environmental Studies” New Age International Publishers. 2018

UC 23.102 **Pragmatic English Communication** **Total Lectures: 26**

2-0-0-2

Objective: This course aims to develop and enhance the linguistic and communicative competence of the students. The students will be exposed to various forms of personal and professional communication. The self-learning tasks designed will facilitate to enhance effective communication skills.

Pre-requisite: Basic knowledge of English grammar.

1. **Sentence Structure:** Elements of a sentence (Subject, verb, object, complement and adjunct) [7]
   Correct Usage of Language: Tenses (Present, Past and Future, Modals (can, could, will, would, shall, should, may, might, must, ought to, need).

2. **Listening and Reading Skills:** Developing effective listening and reading. [6]

   Writing Skills: Theme (Paragraph) writing, Letter (formal letters) and application writing, report writing, résumé writing.

3. **Idioms and Phrasal Verbs:** Understanding idioms, collocations, introduction to phrasal. [5]

4. **Common Errors:** How to avoid common sentence – structural errors, vocabulary and pronunciation. [3]

5. **Technology-based Communication:** Effective e-mail messages; power-point presentation; enhancing editing skills using computer software. [5]

Outcome: The students will learn the essentials of English Grammar, analyze, identify and rectify the common errors in speech and writing. Student can read and write with ease and fluently, enrich vocabulary and enjoy reading and writing.

Text Books:

3. Wren & Martin: English Grammar & Composition, S. Chand & Co, Delhi (Latest edition)
4. Raman, M., & Singh, P. (2017). Business Communication (2nd edition.). New Delhi: Oxford University Press.

Reference Books:

1. Prasad, H. M. How to Prepare for Group Discussion and Interview. New Delhi: Tata McGraw-Hill Publishing Company Limited
2. Bonet, Diana. The Business of Listening: Third Edition. New Delhi: Viva Books, 2004.
3. Hornby A.S.: A Guide to patterns and usage, Oxford University Press, Delhi, 1954.
4. Lesikar, Raymond V and Marie E. Flatley. Basic Business Communication: Skills for Empowering the Internet Generation: Ninth Edition. New Delhi: Tata McGraw-Hill

MA 23.102 **Mathematics II** **Total Lectures: 40**

3-1-0-4

Objective: To acquire fundamental knowledge of Mathematics and apply in engineering disciplines.

Pre-requisite: Mathematics I (MA 23.101)

1. **Computational Methods:** Calculus of finite differences, Forward, Backward and Shift operators and their relationship, Fundamental theorem of difference calculus (without proof), Factorial function, Interpolation schemes for equal intervals (Newton's forward and backward interpolation formulae), divided difference, interpolation for unequal intervals (Newton's divided difference and Lagrange interpolation formulae), Approximation of one real root of Algebraic and Transcendental equations by Newton-Raphson method.. [12]
2. **Ordinary Differential Equations I:** Definition, order and degree of differential equation, first order and first degree differential equations (variable separable, homogeneous, reducible of homogeneous, linear, Bernoulli and exact differential equations). [07]
3. **Ordinary Differential Equations II:** Linear differential equations of second order with constant and variable coefficients, general and particular solutions (complementary functions and particular integrals), and applications. [07]
4. **Partial Differential Equations:** Formation of partial differential equations, Lagrange's multipliers method for solution of first order differential equations, separation of variables for nonlinear differential equations(general and particular solutions) and applications. [06]
5. **Vector Calculus:** Vector and scalar point functions, conservative fields, gradient of scalar point functions, divergence and curl of vector point functions (Solenoidal and irrotational vectors), directional derivative of scalar point functions, line integral (work done), surface integral, volume integral, interpretations and applications. [08]

Outcome: After completion of the course, students would be able to apply mathematical knowledge in engineering and solve curriculum problems.

Text Books:

1. Ramana B.V., Higher Engineering Mathematics, McGraw Hill Education, July, 2017.
2. Bali N. P. and Goyal Manish , A Text Book of Engineering Mathematics, Ninth Edition, Laxmi Publication, January 2016.

Reference Books:

1. Erwin Kreyszig Advanced Engineering Mathematics, 9th Edition, Reprint 2011.
2. Pal and Bhunia, Engineering Mathematics, Oxford University Press, 2015.
3. Ram Babu, Engineering Mathematics, Pearson Education, First Edition, January 2009.

PY 23.101 **Engineering Physics** **Total Lectures: 40**

3-0-0-3

Objective:
1. To provide students with a basic understanding of the Physics that may be required by engineers in the course of their careers
2. To enhance knowledge related to lasers and its different components to make it suitable for various purposes
3. To introduce the learners to the basics of modern physics and Quantum Mechanics

Pre-requisite: Fundamental knowledge of Basic Physics

1. **Modern Physics**: Introduction to Black body radiation spectrum, Photo-electric effect, Compton effect. Wave particle Dualism. de Broglie hypothesis – de Broglie wavelength. Davisson and Germer Experiment. Matter waves and their Characteristic properties, Phase velocity, group velocity and Particle velocity, Relation between phase velocity and group velocity, Relation between group velocity and particle velocity. **[8]**

2. **Quantum Mechanics:** Heisenberg's uncertainty principle and its physical significance. Application of uncertainty principle (Non-existence of electron in the nucleus, explanation for decay and kinetic energy of electron in an atom). Wave function, Properties and physical significance of wave function, Probability density and Normalization of wave function. Setting up of one-dimensional time independent Schrodinger wave equation. Eigen values and Eigen functions. Application of Schrodinger wave equation – Energy Eigen values for a free particle. Energy Eigen values and Eigen functions for a particle in a potential well of infinite depth. **[7]**

3. **Electrical Conductivity in Metals**: Free–electron concept. Classical free-electron theory – Assumptions. Drift velocity, Mean collision time and mean free path. Relaxation time. Expression for drift velocity. Expression for electrical conductivity in metals. Effect of impurity and temperature on electrical resistivity of metals.
   Quantum free-electron theory – Assumptions. Fermi – Dirac Statistics. Fermi-energy, Fermi factor. Density of states (No Derivation). Expression for electrical resistivity / conductivity. Temperature dependence of resistivity of metals. electron in a periodic potential, origin of the energy gap, band theory of solids, distinction of solids into metals, semi-conductors and insulators. **[8]**

4. **Dielectric & Magnetic Properties of Materials**: Dielectric constant and polarization of dielectric materials. Types of polarization. Equation for internal field in liquids and solids (one dimensional). Ferro and Piezo electricity. Frequency dependence of dielectric constant. Important applications of dielectric materials. Classification of dia, para and ferro-magnetic materials. Hysterisis in ferromagnetic materials. Soft and Hard magnetic materials. Applications. **[7]**

5. **Lasers and Optical Fibers**: Einstein's coefficients (expression for energy density). Requisites of a Laser system. Condition for laser action. Principle, Construction and working of CO2 laser and semiconductor Laser. Applications of Laser – Laser welding, cutting and drilling. Propagation mechanism in optical fibers. Angle of acceptance. Numerical aperture. Types of optical fibers and modes of propagation. Attenuation. Applications–Block diagram discussion of point to point communication. **[10]**

Outcome: After completion of this course, students will be able to :
1. Understand the experimental evidence supporting the de Broglie hypothesis and the wave-particle duality of matter.
2. Explain fundamentals of quantum mechanics and apply to one dimensional motion of particles.

3. Describe the band theory of solids.
4. Understand material properties to use in engineering applications and studies.
5. Illustrate the working of lasers and optical fibers.

Text Books:

1. S. O. Pillai, “Solid State Physics”, New Age International, Sixth Edition, 2009.
2. V. Rajendran, “Engineering Physics,” TMH, Fifth Edition , 2013.

Reference Book:

1. G. K. Shivkumar, “Engineering Physics,” Prism Book Pvt. Ltd.
2. Stephen T. Thornton, “Modern Physics for Scientists and Engineers”,Cengage Learning, 4th ed.,2013.

EE 23.101 **Basics of Electrical Engineering** **Total Lectures: 40**

3-1-0-4

Objective: This course facilitates the students to get a comprehensive exposure to various concepts and devices of electrical engineering.

Pre-requisite: Nil

1. **DC Circuits:** Electrical circuit elements (R, L and C), voltage and current sources, Ohm's law, Kirchhoff current and voltage laws, analysis of simple circuits with dc excitation using mesh and nodal method. Network Theorems - Superposition, Thevenin, Norton and Maximum power transfer Theorems. Time-domain analysis of first-order RL and RC circuits. Star-Delta Conversion [8]

2. **AC Circuits:** Basic terminologies, representation of sinusoidal waveforms, average, rms and peak values of a.c. quantities, phasor representation, real power, reactive power, apparent power, power factor. Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel). [8]

3. **Three Phase A.C. Circuits:** Three phase supply, phase sequence, star connection, delta connection, relationship between phase and line quantities in 3-phase circuits, measurements of three phase power under balanced condition. [6]

4. **Transformers:** Magnetic materials, BH characteristics, ideal and practical transformer, equivalent circuit, Transformer testing: open circuit and short circuit test, losses in transformers, regulation and efficiency. Basics of auto-transformer and three-phase transformer connections. [10]

5. **Electrical Machines:** DC Machines – construction, functions of each part, working principle, EMF and torque equations, types of dc machines. Single Phase AC machines, AC machines – classification (Split phase machines, universal machines), construction, operating principles of ac machines. [8]

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

- To understand and analyse basic electric and magnetic circuits.
- To study the working principles of electrical machines.

Text Books:

3. Kothari, D. P., and I. J. Nagrath, "Theory and Problems of Basic Electrical Engineering," PHI Learning Pvt. Ltd., 1998.
4. Fitzgerald, Arthur Eugene, David E. Higginbotham, and Arvin Grabel, "Basic electrical engineering," McGraw-Hill Series in Electrical Engineering, Auckland: McGraw-Hill, 1981, 5th ed.(1981).

Reference Books:

1. H.Cotton, "Advanced Electrical Technology," CBS Publication. 1967.
2. Vincent Del Toro, "Electrical Engineering Fundamentals," 2nd Edition PHI Publication. 1972.
3. Smarajit Ghosh, "Fundamentals of Electrical and Electronics Engineering", PHI Publication, 1st Edition, 2007.

CS 23.101 **Programming for Problem Solving** **Total Lectures: 40**

3-0-0-3

Objective(s):
1. To learn principles of programming by the structured native language 'C'.
2. To comprehend the rudiments, constructs, syntax, and statements with essentials of efficient compiling, running and debugging processes.

Prerequisite(s): NIL

1. **Introduction:** The role of programming languages, programming paradigms, language description and syntax structure, basics of structured and object-oriented programming, functional programming, logic programming, concurrent programming. [5]
2. **Fundamentals of 'C' language**: Character set, variables data types constants, arithmetic, relational and logical operators, type conversion,increment,decrement, bitwise and assignment operators, conditional expressions, statements and blocks, if-else, switch, loops-do-while, while, for; break, continue and goto statements, labels. [10]
3. **Functions, pointers and Arrays**: Basics of functions, storage classes, scope rules, and header files, recursion and C preprocessor, arrays, pointers and addresses, types of pointers, pointers and arrays address arithmetic, character pointers and functions, pointer arrays, pointers to functions, function returning pointer, pointer to array, array of pointers, and multidimensional arrays, command line arguments, dynamic memory allocation-malloc(), calloc(), realloc(), free() [13]
4. **Structures and unions:** Basics of structures and functions, arrays of structures, pointers to structures, passing structure to function, function returning structure, union, self-referential structures. [6]
5. **I/O and File Processing:** Concept of files, standard input and output, formatted output, file access in different modes, reading from and writing to a file, random access file operations. [6]

Outcome(s): Students would be able to apply learning and knowledge of C language analytically, critically and logically to solve mathematical, scientific and real-life problems in an efficient manner.

Text Books:
1. Brain W. Kernighan and Dennis M. Ritchie, The C Programming Language, Second edition, Pearson Education.
2. Ravi Sethi & K.V.Viswanatha, Programming Languages-Concepts, and Constructs, Second edition, Pearson Education,

Reference Books:
1. Herbert Schildt, C: The Complete Reference, Fourth Edition, McGraw-Hill Education,
2. E Balagurusamy, Programming in ANSI C, Tata McGraw - Hill Education,

PY 23.111 **Physics Laboratory** **Total Hours: 26**
0-0-2-1

Pre-requisite: Nil

Objective:
1. To gain practical knowledge by applying the experimental methods to correlate with the Physics theory.
2. To apply the analytical techniques and graphical analysis to the experimental data.

List of Experiments:

1. To study of material constant, temperature coefficient of current and planck's constant.

2. To determine the specific resistance of a given wire by using the Carey Foster's bridge.

3. To measure the numerical aperture of an optical fiber.

4. To measure the cylindrical object of diameter with help of Screw gauge and Vernier caliper.

5. To study the variations of resistivity with temperature and hence determines the energy band gap of the given semiconductor with help of four probe method.

6. To convert a galvanometer into a voltmeter of a given range.

7. To convert a galvanometer into an ammeter of a given ranges.

8. To plot graph showing the variation of magnetic field with distance along the axis of a circular coil carrying current and to estimate from it the radius of the coil.

Outcome:
1. Students will be convergent with operation of equipment and verify the principle of Physics by doing the experiments.
2. Understand the concepts and principles related to material constants, temperature coefficients, and Planck's constant.
3. Analyze the collected data to determine the specific Resistance using Carey Foster's Bridge.
4. Perform measurements and data analysis to determine the numerical aperture of the optical fiber accurately.
5. Gain hands-on experience in measuring and plotting the magnetic field variation along the axis of a circular coil carrying current.
6. Develop the ability to convert a galvanometer into an ammeter and voltmeter.

EE 23.111 **Electrical Laboratory** **Total Hours: 26**

0-0-2-1

Objective: The objective is to provide a basic exposure of installation and operation of electrical equipment.

Prerequisite: Nil

Perform any ten of the list.

1. To Study of the various apparatus used in Electrical Engineering.
2. To perform residential house wiring using fuse, indicator, switch, Socket, plug and lamp.
3. To design a Tunnel wiring for illuminating three lamps.
4. To conduct the open circuit tests on the given single phase transformer and to determine equivalent circuit parameters.
5. To conduct the short circuit tests on the given single phase transformer and to determine equivalent circuit parameters.
6. To construct a fluorescent tube and to measure voltage across tube rod, voltage across choke and current.
7. To conduct the polarity test on the given transformer.
8. To control the speed of DC machine by field current control method.
9. To control the speed of DC machine by Armature Voltage control method.
10. To measure three phase power by using two wattmeter methods.
11. To verify Superposition Theorem using resistive circuit.
12. To verify Thevenin's Theorem using resistive circuit.

Outcome: Students will be convergent with installation and operation of electrical equipment.

CS 23.111 **Programming Laboratory- I** **Total Hours: 26**

0-0-4-2

Objective:
- To make students familiar with syntax and structure of C-programming.
- To learn problem solving techniques using C programs implementation.

Prerequisite: Nil

1. Implement the logic of Data Types & Operators.
2. Implement the logic of Type Conversions.
3. Implement the logic of Arithmetic, Relational, and logical operators.
4. Implementation of Bitwise, unary, assignment operators.
5. Implementation of Increment and Decrement operators.
6. Implementation of Conditional operators.
7. Implement the logic of Increment and Decrement operators.
8. Implement programs in order to cover Control Structure, If-Else statements, Nested If-Else statements, Switch-case statement, Loops- For, While, Do-While, Break Continue, Go-To Statements, and Labels.
9. Implement programs in order to cover processing an array, passing arrays to functions, Multidimensional arrays.
10. Implement programs to cover all possible String operations.
11. Implement programs in order to cover Function prototypes and passing arguments to a function, Recursion.
12. Implement programs in order to cover Pointers declaration, operations on pointers, Array of pointers, pointers to arrays.
13. Implementation of structure and union programs.
14. Implement the use of Storage classes in C programming.
15. Implement programs for Reading and writing from/to a file.
16. Implement random access file operation

Outcome: On completion of this course student will be able to:
- Apply learning and knowledge of C language analytically, critically and logically to solve mathematical, scientific and real-life problems in an efficient manner.

ME 23.112 **Mechanical Workshop** **Total Hours:26**

0-0-2-1

Objectives:

1. Practice on manufacturing of components using workshop trades including fitting, carpentry, sheet metal and welding.
2. Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping.
3. Study and practice on machine tools and their operations.

List of Jobs:

1. **Fitting Shop:** Prepare job that contain various fitting operation like filing, marking, measuring, cutting, drilling etc.
2. **Carpentry Shop:** Prepare job that contain various carpentry operations and making of carpentry joint (T joint).
3. **Sheet Metal Shop:** Prepare job that contain various sheet metal operations and making job from sheet (funnel, tray etc).
4. **Machine Shop:** Perform various operations like, turning, step turning, facing, chamfering, knurling etc. on Lathe.
5. **Welding Shop:** Prepare a weld bead using arc welding process.

Outcomes:

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

1. To acquire skills in basic engineering practice.
2. To identify the hand tools and instruments.
3. To acquire measuring skills.
4. To provides the knowledge of job materials in various shops.
5. Students will be able to analyze the material on the basis of their properties and thus assigning different weight age to their use for technical purposes.

Text Books:

1. Hajara Chaudhary, Workshop Technology Vol I & II, Media Promoters and Publishers PVT. LTD, Mumbai.
2. B.S. Raghuvanshi, Workshop Technology, Dhanpat Rai & Sons. New Delhi.

Reference Books:

1. H S Bawa, Workshop Technology, TMH. New Delhi.

UC 23.201 **Introduction to Management and Leadership** **Total Lectures: 26**
2-0-0-2

Objective: This course introduces students to the principles of leadership and management practices. It will consider how one manages oneself, others, and resources in the pursuit of a well-defined purpose. It acquaints students with the methods managers use to: assess the environment in which the organization operates; design, build, and implement the organization's capacity to serve; make decisions; and evaluate the efficacy of those decisions.

Pre-requisite:

1. **Introduction to Management**: Meaning and importance, Concept of industrial management, Levels of management, Management theories- classical, neo-classical and modern, Managerial roles (Mintzberg), Managerial competencies, Managers and environment. **[5]**
2. **Management Functions**: **Planning** – Concept, types, Strategic planning, Types of strategy, Decision making, Techniques for individual and group decision-making; **Organizing –** Concept, Design of organization structures, Departmentalization, Power and authority, Conflict and coordination; **Staffing** – Concept, Human resource planning, Recruitment and selection. **[6]**
3. **Contemporary Issues in Management**: Management challenges of the 21st Century, Factors reshaping and redesigning management purpose, Performance and reward perceptions, Internationalization, Digitalization, Entrepreneurship, Values and Ethics. **[5]**
4. **Introduction to Leadership**: Concept, Leadership theories (Trait, Behavioral, Situational), Leadership styles, Leadership behavior, Women as leaders, Leadership development, Leadership and change, Leadership and innovation (Audience analysis and engagement). **[5]**
5. **Emerging Challenges to Leadership**: Leadership in changing workplace, Leader's role in fostering teamwork, Methods to enhance creative problem solving, Leadership practices for innovation, Ethical leadership development, Cultural sensitivity, Global leadership skills. **[5]**

Outcome: Students will describe the various levels of management and applicability of management Principles, demonstrate various types of authority, delegation and decentralization in authority, demonstrate various types of leadership styles and identify the motivation techniques used by leaders, and discuss the impact of emerging issues in management.

Text Books:

1. L.M. Parasad, "Principles & practice of management", Sultan Chand & Sons, New Delhi, (Latest edition).
2. Stephen P.Robbins "Organizational Behavior" Pearson Education, New Delhi (Latest edition).

Reference Books:

1. T.N. Chhabra, "Business Organization and Management", Sun India Publications. New Delhi.
2. P.C. Tulsian, and V. Pandey, "Business Organization & Management", Pearson Education, India.

MA 23.201 **Mathematics-III** **Total Lectures: 40**

3-1-0-4

Objective: To acquire fundamental knowledge of Linear programming, Numerical Methods, Probability, Statistics and Integral Transform and apply in engineering disciplines.

Pre-requisite: Basic of Electrical Engineering

1. **Linear Programming:** Introduction to linear programming problems, Graphical solution, Simplex method, Artificial variable technique (Two phase method, Big –M method). [8]
2. **Numerical Methods:** Solution of system of equations (Gauss elimination and Gauss - Seidel methods); Solution of algebraic and transcendental equations (Bisection and Regula Falsi methods); Solution of ordinary differential equation (Euler's modified, Milne's predictor & corrector, Runge -Kutta method of order four). [8]
3. **Integral Transform:** Basics of Laplace transform and inverse Laplace transform; First and Second Shifting theorems; Convolution theorem (without proof); Solution of ordinary differential equations with initial conditions by Laplace transforms. [8]
4. **Probability Theory:** Recapitulation of basics of permutation, combination and probability theory; Law of addition and law of multiplication; Conditional probability; Total probability; Baye's theorem (with proof) and it's applications. [8]
5. **Correlation and Regression:** Concept of least square technique , fitting of least square straight line and quadratic curve (Parabola)**,** correlations analysis, different types, Simple, partial and multiple correlations, correlation of bivariate frequency distribution. [8]

Outcome: After completion of the course, students would be able to apply the knowledge of linear programming, numerical methods, statistics, probability and integral transforms in engineering and solve curriculum problems.

Text Books:

1. Ramana B.V., Higher Engineering Mathematics, TMH, 2016.
2. P. K. Gupta and D.S. Hira, Operations Research, S. Chand, 2019.

Reference Books:

1. Sastry S.S., Introductory Methods of Numerical Analysis, 5th Edition, Pearson.
2. Jain R.K. and S.R.K. Iyenger, Advanced Engineering Mathematics, Narosa Publishing House, 2003.

EE 23.201 **Electrical Machines-I** **Total Lectures: 40**
3-0-0-3

Objective: This course facilitates the students to get a comprehensive exposure to the working principles, construction details and performance of D.C. machines and Transformer.

Pre-requisite: Basic of Electrical Engineering

1. **Basic Concepts of Electrical Machines:** Introduction, Electromagnetic Induction, Flux linkage, Statistically and Dynamically induced emf, Classification and Description of electrical machines, Generator and Motor principles, Leakage flux, Losses and Efficiency, Rating and Loss Dissipation, Electrical and Mechanical degrees, Heating and Cooling of electrical machines. [8]
2. **Introduction to D.C. Machines:** Constructional parts of D.C. machines and their function, Principle of operation, Armature winding: Lap and Wave, Simplex and Duplex, Method of excitation, Classification, Derivation of emf and torque equations, Process of Commutation, Armature Reaction, Inter poles, Compensating winding and equalizer rings. [6]
3. **D.C. Generators:** Operating characteristics: Magnetization, Internal and External characteristics, Critical resistance and critical speed, Process of building up of voltage, Causes of failure of voltage build-up and remedies, Parallel operation of D.C. generators, Applications. [7]
4. **D.C. Motors:** Basic equation for voltage, Power, Torque and Speed, Condition for maximum power, Operating characteristics: Torque-current, Speed-current and Torque-speed characteristics. Comparison, Starters, Speed control methods, testing of D.C. machines: Swinburne, Hopkinson's and Series field tests. Calculation of efficiency, Applications. [7]
5. **Transformers:** Principle, Construction and Operation of single-phase transformers, equivalent circuit, Phasor diagram, Voltage regulation, Losses and Efficiency Testing - Open circuit and Short circuit tests, Polarity test, Back-to-Back test, Separation of hysteresis and eddy current losses. Three-phase transformer - Construction, Types of connection and their comparative features, Parallel operation of single-phase and three-phase transformers, Autotransformers - Construction, Principle, Applications and Comparison with two winding transformer, Three-winding transformers. Cooling of transformers. [12]

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

- Understand the concepts of magnetic circuits.
- Understand the operation of D.C. machines.
- Analyse the differences in operation of different D.C. machine configurations.
- Analyse single phase and three phase transformers circuit.

Text Books:

1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery", New York, McGraw Hill Education, 2013.
2. A. E. Clayton and N. N. Hancock, "Performance and design of DC machines", CBS Publishers, 2004.

Reference Books:

1. M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.
2. P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
3. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.

EE 23.203 **Network Analysis and Synthesis** **Total Lectures: 40**
3-0-0-3

Objective: This course helps students in analyzing the A.C. & D.C. circuits and it also provides design exposure to circuit models for minor and major projects.

Pre-requisite: Basic of Electrical Engineering

1. **Network Theorems:** Superposition theorem, Thevenin theorem, Norton theorem, Maximum power transfer theorem, Reciprocity theorem, Compensation theorem. Analysis with dependent current and voltage sources. Node and Mesh Analysis. Concept of duality and dual networks. [10]
2. **Solution of First and Second Order Networks:** Solution of first and second order differential equations for Series and parallel R-L, R-C, RL-C circuits, initial and final conditions in network elements, forced and free response, time constants, steady state and transient state response. Mutual coupled circuits, Dot Convention in coupled circuits, Ideal Transformer. [8]
3. **Electrical Circuit Analysis Using Laplace Transforms:** Review of Laplace Transform, Analysis of electrical circuits using Laplace Transform for standard inputs, convolution integral, inverse Laplace transform, transformed network with initial conditions. Transfer function representation. Poles and Zeros. Frequency response (magnitude and phase plots), series and parallel resonances. [8]
4. **Two Port Network:** Two Port Networks, terminal pairs, relationship of two port variables, impedance parameters, admittance parameters, transmission parameters and hybrid parameters, interconnections of two port networks. [6]
5. **Synthesis of Passive Network:** Hurwitz polynomials, positive real functions, elementary synthesis procedures, properties of LC immittance function, synthesis of LC driving point immittance, properties of RC driving point impedances, synthesis of RC impedances or RL admittances, properties of RL impedances and RC admittances, synthesis of RLC functions. [8]

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

- Apply network theorems for the analysis of electrical circuits.
- Obtain the transient and steady-state response of electrical circuits.
- Analyse circuits in the sinusoidal steady-state.
- Analyse two port circuit behaviors.

Text Books:

1. M. E. Van Valkenburg, “Network Analysis”, Prentice Hall, 2006.
2. A. Chakrabarti, “Circuit Theory (Analysis and Synthesis)”, Dhanpat Rai & Co. (PVT) Ltd., 2008.

Reference Books:

1. W. H. Hayt and J. E. Kemmerly, “Engineering Circuit Analysis”, McGraw Hill Education, 2013.
2. C. K. Alexander and M. N. O. Sadiku, “Electric Circuits”, McGraw Hill Education, 2004.
3. K. V. V. Murthy and M. S. Kamath, “Basic Circuit Analysis”, Jaico Publishers, 1999.

EC 23.201 **Electronic Devices and Circuits** **Total Lectures: 40**

3-0-0-3

Objective To acquire fundamental knowledge of operation, design and application of variousElectronic devices and circuits.

Pre-requisite Basic Electronics and Physics of electron.

1. **Junction Diode:** Junction breakdown**,** Current components in a p-n diode, Quantitative analysis of p-n diode characteristics and equivalent circuit, diode resistance, interconnections of diodes, transition and diffusion capacitance. [6]
2. **Transistors**: Operation of transistor, transistor current components, transistor circuit configurations, transistor biasing schemes and operating point stabilization, hybrid-pi model of BJT, low and high frequency models of JFET. [11]
3. **Small Signal Amplifiers at Low Frequency:** Coupling schemes for multistage amplifiers, frequency response of coupled amplifier, RC coupled transistor amplifier, transformer coupled transistor amplifier, cascode circuits, Differential amplifier, Darlington amplifier. [7]
4. **Power Amplifiers:** Power amplifier circuits, class-A, class-B, class-AB, class-C, push pullamplifiers- class-A, class-B, Class- AB. [10]
5. **Oscillators:** Classification criterion for oscillation, tuned collector, Hartley, Colpitts, RC phase shift, Wien bridge and crystal oscillators. [6]

Outcome: After completion of this course, students would be able to understand the working phenomena and applications of various electronic devices and circuits.

Text Books:

1. Robert L. Boylestad & Louis Nashelsky, Electronic Devices and Circuit Theory,Pearson Education, 11th Edition, 2013.
2. Thomas L. Floyd, Electronic Devices, Pearson Education, 10th Edition , 2018.

Reference Books:

1. Bell, David A., Operational Amplifiers & Linear ICS, Prentice Hall of India, 3rdEdition, 2018.
2. J. Millman & C. C. Halkias, Electronic Devices and Circuits, McGraw Hill.

CS 23.205 **Total Lectures: 40**

General Purpose Programming

Credit: 3-0-0-3

Objective(s): Python is a general-purpose, versatile and popular programming language. It's great as a first language because it is concise and easy to read, and it is also a good language to have in any programmer's stack as it can be used for everything from software development and scientific applications.

Prerequisite(s): CS 23.101 (Programming for Problem Solving -I)

1. **Introduction**: The basic elements of python, python syntax, python operators, basic input, branching programs, control structures, data types, strings, tuples, lists, sets, dictionaries, bytes, byte array and input iteration, Mutability with different types, ranges and iterators [7]
2. **Functions and Module**: Functions and scoping flow of execution, specifications, recursion, global variables, variable arguments, default arguments, system functions and parameters, input and output, modules , making your own module, importing modules, decorators, generators, command line argument. [7]
3. **Classes and Object-Oriented Programming**: Abstract data types and classes, class attribute, instances, object overhead, constructor, self, inheritance, encapsulation and information hiding, polymorphism, getter & setter, abstract class, duck typing, monkey patching, operator overloading, method overloading using multiple dispatch decorator. [8]
4. **Testing and Debugging**: Exceptions and assertions, types of testing – black-box and glass-box, debugging, handling exceptions, assertions. [6]
5. **Advance Python:** Regular expressions – REs and Python, plotting using matplotlib and Multithreaded Programming, GUI & event handling programming using Tkinter & pygame. Introduction to machine learning and deep learning [12]

Outcome(s): Upon completion of this course students will be

- Familiar with Python syntax.
- Able to use python to implement a given logic.

Text Books:

1. John V Guttag, Introduction to Computation and Programming using Python, Prentice Hall of India, 2nd Edition, 2013.
2. Martin C. Brown, Python: The Complete Reference,Mc Graw Hill, 2018

Reference Books:

1. Zed A. Shaw ,Learn Python the hard way: a very simple introduction to the terrifyingly beautiful world of computers and code, 3rd edition, 2014.
2. Richard L. Halterman,Learning to Program with python, 2011.
3. Allen Downey ,Think Python How to Think Like a Computer Scientist, Version 2.0.17, Green Tea Press Needham, Massachusetts,2012.

EE 23.221 **Electrical Machines-I Laboratory** **Total Hours:26**
0-0-2-1

Objective: The objective of the Electrical Machine Lab is to provide an exposure of operation of D.C. machines and transformers and give them experimental skill. It also aims to understand the generation of D.C. voltages by using shunt generator and study their performance. It also enables the students to understand the working principles of D.C. motors and their load characteristics and methods of speed control. It also enables students to test and performance of D.C. machines and transformers.

Prerequisite: Electrical Lab

1. To conduct the open circuit and short circuit tests on the given single phase transformer and to pre-determine (i) equivalent circuit parameters (ii) voltage regulation and (iii) efficiency.
2. To connect the given three, single phase transformers as three phase bank in (i) star-star (ii) star-delta (iii) delta-delta and (iv) delta-star configurations.
3. To perform the no-load test on the given D.C. shunt motor to study its speed variation by (i) field control method and (ii) armature voltage control method.
4. To obtain the open citcuit characteristics of a separately excited D.C. generator at rated speed and to determine (i) critical field resistance at rated speed (ii) critical speed (iii) voltage built up by the generator at rated speed and (iv) to plot the O.C.C. at different speeds.
5. To conduct the load test on the given D.C. shunt generator and its internal and external characteristics.
6. To determine the no load losses and hence to predetermine the efficiency, at any desired load, of the d.c. machine running. (i) as a motor and (ii) as a generator
7. To conduct the polarity test on the given transformer and to operate two single phase transformers in parallel to share a common load.
8. To determine the efficiency of two identical D.C. shunt machines by Hopkinson's regenerative test.
9. To conduct the back-to-back test on the given two, identical single phase transformers and to pre-determine (i) equivalent circuit parameters (ii) voltage regulation and (iii) efficiency.
10. To connect the given two, single phase transformers in Scott connection so as to
    (i) Show that the secondary voltages are at right angles to each other
    (ii) Supply two phase load from three-phase supply.
11. To conduct:
    (i) Field's test on two similar mechanically coupled series machines.
    (ii) Compute efficiency at different outputs.

    Plot the following curves for the motor efficiency, torque and speed v/s output.
12. To determine the no load stray losses of a given D.C. shunt machine and to separate the mechanical losses from iron losses.

Outcome: Students will be convergent with transformer and D.C. machines and their testing and performance aspects.

EE 23.223 **Network Analysis and Synthesis Laboratory** **Total Hours:26**

0-0-2-1

Objective: This Lab course helps us to gain basic knowledge of principle, operation, application and design/verification of various Electrical components /devices/ circuits/theorems by conducting the experiments.

Prerequisite: Basic of Electrical Engineering

1. To study the series and parallel connected resistive circuits.
2. To study the equivalent star of a delta connected resistive circuit and also the equivalent delta of a star connected resistive circuit.
3. To verify the Kirchhoff's current Law and Kirchhoff's Voltage law.
4. To verify the superposition theorem using resistive circuit.
5. To verify the Reciprocity Theorem using resistive circuit.
6. To verify the Thevenin's Theorem using resistive circuit.
7. To verify of Norton's Theorem using resistive circuit.
8. To verify of Maximum Power Transfer Theorem using resistive circuit.
9. To determine Z-parameter, Y-parameter and ABCD parameter of a given Two-port network.
10. To design a zero PCB for a given circuit to verify the Thevenin's Theorem.
11. To find out the time- constant of RL-series circuit when connected to step function.
12. To find out the time constant of RC-series circuit when connected to step function.

Outcome: After completion of this lab course, students would be able to demonstrate the working phenomena and applications of various electrical components and circuits. Knowledge gained from this course would also be utilized in designing different electrical circuits/theorems and devices.

Reference Book: Lab Manual.

EC 23.221 **Electronics Devices and Circuits Laboratory** **Total Hours: 26**

0-0-2-1

Objective: To acquire fundamental knowledge of operation, design and application of various Electronic devices and circuits by doing the experiments.

Pre-requisite: Electronics Laboratory

1. To plot the diode characteristics and its dynamic resistance and cut-in Voltage.
2. Plot the characteristics of a Zener diode and find its dynamic resistance under reverse biased condition. Plot the Line-Regulation and Load-Regulation curve using Zener diode.
3. To implement a diode clipper circuit which clips the positive peak of the input voltage (i) By 1V and (ii) negative peak by 1.5V? (For given sinusoidal input $V_{pp} = 4V, 1kH$).
4. To implement a diode clamper circuit which clamps the positive peak of the input voltage $1V$ and the negative peak of the input voltage 1.5V. (For given square wave input $V_{pp} = 10V, 1kHz$)
5. To plot the frequency response of a emitter follower.(For given sinusoidal input $V_{pp} = 3V$, $1kH$.
6. Design a Half Wave Rectifier circuit with and without capacitor filter, measure the rms and Dc values of output voltage and calculate the ripple factor for given sinusoidal input $V_{pp} = 10V, 1kH$.
7. To plot the input and output characteristics of a transistor in CE Configuration.
8. Design a two stage RC coupled transistor amplifier and calculate the gain. (for given sinusoidal input $V_{pp} = 200mV, 1kHz$).
9. To plot the Transfer characteristics (for $V_{DS} = 5V$) and Drain (for $V_{GS} = -1V$) characteristics of a JFET in CS Configuration.

Outcome: After completion of this lab course, students would be able to demonstrate the working phenomena and applications of various electronic devices and circuits. Knowledge gained from this course would also be utilized to design different electronic circuits and devices.

CS 23.255 **General Purpose Programming Laboratory** **Total Hours:26**
0-0-2-1

Objective: The objective of this course is to:

- Become comfortable with Python programming, starting from basics of data types to deep learning.
- Provide the foundation of to explore any expansions of Python whether it is machine learning, deep learning, web development or gaming. It will also put focus to learn various skills to design object-oriented software.

Prerequisite: Programming Laboratory-I

1. Code different data types and operations on list, tuple, dictionaries, sets, String etc
2. Code basic programs like factorial, fibonacci etc. to understand functions and recursions.
3. Implement different built-in functions in Python like eval, exec,lambda, map reduce, filter etc.
4. Implement the concept of class, objects, inheritance and polymorphism.
5. Implement constructor and self.
6. Code programs to implement exceptions and assertions.
7. Implement regular expressions.
8. Implement a small gaming application using Pygame.
9. Implement user interface and event handling using TKinter.
10. Code programs to implement the logic for machine and deep learning.
11. Implement multithreading.

Outcome: Upon completion of this course, students will be:

- Able to develop application in Python
- Able to develop scientific applications for machine learning
- Able to use python to implement a given logic.
- Able to use various Python IDE like Anaconda, Pycharm etc.

UC 23.202 **Entrepreneurship Development** **Total Lectures: 26**
2-0-0-2

Objective: This course is intended to provide engineering students with a solid foundation in terms of the vital role played by entrepreneurs and entrepreneurship in the 21st century global economy.

Pre-requisite: NIL

1. **Entrepreneurship**: Definition and concept of entrepreneurship, Entrepreneur Characteristics, Classification of Entrepreneurs, Role of Entrepreneurship in Economic Development, Start-ups. [5]
2. **Idea Generation and Project Formulation**: Ideas in entrepreneurships, Sources of new ideas, Techniques for generating ideas, Guidelines for report preparation, Project appraisal techniques, EDP organizations - MDI, EDII, Industrial Sickness and Role of BIFR. [6]
3. **Institutions Supporting and Taxation Benefits**: Central level institutions - NABARD, SIDBI, KVIC, State Level Institutions – DICs, SFC, Government policy for MSMEs, Tax incentives and concessions. [5]
4. **Small Scale Industries (SSI)**: Concept, Evolution, Role, Problems and prospects, Policies governing SSIs, Organizational structure, Ownership pattern, Export potential of SSIs. [5]
5. **Project Identification and Financial Analysis**: Meaning of project, project identification, formulation, feasibility analysis, Economic analysis, Financial analysis, Market analysis. [5]

Outcome: By the end of the course, students should be able to:

- Recognize the entrepreneurial potential within self and others in their environment.
- Identify the ways in which entrepreneurship manifests itself, including start-up contexts, corporate contexts, social contexts, public sector contexts, and others;
- Appraise the nature of creative new business concepts that can be turned into sustainable business ventures;

Identify the financial, marketing, legal, human resource, operations, and general management skills that are necessary to successfully launch and operate a successful new venture.

Text Books

1. Khanna, S. S., Entrepreneurial Development, S. Chand, New Delhi.
2. Hisrich D. Robert, Michael P. Peters, Dean A. Sheperd, Entrepreneurship, McGraw-Hill.

Reference Book

1. Kuratko, F. Donald, Richard M. Hodgetts, 'Entrepreneurship: Theory, Process, Practice', Thomson, 7ed.
2. Gupta, C B. and Shrinivasan, N.P., 'Entrepreneurship Development in India', Sultan Chand & Sons, New Delhi.

EE 23.202 **Electrical Machines-II** **Total Lectures: 40**

3-1-0-4

Objective: This course facilitates the students to get a comprehensive exposure to the working principles, construction and performance of 1-ϕ, 3-ϕ induction and synchronous machines.

Pre-requisite: Electrical Machine-I

1. **Fundamentals of AC Machine Windings:** Physical Arrangement of windings in Stator and Cylindrical rotor; Slots for windings; Single turn coil - active portion and overhang; Full-pitch Coils, Concentrated Winding, Distributed Winding, Winding axis, 3D visualization of the above winding types, Air-gap MMF Distribution with Fixed Current through winding - Concentrated and Distributed, Sinusoidally Distributed Winding, Winding Distribution Factor. [8]
2. **Pulsating and Revolving Magnetic Fields:** Constant Magnetic Field, Pulsating Magnetic Field - Alternating Current in Windings with Spatial Displacement, Magnetic Field produced by a Single Winding - Fixed Current and Alternating Current Pulsating Fields produced by spatially Displaced Windings, Windings Spatially shifted by 90 degrees, Addition of Pulsating Magnetic Fields, Three Windings Spatially Shifted by 120 degrees (Carrying Three-phase Balanced Currents), Revolving Magnetic Field. [4]
3. **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). Methods of Starting, Braking and Speed Control for Induction Motors. Generator Operation. Self-Excitation. Doubly-Fed Induction Machines. [12]
4. **Single Phase Induction Motors:** Constructional Features Double Revolving Field Theory, Equivalent Circuit, Determination of Parameters. Split-phase Starting Methods and Applications. [6]
5. **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 and inverted V-Curves. Salient Pole Machine – Two Reaction Theory, Analysis of Phasor Diagram, Power Angle Characteristics. Parallel Operation of Alternators - Synchronization and Load Division. [10]

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

- Understand the concepts of rotating magnetic fields.
- Understand the operation of ac machines.
- Analyse performance characteristics of ac machines.

Text Books:

1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery", McGraw Hill Education, 2013.
2. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.

Reference Books:

1. M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.
2. P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
3. A. S. Langsdorf, "Alternating current machines", McGraw Hill Education, 1984.
4. P. C. Sen, "Principles of Electric Machines and Power Electronics", John Wiley & Sons, 2007.

EE 23.204 **Electrical Measurement and Instrumentation** **Total Lectures: 40**
3-0-0-3

Objective: To make students conversant with concepts of smart measurement and various electrical and electronics instruments, transducers and bridges.

Pre-requisite: Basic of Electrical Engineering, Basic of Electronics Engineering

1. **Concepts of Measurements:** Introduction, accuracy and precision, repeatability, errors in measurement, sources of errors, types of errors, statistical analysis of measurement data, graphical representation of measurement, data as distributions, Gaussian graph and precision indices. [8]
2. **Analog Instruments:** Types of operating torques in an analog instrument, Moving coil, moving iron, electrodynamic and induction instruments-construction, operation, torque equation and errors. Shunts and multipliers. Applications of instruments for measurement of single-phase power and single-phase energy. Errors in wattmeter and energy meter and their compensation and adjustment. [12]
   Electronic Instruments for Measuring Basic Parameters: Electronic Voltmeter, Electronic Multimeters, Digital Voltmeter, Q meter, Digital measurement of Time and Frequency, Signal Analyzers- Wave Analyzers, Harmonic Distortion Analyzers and Spectrum Analyzers.
3. **Bridge:** DC bridges for measurement of resistance Wheatstone bridges, Kelvin's double bridges and AC bridges for measurement of L, R, C & M, Maxwell's bridges, Anderson's bridges and Wein bridge. [5]
4. **Transducers:** Classification, Types and Characteristics of transducers: Measurement of physical quantities: temperature, pressure, flow, stain, displacement: commonly used transducers: resistive potentiometer, strain gauge, RTD, thermistors, thermocouples, capacitive, inductive, piezo-electric, hall-effect and ultrasonic transducers [8]
5. **Sensors and Actuators:** Terminology, Principles, Characteristics and Classifications, Applications: Automotive Sensors, Home Appliance Sensors, Aerospace Sensors, Sensors for manufacturing and environmental monitoring, Pneumatic, hydraulic, mechanical and electrical actuators, Types of Control Valves, Types of Motion, Electrical Actuation Systems. [7]
   Internet of Things: Introduction to IOT: Sensors, Actuators, Smart Objects, Basics of IOT networking. IOT Architecture and Design.

Outcome: Students will be able to understand electrical and electronic measuring devices and instrumentation like bridges, transducers, CRO etc.

Text Books:

1. J. B. Gupta, “Electrical Measurements and Measuring Instruments”, S. K. Kataria & Sons, Reprint Edition, 2012.
2. A.K.Sawhney, “A Course in Electrical and Electronic Measurements & Instrumentation”, Dhanpat Rai and Co., 2005.

Reference Books:

1. Albert D. Helfrick, Wiliam D. Cooper, “Modern Electronic Instrumentation and Measurement Techniques”, PHI Learning Private Limited, 2011.
2. Prithwiraj Purkait, Budhaditya Biswas, Santanu Das, Chiranjib Koley, “Electrical and Electronics Measurements And Instrumentatio”, McGraw-Hill Education, 1st Edition, 2013.
3. F.W. Golding and Widdis, Electrical Measurements and Measuring Instruments, 5th Edition, 2010.

EE 23.206 **Electromagnetic Fields** **Total Lectures: 40**
3-0-0-3

Objective: To develop the understanding of basics concepts of electromagnetic field theory and its applications.

Pre-requisite: Basic understanding of laws of Physics and Mathematics

1. **Introduction**: Transformation of a point and a vector in different coordinate systems, Differential length, area, volume. Physical meaning of gradient, divergence and curl, Laplacian of a scalar, Conversion of a vector from one coordinate system to another. Divergence theorem, Stoke's theorem, reviews of electro-static and magneto-static fields. [6]
2. **Static Electric Field:** Coulomb's law, Electric field intensity, Electrical field due to point charges. Line, Surface and Volume charge distributions. Gauss law and its applications. Conductors, Dielectrics and Capacitance: Current and current density, Ohm's Law in Point form, Continuity of current, Boundary conditions of perfect dielectric materials. Permittivity of dielectric materials, Capacitance, Capacitance of a two wire line, Solution and Application of Laplace and Poisson's equations. [9]
3. **Static Magnetic Fields:** Biot-Savart Law, Ampere Law, Magnetic flux and magnetic flux density, Scalar and Vector Magnetic potentials. Steady magnetic fields produced by current carrying conductors. Magnetic Forces, Materials and Inductance: Force on a moving charge, Force between differential current elements, Nature of magnetic materials, Magnetization and permeability, Magnetic boundary conditions, Magnetic circuits. [9]
4. **Time Varying Fields and Maxwell's Equations:** Faraday's law of electromagnetic induction, Displacement current, Point form of Maxwell's equation, Maxwell's equations in integral and differential form, potential functions, electromagnetic boundary conditions. [8]
5. **Electromagnetic Waves:** Derivation of wave equations and their solutions for free space, uniform plane waves, Maxwell's equation in phasor form, wave equation in phasor form, plane waves in free space and in a homogenous material, wave equation for a conducting medium, plane waves in lossy dielectrics, propagation in good conductors, Skin effect. Poynting theorem. [8]

Outcome: At the end of the course, students will demonstrate the ability

- To understand the basic laws of electromagnetism.
- To obtain the electric and magnetic fields for simple configurations under static conditions.
- To analyze time varying electric and magnetic fields.
- To understand Maxwell's equation in different forms and different media.

Text Books:

1. Matthew N. O. Sadiku, "Principles of Electromagnetics", Oxford University Press, 4th Edition, 2009.
2. William H. Hayt, "Engineering Electromagnetic", McGraw Hill, 8th Edition, 2001

Reference Books:

1. David J. Griffiths, "Introduction to Electrodynamics", Pearson New International Education, 3rd Edition, 2004.
2. M.L. Sisodia and G. S. Raghuvanshi, "Microwave Circuits and Passive Devices", New Age Publication, 3rd Edition, 2009.

EC 23.202 **Digital Electronics** **Total Lectures: 40**

3-0-0-3

Objective: The aim of this course is to present the principles and techniques of combinational and sequential digital logic design and optimization at a gate level. The use of transistors for building gates is also introduced.

Pre-requisite: Basic of Electronics Engineering

1. **Number Systems and Boolean Algebra:** Introduction to number systems, weighted and non- weighted codes, 1's complement, 2's complement, complement arithmetic, Postulates and theorems of Boolean algebra, Boolean functions, canonical and standard form, simplification of Boolean function using Boolean laws and theorems. [5]

2. **Logic Gates and Simplification of Boolean Functions:** Basic Logic gates, Universal gates, K-map representation, incompletely specified functions, simplification realization with gates, Quine-McCluskey method. [5]

3. **Combinational Logic:** Analysis and design of combinational circuits, half adder and full adder, half subtractor and full subtractor, binary serial and parallel adder, BCD adder, binary multipliers, magnitude comparator, decoders, encoders, multiplexers, de-multiplexers. [10]

4. **Sequential Circuits:** Latches, flip-flops, triggering of the flip-flops, master-slave flip-flop, excitation tables, conversion of the flip-flops, analysis and design of clocked sequential circuits, shift registers, counters. [12]

5. **Programmable Logic & Introduction to Verilog HDL:** ROM, ASIC, PAL, PLA, FPGA, Verilog as HDL, An overview of VHDL, Role of VHDL in system design. [8]

Outcomes: Upon successful completion of this course, students should be able to:

1. Gain fundamental knowledge of the basic logic gates such as AND, OR, NAND NOR, EX-OR andtheir implementation in Logic Circuits.
2. Design multipliers, Combinational Circuits and registers.

Text Books:

1. M. M. Mano and M. D. Ciletti, Digital Design, Pearson Education, 4th Edition, 2009.
2. T. L. Floyd and R.P. Jain, Digital Fundamental, Pearson Education, 8th Edition, 2009.

References

1. V. K. Puri, Digital Electronics: Circuits and Systems, Tata McGraw-Hill, 4th Edition, 2001.
2. R. P. Jain, Modern Digital Electronics, Tata McGraw-Hill, 4th Ed, 2003.

EE 23.222 **Electrical Machines-II Laboratory** **Total Hours:26**

0-0-2-1

Objective: The objective of the Electrical Machines-II Lab is to provide an exposure of operation of different types of A.C. motor and generator and give them experimental skill. It also aims to understand the generation of A.C. voltages by synchronous generator and induction generator and study their performance. It also enables the students to understand their testing, load characteristics and methods of speed control.

Pre-requisite: Electrical Machines

1. To conduct no-load test and blocked rotor test on three-phase Squirrel cage Induction motor and to draw the circle diagram.
2. To perform load test on three-phase Squirrel cage Induction Motor.
3. To obtain the equivalent circuit of a single-phase induction motor by no-load test and blocked rotor test.
4. To determine the regulation of a three-phase alternator at full load condition by ZPF method.
5. To determine the regulation of a three-phase alternator at full load condition by ASA method.
6. To conduct load test on single phase induction motor and to draw the performance characteristics.
7. To determine the regulation of a three-phase alternator by EMF and MMF method.
8. To conduct the parallel operation/synchronization of an alternator with bus bar by Synchroscope.
9. To perform the starting of Induction motor automatically by Start-delta starter.
10. To plot V and inverted V-curves of three phase synchronous motor.
11. To conduct the experiment for separation of no-load losses of three-phase induction motor.

Outcome: Students will be convergent with transformer, A.C. machines and their testing and performance aspects.

EE 23.224 Electrical Measurement and Instrumentation Laboratory Total Hours:26
0-0-2-1

Objective: The aim of this Measurements and Instrumentation Laboratory is to reinforce the students with an adequate work experience in the measurement of different quantities and also the expertise in handling the instruments involved. It also helps to train the students in the measurement of displacement, resistance, inductance, frequency and angle etc., and to give exposure to AC, DC bridges and transient measurement.

Pre-requisite: Basic Electrical and Electronics

1. To measure unknown resistance using Wheat stone bridge.
2. To measure unknown inductance, capacitance and resistance using Maxwell bridge.
3. To Measure unknown frequency and capacitance using Wein's bridge.
4. To study the working of Q meter and measure Q of coils.
5. Study of Input-Output characteristics of LVDT.
6. Measurement of phase difference between LVDT secondary.
7. Study of Strain measurement using strain gauges and cantilever assembly.
8. To determine the Sensitivity of Strain gauge Trainer.
9. To study the Characteristics of IC temperature sensor (LM 335).
10. To study the Characteristics of Platinum RTD (Temperature sensor).
11. To study the Characteristics of NTC Thermistor.
12. Determining Linear Range of operation (Strain Gauge).
13. To measure unknown inductance, capacitance and resistance using Anderson bridge.
14. To study the loading effect of a PMMC type voltmeter and hence to observe the change in percentage error in its full scale reading when it is used to find out the voltage across different load resistances.
15. To measure very low unknown resistance using Kelvin's Double bridge.

Outcome: The student will be able to:(Knowledge based):

- identify electronics/ electrical instruments, their use, peculiar errors associated with the instruments and how to minimize such errors
- explain the industrial and laboratory applications of such instruments
- service and maintain such instruments in case of damage or misuse,
- understand the basic design techniques of electronic equipment (Skills) The students will
- use various laboratory instruments like cathode ray oscilloscope, function generators, dismantle and recouple serviceable parts of some other selected instruments without damaging them.
- be well grounded in their knowledge about various types of transducers, their applications and how they can be used for design purposes.

EE 23.226 **Electrical Simulation Laboratory** **Total Hours:26**

0-0-4-2

Objective: To make the students exposure about the use and applications of MATLAB and ETAP software in electrical engineering.

Pre-requisite: Basic of Electrical Engineering

1. Basic MATLAB desktop, help Browser, types of files, basic commands.
2. Introduction to SIMULINK, creating and simulating a SIMULINK model.
3. Plotting of single phase voltage waveform using MATLAB through programming techniques.
4. Simulink model to generate sine and cosine waveforms.
5. Response of RL and RC circuits and its transient study using MATLAB.
6. Response of RLC circuit and its transient study using MATLAB.
7. Introduction to basics of Electrical Transients Analyzer Program (ETAP).
8. Construction of single line diagram of an electrical network using ETAP Software.
9. Modeling and analysis of single line diagram of an inductive load using ETAP Software.
10. Modeling and analysis of single line diagram of a capacitive load using ETAP Software.

Outcome: Upon completion of this course, the student will be able to:

- Develop computer based program for electrical circuits in power system.
- Develop computer based models for power system components.
- Design, simulate and analyze circuits using simulation packages.

EE 23.228 **Electrical Estimation and Costing Laboratory** **Total Hours:26**
0-0-2-1

Objective:

- Emphasize the estimating and costing aspects of all electrical equipment, installation and designs to analyze the cost availability.
- Exposure to design and estimation of wiring, design of overhead and underground distribution lines, substations and illuminations design.

Pre-requisite: Basic of Electrical Engineering

1. To study the various Indian electricity rules (IER) as per standard of Central Electricity Regulatory Commission (CERC).
2. To carryout wiring diagram of residential building, Educational institute and Industry. Giving selection of appropriate wiring, list materials and accessories for given project.
3. To study the design consideration of Panel Boards.
4. To study the design consideration of various electrical systems:
   i. 3 phase four wire distribution systems.
   ii. To study the design consideration of different types of earthing schemes.
5. To estimate the cost of industrial installation (Work shop, agriculture, flour mill etc.).
6. To estimate the cost of overhead service connection (Single phase and three phase).
7. To estimate the cost of underground service connection (single phase and three phase).
8. To estimate the cost of overhead, 440 V, 3-phase, 4 wire or 3 wire distribution line.
9. To estimate the cost of underground, distribution line.
10. To estimate the cost of any one electrical appliance.
11. To estimate the cost of repairs and maintenance of any one domestic appliance.
12. To study various types of light sources and lighting schemes.

Outcome: Upon completion of this course, the student will be able to:

- Develop computer based program for electrical circuits in power system.
- Develop computer based models for power system components.
- Design, simulate and analyze circuits using simulation packages.

EE 23.301 **Transmission and Distribution** **Total Lectures: 40**

3-0-0-3

Objective:
1. To learn the fundamentals designing of power system that meets specific need.
2. To understand the factors affecting Insulators and also in Under Ground cables.
3. To calculate the various parameters in Distribution System.

Pre-requisite: Network Analysis and Synthesis

1. **Introduction:** Evolution of Power Systems and Present-Day Scenario. Structure of a power system: Bulk Power Grids and Micro-grids. Effect of Transmission voltage, Load factor, diversity factor, plant capacity factor, plant utilization factor, different types of tariffs, per unit quantities and its advantages. Impedance and Reactance Diagram. Analysis of simple three-phase circuits. Power Transfer in AC circuits and Reactive Power. [5]
2. **Parameter and Performance of Transmission Line:** Parameter: Configuration, Type of conductors, Resistance of line, Skin & Proximity Effects, Calculation of Inductance and capacitance of single phase, three phase, Single circuit and double circuit transmission lines. Performance: Representation of short, medium and long transmission lines, Ferranti effect, SIL, Tuned Power Line, Power flow through transmission lines. [12]
3. **Insulator, Corona and Underground Cables:** Overhead lines insulators type of insulators and their applications Potential distribution over a string of insulators, Methods of Equalizing the potential, Phenomenon of Corona, Corona Loss, Factors affecting Corona, Methods of reducing corona. Types of Insulation for Cable, Sheath, Armour and Covering, Classification of cables, Effective Conductor Resistance, Inductive Reactance, Capacitance of single phase and three phase cables, Grading of Cables, Problems with Underground cables. [12]
4. **Mechanical Design of Transmission Lines:** Catenary curve, Calculation of sag and Tension, Effects of wind and ice Loadings, Sag Templates, Vibration dampers. [5]
5. **Distribution:** Comparison of various distribution systems, type of primary and secondary distribution systems, choice of transmission voltage, Kelvin's law, limitation of Kelvin's law. Necessity of neutral grounding, various methods of neutral grounding. [6]

Outcome: At the end of this course, students will demonstrate the ability to
- Understand the concepts of power systems components, generation of over-voltages and insulation coordination.
- Understand the concepts of Mechanical, electrical design of overhead lines and performance of transmission lines.
- Evaluate fault currents for different types of faults.

Text Books:
1. Wadhwa C. L. "Electrical Power Systems Electronics", New Age International Publishers, 4th Edition, 2011.
2. Gupta, B. R., "Power System Analysis and Design" S. Chand and Co., Ltd, 2nd Edition, 2005.

Reference Books:
1. Grainger J. J. and William D. Stevenson Jr., "Power System Analysis", McGraw Hill, 3rd Edition, 2005.
2. Abhijit Chakrabarti and SunitaHalder, "Power System Analysis: Operation and Control", Prentice Hall of India, 2nd Edition, 2008.

EE 23.303 **Control System Engineering** **Total Lectures: 40**

3-0-0-3

Objective: The student gains the knowledge of the fundamental principles of analog and digital control system engineering, time response and frequency response analysis with its practical implementation. This course helps in understanding the design of Compensator and PID controller for the Automatic control of Industry.

Pre-requisite: Mathematics-III, Network Analysis & Synthesis

1. **Introduction:** Industrial control examples. Mathematical models of physical systems. Control hardware and their models. Transfer function models of linear time-invariant systems. Feedback Control: Open-Loop and Closed-loop systems. Benefits of feedback. Block diagram reduction and signal flow graph representation of systems. [9]
2. **Time Domain Analysis:** Standard test signals, time response of 1st and 2nd order systems for standard test inputs, time domain design specifications, Steady state errors for unit step, unit ramp and unit parabolic inputs, Error constants. Concept of stability: conditions for stable system, relative and marginal stability, Routh-Hurwitz criterion. Root-Locus technique. Construction of Root-loci. [10]
3. **Frequency Domain Analysis:** Relationship between time and frequency response. Polar plots. Bode plots. Nyquist stability criterion. Relative stability using Nyquist criterion – gain and phase margin. [9]
4. **Compensator and Controller:** Realization of basic compensators, cascade compensation in time domain and frequency domain, feedback compensation - Design of lag, lead, lag-lead series compensator (using Bode plot), P, PI and PID controllers in frequency domain. [8]
5. **State Variables:** Analysis of systems, state vector, state space, advantages of state space techniques, state space representation, State variable analysis and design. [4]

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

- Understand the concept of stability and its assessment for linear-time invariant systems.
- Design simple feedback controllers.
- Knowledge of stability analysis and improvement of stability for control system.
- Benefit the graduates who wish to work in core sector industry as most of the core sector is state-of-art control.

Text Books:

1. K. Ogata, "Modern Control Engineering," Pearson Education/Prentice Hall of India, 4th Edition, 2003.
2. I. J. Nagrath and M. Gopal, "Control System Engineering," New Age International Publishers, 2nd Edition, 2003.

Reference Books:

1. Syed Hasan Saeed, "Automatic Control Systems (with MATLAB Programs)," S.K. Kataria& Sons Publishers, 6th Edition, 2008.
2. Samarjit Ghosh, "Control Systems: Theory and Applications," Pearson Education, 2nd Edition, 2012.

EE 23.305 **Power Plant Engineering** **Total Lectures: 40**

3-0-0-3

Objective: This course facilitates the students to understand the basic functioning of generation and design/economics consideration of various power plants.

Pre-requisite: Elements of Electrical Engineering, Power System-I

1. **Introduction:** Energy sources and their availability, Principle types of power plants, Their special features and applications, Present status and future trends. Economic aspects in power Generation: Terms commonly used in system operation, various factors affecting cost of generation: Load curves, load duration curves, Connected load, maximum load, Peak load, base load and peak load power plants, load factor, Plant capacity factor, Plant use factor, Demand factor, diversity factor, Cost of power plant, different types of tariffs, power factor improvements. [10]
2. **Thermal and Nuclear Power Plant: Thermal Power Plant:** General developing trends, Essentials, Plant layout, Coal storage, Preparation, Handling, Feeding and burning, Ash handling, Dust collection, High pressure boilers and steam turbines, Their main components like super heaters, Economizers, Pre-heaters etc., Fuel efficiency/heat balance. **Nuclear Power Plant:** Nuclear fuels, Nuclear energy, Main components of nuclear power plant, Nuclear reactors types and applications, Radiation shielding, Radioactive and waste disposal safety aspect. [12]
3. **Hydro Electric Power Plants:** Classifications, Plant layout, various components, Types of turbines, Pumped storage, hydro-electric plants, advantages and disadvantages. Environmental aspects for selecting the sites and locations of hydro power stations. [6]
4. **Gas Turbine Power Plants:** Schematic arrangement, advantages and disadvantages of Gas turbine power plant. Open cycle and Closed cycle gas turbine power plant, Combined cycle power plant, Comparison of various power plants. [6]
5. **Renewable Energy Power Plants:** Introduction to different Renewable Energy Sources and their availability. Block diagram, Plant layout and various Components of solar power plants. On grid and off grid solar power plants. Block diagram, Plant layout and various Components of wind power plants. [6]

Outcome: The students shall develop an insightful knowledge to apply the basic laws and operating principles in various power plants.

Text Books:

1. Deshpande, M.V., “Power Plant Engineering”, McGraw Hill, 4th Edition 2004.
2. Gupta B. R., “Generation of Electrical Energy”, S. Chand Publications, 14th Edition, 2011.

Reference Books:

1. Wood A.J. & Wallenberg B.F, “Power Generation and Control”, John Wiley & Sons, 2nd Edition, 2012.
2. P.K Nag “Power Plant Engineering”, McGraw Hill publications, 2nd Edition, 2008.
3. Arora S.C &Domkundawar S, “A course in Power Plant Engineering”, Dhanpat Rai, 2nd Edition, 2002.

EE 23.307 **Renewable Energy Technology** **Total Lectures: 40**

3-0-0-3

Objective:
- To provide knowledge, understanding and application oriented skills on solar, wind, ocean, biomass, wave, tidal, ocean, geothermal and other energy sources and relevant technologies towards their effective utilization for meeting energy demand.
- To develop clear understanding of these technologies to be able to select an appropriate type of plant for given energy requirements.

Prerequisite: Nil

1. **Solar and Wind Energy:** Solar radiation, Measurements of solar radiation and sunshine, Solar thermal collectors, Flat plate and concentrating collectors, Fundamentals of photo voltaic conversion, applications. Wind data and energy estimation, Wind energy Conversion Systems, Wind energy generators and performance, applications. [10]
2. **Biomass Energy:** Biomass resources and their classification, Biomass production for Energy farming, Direct combustion for heat, Pyrolysis, Thermo chemical process, Anaerobic digestion, Digester sizing, waste and residues, vegetable oils and biodiesels, Applications of Biogas-Social and environmental aspects. [7]
3. **Wave and Tidal Energy:** Concept of energy and power from waves, Wave characteristics, period and wave velocities, Different wave energy conversion devices (Tapchan, oscillating water column type); Principles of tidal power generation, components of power plant, Single and two basin systems, Estimation of energy, Maximum and minimum power ranges. [8]
4. **Ocean and Geothermal Energy:** OTEC Principle, Lambert's law of absorption, Open cycle and closed cycle, Heat exchanger calculations (elementary treatment), Major problems and operational experience, Classification of geothermal resource, Fundamentals of geophysics, Availability and estimation of thermal power, Extraction techniques. [7]
5. **Hydrogen and Fuel Cell:** The Hydrogen economy, Advantages of hydrogen as an energy carrier, Components of the hydrogen economy, Generation of hydrogen, Transport and storage of hydrogen: physical and chemical, Fuel Cells, classification of fuel cells, power generation and economics. [8]

Outcome: Upon successful completion of this course, students should be able to:
- Gaining appropriate knowledge on principles of operation, construction and working and technological advances in solar photovoltaics, solar thermal, wind, ocean, tidal, geothermal and other systems.
- Ability to design and describe the challenges and problems with different types renewable energy technologies.

Text Books:
1. Twidell, J.W. and Weir, A., "Renewable Energy Sources", EFN Spon Ltd, 2nd Edition, 2006.
2. G.N.TiwariandM.K.Ghosal, "Renewable Energy Resources Basic Principles and Applications", Narosa Publishing House, New Delhi, 1st Edition, 2005.

Reference Books:
1. Sukhatme, "S.P., "Solar Energy", McGraw Hill, 3rd Edition, 2008.
2. LivinOniciu, "Fuel cell", Abacus press, 5th Edition, 1976.

EC 23.301 **Microprocessor and Microcontroller** **Total Lectures: 40**

3-0-0-3

Objective: To develop an in-depth understanding of the operation of microprocessors and microcontrollers,machine language programming & interfacing techniques.

Prerequisite: Digital electronics

1. **The 8086 Microprocessor Architecture :** Architecture, details of sub-blocks such as EU, BIU; memory segmentation and physical address computations, pin diagram and description of various signals, minimum and maximum mode of operations, supporting chips viz. 8284, 8288 and memory mapping. [8]
2. **Programming of 8086:** Addressing modes of 8086, instruction set of 8086, assembly language programming, counters and time delays, stack structure of 8086 and subroutine. [7]
3. **Interfacing of 8085 / 8086 with Programmable Chips:** Interfacing of 8255 Programmable peripheral interface, 8251 USART, 8253/8254 Programmable Interval Timer and Direct Memory Access Controller 8237/8257 DMA, 8259 Programmable Interrupt Controller. [8]
4. **Introduction to Microcontrollers, Architecture and Memory Interfacing:** Overview of the 8051 family, 8051 Microcontroller's Architecture, Pin configuration, Common memory types and Tradeoffs, External Memory interfacing. [7]
5. **Programming and Interfacing of 8051:** Addressing modes of 8051, instruction set of 8051, assembly language programming of 8051, stack structure of 8085, delays, and subroutines, Applications of interrupts, timer/counter and serial port, Components of Integrated Development Environment for software development, Interfacing of 8051 with sensors, ADC, DAC, Stepper Motor, Introduction to ARM processors. [10]

Outcome: Upon completion of this course, the student will be able to:

- The student will learn the internal organization of some popular microprocessors and microcontrollers.
- The student will learn hardware and software interaction and integration and memory.

Text Books:

1. Ramesh S. Gaonkar, Microprocessor Architecture, Programming and Application with the 8085, Penram International Publishing, 6th Edition, 2013.
2. M. A. Mazidi, The 8051 Microcontroller & Embedded Systems, Pearson Education, 2nd Edition, 2006.

Reference Books:

1. I. Scott McKenzie and Raphael C.W. Phan, The 8051 Microcontroller, Pearson Education, 4th Edition, 2007.
2. D. V. Hall, Microprocessors and Interfacings; TMH, 3rd Edition, 2012.

EE 23.321 **Power System-I Laboratory** **Total Hours: 26**

0-0-2-1

Objective:
- To make the students aware about the use and applications of MATLAB and ETAP software in electrical engineering.
- Study of circuit characteristics using MATLAB & ETAP. It also gives practical exposure to the usage of different power circuits with different condition.

Pre-requisite: Basic electrical engineering and Network analysis.

1. Plotting of three phase voltage waveforms using MATLAB through programming techniques.
2. Plot of daily load curve for the given data using MATLAB.
3. Calculation of Transmission Line Parameters and verify using MATLAB.
4. Determine the positive sequence line parameters L and C per phase per kilometre of a three phase single circuit transmission lines for different conductor arrangements.
5. Determination of Receiving end quantities and the line performance of a medium/long transmission line using MATLAB.
6. Study and operation of various ETAP modules Viz. load flow, short circuit and harmonics.
7. Construction of single line diagram of a power system using ETAP Software.
8. Modeling of power distribution network using ETAP Software.
9. Determination of Receiving end quantities and the line performance of a medium/long transmission line using ETAP Software.
10. Harmonic Analysis of Hybrid and Renewable Generation Networks.

Outcome: Upon completion of this course, the student will be able to:
- Develop computer programs for electrical circuits and power system.
- Develop computer models for power system components.
- Design, simulate and analyze circuits using simulation packages.

EE 23.323 **Control System Laboratory** **Total Hours: 26**
0-0-2-1

Objective: This laboratory course facilitates the students to get a comprehensive exposure to various techniques/principles and applications of control systems for real life implementation like temperature control of oven, position control of DC/AC servomotor, synchro devices as a control transformer, robotic control systems etc.

Pre-requisite: Nil

Perform any ten of the list.

1. To study the performance of various types of controllers (P, PI, PID) in order to control the temperature of an oven.
2. To study the performance analysis of PC based analogue and digital motor control system (DCMC) with second order feedback system behavior.
3. To study the characteristics of a Synchro Transmitter Receiver pair and use these as torque-synchro and angular error detector.
4. To study the performance characteristics of angular position error detector (AC&DC excitation) using two Potentiometers.
5. Using Nyquist Stability technique, find the stability of negative feedback control system whose open loop transfer function is given by $G(s)\,H(s) = 10/[(s+1)(s+2)(s+3)]$ Also verifies the MATLAB results/stability with theoretical method after plotting on graph sheets.
6. To study the performance characteristics of an AC servo motor angular position control system and analysis of transient characteristics with gain Variation.
7. To study the performance characteristics of a DC servo motor angular position control system and analysis of transient characteristics with gain Variation and additional tachometer feedback.
8. To study the Characteristics of an A.C. Servo Motor and determine its transfer function.
9. Plot the Root locus diagram for investigating the stability for the system whose open loop transfer function given by $G(s)\,H(s) = K/[s(s+4)(S+5)]$. Using MATLAB Code, verify the results with Conventional method.
10. To study and design the pc based universal robotic system as snake.
11. Draw the bode plot for the transfer function $G(s) = 50/[s(1+0.25s)(1+0.1s)]$.
    From the graph, determine:
    1. Gain and Phase Crossover Frequency
    2. Gain Margin and Phase Margin
    3. Stability of the system

    Also, verify the MATLAB results with theoretical value.
12. Obtain the state space, pole-zero and residue pole form of the control system whose transfer function is given by.

Outcome: The students shall develop an insightful knowledge on various techniques and concepts of analysis & design of control system for different applications like temperature control of oven, position control of DC/AC servomotor, synchro devices, Robotic control systems etc.

EE 23.302 **Power System Analysis and Design** **Total Lectures: 40**

3-0-0-3

Objective:
- To know the necessity of load flow in a regulated system.
- To examine the need of various analysis like fault analysis, short circuit analysis stability analysis, steady state and transient analysis.

Pre-requisite: Power System-I

1. **Load Flow Studies:** Bus admittance(Y bus) and Impedance (Z bus) matrices and their formation. Power flow in a transmission system, bus classification, Load flow equations and solution techniques-Gauss iterative method, Gauss-Seidel method, Newton-Raphson method, comparison of load flow solution techniques. [9]
2. **Fault Calculation and Network:** Symmetrical fault, Significance of Positive, Negative and Zero Sequence Components, Fault calculation, Sequence Networks, Unsymmetrical fault analysis – Single Line to Ground faults, Line to Line fault, Double line to Ground fault. [9]
3. **Power System Stability:** Steady state stability and transient stability- stability problem, rotor dynamics and swing equation, power angle equation and diagram, equal area criterion and its application, critical clearing angle, fault clearing time, factors influencing transient stability, methods of improving stability. [8]
4. **Economic Load Dispatch:** Station performance and operating characteristics, Incremental rate theory, optimal Load distribution within generating station and between various generating stations in a region, Transmission loss equation, Calculation of losses and Generation scheduling and dispatch. [8]
5. **Power System Control:** Load Frequency Control: Load Frequency Problems, Speed Governing System, Reasons for Limits on Frequency. Excitation systems, Automatic Voltage Regulators, SCADA and Computer control. [6]

Outcome: After the completion of the course, the students will be able to:
- Apply the load flow application to various power system problems like minimization of transmission line losses and minimization of the total fuel cost.
- Analyze the economic dispatch problem in thermal power plant.
- Design a power system solution based on the problem requirements and realistic constraint.

Text Books:
1. Grainger, J. J. and William D. Stevenson Jr., “Power System Analysis”, McGraw Hill, 4th Edition, 2005.
2. Wadhwa. C. L. “Electrical Power Systems Electronics”, New Age International Publishers, 3rd Edition, 2011.

Reference Books:
1. Ashfaq Husain, “Electrical Power Systems”, CBS Publishers and Distributors, 4th Edition, 1996.
2. Abhijit Chakrabarti, Sunita Halder “Power System Analysis: Operation and Control”, Prentice Hall of India, 2nd Edition, 2008.

EE 23.304 **Power Electronics** **Total Lectures: 40**

3-0-0-3

Objective:
- To introduce to students the theory and applications of power electronics systems for high efficiency, renewable and energy saving conversion systems
- To prepare students to know the characteristics of different power electronics switches, drivers and selection of components for different applications
- To develop students with an understanding of the switching behavior and design of power electronics circuits such as DC/DC, AC/DC, DC/AC and AC/AC converters

Prerequisite: Network Analysis and Synthesis, Basics of Electronics Engineering

1. **Introduction to Power Devices:** Review of power semiconductor devices, SCR, Static and dynamic characteristics, Turn-on and Turn-off methods and circuits, Ratings and protection of SCRs, Series and parallel operation of thyristor, Other members of thyristor family. [8]
2. **Controlled AC to DC Converter:** Principle of phase control, 1-ϕ (Single phase) half wave circuit with different types of loads, 1-ϕ and 3-ϕ semi converter and full converter bridge circuits, 1-ϕ dual converters and their operation with circulating and non-circulating currents. [10]
3. **Controlled AC to AC Converter:** AC Voltage Controllers - Types of 1-ϕ voltage controllers, 1-ϕ voltage controller with R and RL type of loads, gate pulse requirements to trigger the SCRs of ac voltage controllers. Cycloconverters - Principles of operation, 1-ϕ to 1-ϕ step up and step down cycloconverters. 3-ϕ to 1-ϕ cycloconverter. [10]
4. **Controlled DC to DC Converter:** Introduction to dc chopper, Principle of chopper operation, Control strategies, Types of choppers and its operation. [5]
5. **Controlled DC to AC Converter:** Introduction to inverter, 1-ϕ VSI: half bridge and full bridge inverters. 3-ϕ bridge inverters with 180 degree and 120 degree modes of operation, Series and parallel inverters, Introduction to current source inverters. [7]

Outcome: After the completion of the course, the students will be able to:
- Understand the principle of operation of commonly employed power electronic converters.
- Capable of analyzing non-linear circuits with several power electronic switches.
- Take up advanced courses in Power Electronics and its application areas.

Text Books:
1. Rashid, M., "Power Electronics", Prentice Hall of India Private Limited, 4th Edition,2006.
2. P.S. Bimbhra, "Power Electronics," Khanna publishers, 5th edition, 2012.

Reference Books:
1. Mohan,N., Undel, T.M. and Robbins, W. P., "Power Electronics: Converter Applications and Design," John Wiley and Sons, 3rd Edition, 2007.
2. Jain,A., "Power Electronics and its Applications," Penram International Publishing (India) Pvt. Ltd., 4th Edition, 2008.
3. Dubey, G.K., Doradla, S.R., Joshi, A. and Sinha, R.N.K., "Thyristoried Power Controllers," New Age International (P) Limited, Publishers, 2nd Edition, 2004.

EE 23.306 **Power System Protection** **Total Lectures: 40**

3-0-0-3

Objective: This course facilitates the students to get a comprehensive exposure to the working principles of various power system protection equipment and its simulation-Modeling schemes.

Pre-requisite: Power System-I

1. **Introduction and Components of a Protection System:** Principles of Power System Protection, Relays, Instrument transformers, Circuit Breakers. [4]
2. **Faults and Over-Current Protection:** Review of Fault Analysis, Sequence Networks. Introduction to Overcurrent Protection and overcurrent relay co-ordination. [8]
3. **Equipment Protection Schemes:** Directional, Distance, Differential protection. Transformer and Generator protection. Bus bar Protection, Bus Bar arrangement schemes. [8]
4. **Digital Protection:** Computer-aided protection, Fourier analysis and estimation of Phasors from DFT. Sampling, aliasing issues. [8]
5. **Modeling and Simulation of Protection Schemes and system protection:** CT/PT modeling and standards, Simulation of transients using Electro-Magnetic Transients (EMT) programs. Relay Testing. Effect of Power Swings on Distance Relaying. System Protection Schemes. Under-frequency, under-voltage and df/dt relays, Out-of-step protection, Synchro-phasors, Phasor Measurement Units and Wide-Area Measurement Systems (WAMS). Application of WAMS for improving protection systems. [12]

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

- Understand the different components of a protection system.
- Evaluate fault current due to different types of fault in a network.
- Understand the protection schemes for different power system components.
- Understand the basic principles of digital protection.
- Understand system protection schemes, and the use of wide-area measurements.

Text Books:

1. J. L. Blackburn, “Protective Relaying: Principles and Applications”, Marcel Dekker, New York, 1987.
2. Y. G.Paithankar and S. R. Bhide, “Fundamentals of power system protection”, Prentice Hall, India, 2010.

Reference Books:

1. A. G. Phadke and J. S. Thorp, “Computer Relaying for Power Systems”, John Wiley & Sons, 1988.
2. A. G. Phadke and J. S. Thorp, “Synchronized Phasor Measurements and their Applications”, Springer, 2008.
3. D. Reimert, “Protective Relaying for Power Generation Systems”, Taylor and Francis, 2006.

EE 23.308 **Electrical and Electronics Engineering Materials** **Total Lectures: 40**

3-0-0-3

Objective:

- Use the fundamental science and engineering principles relevant to materials that include the relationships between nano/microstructure, characterization, properties, processing, performance and design of materials.
- Use their knowledge of the significance of research, the value of continued learning and environmental/social issues surrounding materials.
- Use lifelong learning skills to develop knowledge and skills, to pursue new areas of expertise, careers and to take advantage of professional development opportunities.

Pre-requisite: Nil

1. **Introduction**: Engineering properties of material. Structure, properties and performance, types of materials. Classical theory of electrical and thermal conduction in solids, temperature dependence of resistivity, skin effect, Hall effect. [6]
2. **Dielectric Properties of Insulators in Static and Alternating Fields:** Types of Polarizations**,** static dielectric constant of gases and solids, properties of ferroelectrics materials. Spontaneous polarization, Piezoelectricity, Frequency dependence of Electronic and Ionic Polarizability, complex dielectric constant of non-dipolar solids, dielectric relaxation, dielectric losses. [10]
3. **Magnetic Properties and Superconductivity:** Magnetization of matter, Classification of Magnetic Materials, Ferromagnetic Origin, Curie-Weiss Law, Soft and Hard Magnetic Materials, Superconductivity and its origin, Zero resistance and Meissner Effect, critical current density. [10]
4. **Conductivity of Metals**: ohm's law and the relaxation time of electrons, relaxation time, collision time and mean free path, electron scattering and resistivity of metals, thermal conductivity of metals. [8]
5. **Semiconductor Materials:** Classification of semiconductors, semiconductor conductivity, temperature dependence, Carrier density and energy gap, Trends in materials used in Electrical Equipment. [6]

Outcome: After the completion of the course, the students will be able to:

- Learn the basics of materials used in electrical engineering.
- Realize the dielectric properties of insulators in static and alternating fields.
- Importance of magnetic properties and superconductivity.
- Behavior of conductivity of metals and classifications of semiconductor materials.

Text Books:

1. AdrianusJ. Dekker, "Electrical Engineering Materials" Prentice Hall India Learning Publishers, 1970.
2. Solymar, "Electrical Properties of Materials" 8th Edition, Oxford University Press-New Delhi, 2012.

Reference Books:

1. T. K. Basak, "Electrical Engineering Materials" New Age International Private Limited Publisher, 2010.
2. C. S. Indulkar, S. Thiruvengadan, "An Introduction to Electrical Engineering Materials", Revised Edition, S. Chand & Company Pvt. Ltd, 2008.

EE 23.310 Utilization of Electrical Energy and Traction System Total Lectures: 40

3-0-0-3

Objective: This Course provides an introduction to the principles of electrical drives and their applications in daily life. It deals with the fundamentals of illumination and its classification and provides knowledge on electrical traction systems.

Pre-requisite: Electrical Machines, Power System-I

1. **Electric Drives:** Electrical drives & Mechanical drives, Concept of electrical drives, Basic features of industrial drives, review of operating and starting characteristics of different types of electric motors for various drives. [5]
2. **Electric Heating and Welding:** Methods of electric heating, types of electric heating, constructional details and performance of resistance heating furnace. Dielectric heating, AC and DC Welding, Resistance and Arc Welding. Electric Beam Welding, Laser Welding. Typical construction of electrical welding AC and DC set. [10]
3. **Illumination and Electrolysis:** Production of light by different methods, terms used, laws of illumination, Different Artificial light sources, their construction and operating principles, Design of lighting schemes and equipment used for indoor, industrial and flood lighting. Laws of Electrolysis, Process voltage, current, energy, efficiency, Applications of electrolysis. [9]
4. **Refrigeration and Air conditioning:** Refrigeration system, Domestic refrigeration, Air conditioner, Comfort Air conditioning, Effective temperature. [9]
5. **Electric Traction:** Introduction to Indian railways system, Electric Locomotive Classes, Various types of Traction system, single phase feeding arrangement prevalent in India. Substation. Arrangements, Different Types of Catenary construction and line insulation, Span and dropper design Calculations. [7]

Outcome: After the completion of the course, the students will be able to:

- Describe the methods of electric heating, types of Electric welding and the principle of Electro deposition, laws of electrolysis and its applications
- Explain the laws of illumination and explain the principle of refrigeration and air-conditioning.
- Describe the salient features of traction drive.

Text Books:

1. J.B. Gupta, 'Utilization of Electric Power and Electric Traction', Kataria & Sons publishers, Delhi, IX Edtion, 2004.
2. C.L. Wadhwa, 'Generation, Distribution and Utilization of electrical Energy', New Age International (P) Limited Publishers, 3rd Edition, 2010.

Reference Books:

1. H. Partab, ' Modern Electric Traction' Dhanpat Rai & Sons.
2. G.K. Dubey, 'Fundamentals of Electric Drives' Narosa Publishing House.

EE 23.316 **Electrical Machine Design** **Total Lectures: 40**
3-0-0-3

Objective: To provide knowledge of design aspects of various dc machines, ac machines and transformers.

Pre-requisite: Electrical Machines

1. **Fundamentals of Electrical Machine Design:** Standard specification of frame size, conductors and insulation, Magnetization and loss curves, Choice of specific loadings Heating and cooling of electrical machines. [6]
2. **D.C Machines:** Construction details, output equation, main dimensions, Choice of specific loadings, choice of number of poles, armature design, design of field poles and field coils ,design of commutator and brushes. [8]
3. **Transformers:** Construction details of core and shell type transformers, output rating of single phase and three phase transformers, optimum design of transformers, design of yoke, core and winding for core and shell type transformers, equivalent circuit parameters from design data and design of tank and cooling tubes of transformers. [10]
4. **A.C. Machines:** Construction details of A.C. machines, output equation, main dimensions, Choice of specific loadings, design of stator, design of squirrel cage and slip ring rotor equivalent circuit parameter from design data, Short circuit ratio, design of rotor of cylindrical pole and salient pole machines. [10]
5. **Computer Aided Design:** Need for computer aided design, Analysis method, Synthesis method, Introduction to analysis of Electric machine parameters using FEM. [6]

Outcome: After completion of the course, students would be able to apply the knowledge of magnetism in the design of transformer and rotating electrical machines.

Text Books:

1. A.K.Sawhney, ‘A course in Electrical Machine Design’, DhanpatRai and sons, New Delhi, (Latest Edition).
2. S K Sen, ‘Principles of Electrical Machine Design with Computer Programme’,Oxford and IBH publishing Co. Pvt Ltd., New Delhi, 1987

Reference Books:

1. R.K Agarwal, ’Principles of Electrical Machine Design’, S.K.Katariasons , New Delhi, 2002.
2. V.N. Mittle and A.Mittle, ‘Design of Electrical Machines’ , Standard Publications and Distributors, Delhi, 2002.

EE 23.322 **Power System-II Laboratory** **Total Hours: 26**
0-0-2-1

Objective: To enhance the model building, advanced analyzing and problem solving skills of the students in the area of power system, power electronics and control through computer programming and simulation.

Pre-requisite: Power System-I

1. To study and testing the operation Gas actuated Buchholz Relay.
2. To study and testing of IDMT type Over current Relay with different and time setting & draw characteristics.
3. To study and testing of under voltage relay with different voltage setting multiplier & plot IDMT characteristics.
4. To study and testing of under frequency relay with IDMT characteristics.
5. To study and testing of microcontroller based Earth Fault relay with IDMT and DMT mode.
6. To study and testing the operating characteristics of percentage-biased differential relays and plot the characteristics of percentage biased differential relay for 30%, 40%, & 20%.
7. Simulation of load Flow analysis and related problems using Newton-Raphson and Fast-Decoupled methods using MATLAB.
8. Simulation and study of various power quality events like voltage sag, harmonics and transients etc.
9. Developing a simple simulation models for harmonic filter in power system distribution lines.
10. Simulation of various faults and short circuit analysis for a given power system.
11. Draw I-V and P-V characteristics of PV panel by variable resistive load and find out maximum power point by FF (fill factor) calculation.
12. Simulation of transient and small signal stability analysis: single-machine Infinite Bus System using SIMULINK.
13. Transient Stability Analysis of Multi-machine Power Systems using MATLAB.

Outcome: Upon completion of the course students will be able to

- Develop computer programs for advanced power system studies.
- Develop computer models for power system components.
- Simulate and visualize the real time phenomenon.

EE 23.324 **Power Electronics Laboratory** **Total Hours: 26**

0-0-2-1

Objective: To enable the students to develop hands on experience in analyzing, designing and carrying out experiments on various electrical networks by using power electronic components. It aims to familiarize the switching devices, power converters and its applications in various systems for power control.

Pre-requisite: Network Analysis and Synthesis, Basics of Electronics Engineering

Perform any ten of the list.

1. To obtain the V-I characteristic of an SCR and to find out it's latching and holding currents.
2. To obtain the Drain and Transfer Characteristic of a MOSFET.
3. To obtain the V-I characteristic of TRIAC.
4. Study of SCR (i) Resistor Triggering circuit (ii) Resistor Capacitor Triggering circuit for Half wave rectifier.
5. Study of SCR (i) Resistor Triggering circuit (ii) Resistor Capacitor Triggering circuit for Full wave rectifier.
6. Study of Step-Up Chopper with (i) resistive load (ii) resistive, inductive load.
7. Study of Step Down Chopper with (i) resistive load and (ii) resistive – inductive load.
8. To study the forced commutation process of an SCR.
9. Study of Single Phase Bridge Inverter with
   i. Resistive-Capacitive load
   ii. Inductive-Capacitive load
   iii. Resistive, Inductive and Capacitive load.
10. To write and execute a program (i.e. STL and Ladder Logic) for SIEMEN make P.L.C to flash a light at regular intervals of time.
11. To simulate a program for a PLC controller to control the traffic lights using 'BRYTONIC' software.
12. To design and develop a simulation schematic for the performance analysis of Half wave rectifier with different loads, using MATLAB SIMULINK toolbox.
13. To design and develop a simulation schematic for the performance analysis of Full wave rectifier with different loads, using MATLAB SIMULINK toolbox.

Outcome: Upon completion of this course, the student will be able to:

- Understand the characteristics of various switching devices and appreciate its applications in various electrical networks/systems.
- Analyze and design the operation of power switching converters.
- Develop practical control circuits for various real time applications.
- Analyze and prepare the technical report on the experiments carried out.

EE 23.401 **Electrical Drives and Control** **Total Lectures: 40**

3-0-0-3

Objective: This course facilitates the students to get a comprehensive exposure to the working principles, characteristics details, control and performance of Electrical Drives.

Pre-requisite: Electrical Machines, Control System Engineering, Power Electronics

1. **DC Motor Characteristics and Chopper fed DC Drive:** Review of emf and torque equations of DC machine, review of torque-speed characteristics of separately excited DC motor, change in torque-speed curve with armature voltage, example load torque-speed characteristics, operating point, armature voltage control for varying motor speed, flux weakening for high speed operation. Review of DC chopper and duty ratio control, chopper fed DC motor for speed control, steady state operation of a chopper fed drive, armature current waveform and ripple, calculation of losses in DC motor and chopper, efficiency of DC drive, smooth starting. [10]
2. **Multi-quadrant DC Drive:** Review of motoring and generating modes operation of a separately excited DC machine, four quadrant operation of DC machine; single-quadrant, two-quadrant and four-quadrant choppers; steady-state operation of multi-quadrant chopper fed DC drive, regenerative braking. [6]
3. **Closed-loop Control of DC Drive:** Control structure of DC drive, inner current loop and outer speed loop, dynamic model of DC motor – dynamic equations and transfer functions, modeling of chopper as gain with switching delay, plant transfer function for controller design, current controller specification and design, speed controller specification and design. [6]
4. **Induction Motor Characteristics:** Review of induction motor equivalent circuit and torque-speed characteristic, variation of torque-speed curve with applied voltage, applied frequency and applied voltage and frequency. Typical torque-speed curves of fan and pump loads, operating point, constant flux operation, flux weakening operation. [6]
5. **Scalar Control or Constant V/f Control of Induction Motor and Control of Slip Ring Induction Motor:** Review of three-phase voltage source inverter, generation of three-phase PWM signals, sinusoidal modulation, space vector theory, conventional space vector modulation; constant V/f control of induction motor, steady-state performance analysis based on equivalent circuit, speed drop with loading, slip regulation. Impact of rotor resistance of the induction motor torque-speed curve, operation of slip-ring induction motor with external rotor resistance, starting torque, power electronic based rotor side control of slip ring motor, slip power recovery. [12]

*Assignments based on numerical tutorials are required to be submitted.

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

- Understand the characteristics of DC motors and induction motors.
- Understand the principles of speed-control of DC motors and induction motors.
- Understand the power electronic converters used for DC motor and induction motor speed control.

Text Books:

1. G. K. Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall, 1989.
2. R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control”, Prentice Hall, 2001.

Reference Books:

1. G. K. Dubey, “Fundamentals of Electrical Drives”, CRC Press, 2002.
2. W. Leonhard, “Control of Electric Drives”, Springer Science & Business Media, 2001.
3. Leonhard, Werner. Control of electrical drives. Springer Science & Business Media, 2001.

EE 23.402 **Solar PV Technology** **Total Lectures: 40**
3-0-0-3

Objective: This course facilitates the students to attain a broad comprehension of solar photovoltaic systems used for various applications.

Pre-requisite: Basic of Electrical Engineering

1. **Photovoltaic basics:** [7]
Structure and working of Solar Cells - Types, Electrical properties and Behaviour of Solar Cells - Cell properties and design - PV Cell Interconnection and Module Fabrication - PV Modules and arrays - Basics of Load Estimation.

2. **Stand alonepv systems:** [8]
Schematics, Components, Batteries, Charge Conditioners - Balance of system components for DC and/or AC Applications - Typical applications for lighting, water pumping etc.

3. **Grid connected pv systems:** [8]
Schematics, Components , Charge Conditioners, Interface Components - Balance of system Components - PV System in Buildings

4. **Hybrid systems:** [8]
Solar, Biomass, Wind, Diesel Hybrid systems - Comparison and selection criteria for a given application.

5. **Design of pv systems:** [9]
Radiation and load data - Design of System Components for different PV Applications - Sizing and Reliability - Simple Case Studies.

*Assignments based on numerical tutorials are required to be submitted.

Outcome: At the end of this course, students will demonstrate the ability to
- To explain basics of solar photovoltaic systems.
- To know in depth of its types and design of various PV-interconnected systems.

Text Books:
1. Gilbert M. Masters, Renewable and Efficient Electric Power Systems, Wiley-Interscience, ISBN 0-471-28060-7.
2. CS Solanki: Solar Photovotaics – Fundamentals, Technologies and Applications, PHI Learning Pvt. Ltd., 2011.

Reference Books:
1. Martin A. Green, Solar Cells Operating Principles, Technology, and System Applications Prentice- Hall, 2008.
2. Nelson, J The Physics of Solar Cells. Imperial College Press, 2003. Thomas Markvart, Solar Electricit, John Wiley and Sons, 2001.
3. Stuart R. Wenham, Martin A. Green, Muriel E. Watt, Richard Corkish (Editors), Applied Photovoltaics, Earthscan, 2008.

EE 23.403 **Nonlinear Control System** **Total Lectures: 40**

3-0-0-3

Objective: This graduate course will cover fundamentals of nonlinear systems analysis and control.

Pre-requisite: Linear dynamical systems, differential equations, and linear algebra

1. **Introduction:** Examples – violin strings, heart rhythms, double pendulum, van der Pol oscillator. Existence and uniqueness of solutions [6]
2. **Analysis:** Linearization through Taylors series, Hartman-Grobmann Theorem, local stability. Multiple equilibria, limit cycles, bifurcations. [9]
3. **Second-order systems and Input-output analysis and stability:** Phase plane techniques, Poincare-Bendixson Theorem. Small gain theorem, passivity, describing functions [9]
4. **Mathematical background and Lyapunov stability theory:** Contraction mapping theorem, homeomorphisms, norms. Basic stability and instability theorems. Uniform stability, asymptotic stability, exponential stability. LaSalles Theorem, indirect method. [8]
5. **Feedback linearization, Sliding mode control and Gain scheduling:** Input-output linearization, full-state linearization, stabilization, tracking. Zero dynamics, MIMO systems, non-minimum phase systems, singularities. Sliding surfaces, differential inclusions, solutions in the sense of Filippov. Controller and scheduling design [8]

*Assignments based on numerical tutorials are required to be submitted.

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

- Understand the concepts of stability for linear and non-linear systems.
- Approach and understand non-linear control literature.
- Analyze simple non-linear systems to determine system stability.
- Synthesize control methods to achieve the desired performance of practical non-linear systems.

Text Books:

1. S. Sastry, Nonlinear Systems: Analysis, Stability, and Control, Springer 1999.
2. H. Khalil, Nonlinear Systems, Prentice Hall, 2002.

Reference Books:

1. Slotine, J.-J. E and Li, W. Applied Nonlinear Control. Englewood Cliffs, NJ: Prentice Hall, 1991.
2. H. J. Marquez, Nonlinear Control Systems: Analysis and Design, John Wiley Interscience, 2003.
3. J. E. Gibson Nonlinear Automatic Control, McGraw-Hill,1963

EE 23.404 **Power Electronics in Renewable Energy Technology** **Total Lectures: 40**

3-0-0-3

Objective: This course facilitates the students to develop the competency of maintaining renewable energy equipment using power electronic devices and circuits. The purpose of power electronic interface is to regulate the voltage, frequency, and power to make energy useable as per requirement.

Pre-requisite: Power Electronics.

1. **Introduction:** Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) – Qualitative study of different renewable energy resources ocean, Biomass, Hydrogen energy systems: operating principles and characteristics of: Solar PV, Fuel cells, wind electrical systems-control strategy, operating area. [8]

2. **Electrical machines for renewable energy conversion:** Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG. [8]

3. **Power converters:** Solar: Block diagram of solar photo voltaic system: line commutated converters (inversion- mode) – Boost and buck-boost converters- selection Of inverter, battery sizing, array sizing. Wind: 3-Φ AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters. [8]

4. **Analysis of wind and PV systems:** Stand-alone operation of fixed and variable speed wind energy conversion systems and solar system-Grid connection Issues -Grid integrated PMSG and SCIG Based WECS-Grid Integrated solar system. [8]

5. **Hybrid renewable energy systems:** Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PV- Maximum Power Point Tracking (MPPT). [8]

*Assignments based on numerical tutorials are required to be submitted.

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

- Identify renewable energy sources for generation of power.
- Maintain PE devices in PV power system.
- Maintain PE devices in Wind power system.
- Maintain PE devices in power system of power generation from solid waste.
- Maintain PE devices in hybrid power system of renewable energy.

Text Books:

1. S.N.Bhadra, D. Kastha, & S. Banerjee “Wind Electrical Systems”, Oxford University Press, 2009
2. Ned Mohan, Tore M. Undel and William P. Robbins, “Power Electronics: Converters, Applications and Design”, Third Edition, John Wiley & Sons, 2007

Reference Books:

1. L. Umanand, “Power Electronics: Essentials and Applications”, Wiley India, 2009.
2. Non-conventional Energy sources B.H.Khan Tata McGraw-hill Publishing Company, New Delhi.

EE 23.405 **Robotic Engineering** **Total Lectures: 40**
3-0-0-3

Objective: This course facilitates to enlighten the students about the fundamentals of robotic systems.

Pre-requisite: NIL

1. **Introduction:** Robot anatomy-Definition, law of robotics, History and Terminology of Robotics-Accuracy and repeatability of Robotics-Simple problems Specifications of Robot-Speed of Robot-Robot joints and links-Robot classifications-Architecture of robotic systems-Robot Drive systems, Hydraulic, Pneumatic and Electric system. [8]

2. **End effectors and robot controls:** Mechanical grippers-Slider crank mechanism, Screw type, Rotary actuators, cam type-Magnetic grippers-Vacuum grippers-Air operated grippers-Gripper force analysis-Gripper design-Simple problems-Robot controls-Point to point control, Continuous path control, Intelligent robot-Control system for robot joint-Control actions-Feedback devices-Encoder, Resolver, LVDT-Motion Interpolations-Adaptive control. [8]

3. **Robot transformations and sensors:** Robot kinematics-Types- 2D, 3D Transformation-Scaling, Rotation, Translation- Homogeneous coordinates, multiple transformation-Simple problems. Sensors in robot – Touch sensors-Tactile sensor – Proximity and range sensors – Robotic vision sensor-Force sensor-Light sensors, Pressure sensors. [8]

4. **Robot cell design and applications:** Robot work cell design and control-Sequence control, Operator interface, Safety monitoring devices in Robot-Mobile robot working principle, actuation using MATLAB, NXT Software Introductions-Robot applications. Material handling, Machine loading and unloading, assembly, Inspection, Welding, Spray painting and undersea robot. [8]

5. **Micro/Nano robotics system:** Micro/Nano robotics system overview-Scaling effect-Top down and bottom up approach- Actuators of Micro/Nano robotics system-Nano robot communication techniques-Fabrication of micro/nano grippers-Wall climbing micro robot working principles-Biomimetic robot-Swarm robot-Nano robot in targeted drug delivery system. [8]

*Assignments based on numerical tutorials are required to be submitted.

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

- The basics of robot, end effectors and robot controls.
- Robot Transformations, Sensors, robot cell design and its applications.
- Micro/Nano robotic systems

Text Books:

1. S.R. Deb, Robotics Technology and flexible automation, Tata McGraw-Hill Education., 2009
2. Robert J. Schilling, Fundamentals of Robotics Analysis and Control, PHI Learning., 2009.

Reference Books:

1. Richard D. Klafter, Thomas .A, ChriElewski, Michael Negin, Robotics Engineering an Integrated Approach, Phi Learning., 2009.
2. P.A. Janaki Raman, Robotics and Image Processing An Introduction, Tata Mc Graw Hill Publishing company Ltd., 1995.

EE 23.406 **PLC and Automation** **Total Lectures: 40**

3-0-0-3

Objective: This course facilitates the students to get a comprehensive exposure to the Industries Automation techniques and the importance of PLC, SCADA and robots in automation.

Pre-requisite: Elements of Electrical Engineering, Digital Electronics, Electrical Measurement and Instrumentation.

1. **Introduction:** Automation overview, Requirement of automation systems, Architecture of Industrial Automation system, Introduction of PLC and supervisory control and data acquisition (SCADA). Industrial bus systems: modbus & profibus. [9]

2. **Automation components:** Sensors for temperature, pressure, force, displacement, speed, flow, level, humidity and pH measurement. Actuators, process control valves, power electronics devices DIAC, TRIAC, power MOSFET and IGBT. Introduction of DC and AC servo drives for motion control. [7]

3. **Computer aided measurement and control systems:** Role of computers in measurement and control, Elements of computer aided measurement and control, man-machine interface, computer aided process control hardware, process related interfaces, Communication and networking, Industrial communication systems, Data transfer techniques, Computer aided process control software, Computer based data acquisition system, Internet of things (IoT) for plant automation. [9]

4. **Programmable logic controllers:** Programmable controllers, Programmable logic controllers, Analog digital input and output modules, PLC programming, Ladder diagram, Sequential flow chart, PLC Communication and networking, PLC selection, PLC Installation, Advantage of using PLC for Industrial automation, Application of PLC to process control industries. [7]

5. **Distributed Control System:** Overview of DCS, DCS software configuration, DCS communication, DCS Supervisory Computer Tasks, DCS integration with PLC and Computers, Features of DCS, Advantages of DCS. [8]

*Assignments based on numerical tutorials are required to be submitted.

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

- Understand various automation components and systems
- Explain architecture of industrial automation system and fundamentals of process control
- Measure industrial parameters like temperature, pressure, force, displacement, speed, flow, level, humidity and pH.
- Use programmable logic controllers and IOTs for industrial automation
- Draw block diagram of SCADA and integrate SCADA with PLC systems

Text Books:

1. Industrial Instrumentation and Control By. S.K. Singh The McGraw Hill Companies.
2. Process Control Instrumentation Technology By. C.D. Johnson, PHI/

Reference Books:

1. Chemical Process Control,An Introduction to Theory and Practice, George Stephanopoulos,Prentice Hall India, 2012
2. Electric Motor Drives, Modelling,Analysis and Control, R.Krishnan,Prentice Hall India, 2002
3. Hydraulic Control Systems, Herbert E. Merritt, Wiley, 1991

EE 23.407 **High Voltage Engineering** **Total Lectures: 40**
3-0-0-3

Objective: To provide an in-depth understanding the principle of High Voltage (HV) generation, various measurement methods, testing aspects of HV electrical apparatus and HV laboratories facilities.

Pre-requisite: Power System-I, Power System-II

1. **Breakdown in Gases, liquid and solid Insulating materials:** Ionization processes and de-ionization processes, Types of Discharge, Gases as insulating materials, Breakdown in Uniform gap, non-uniform gaps, Townsend's theory, Streamer mechanism, Corona discharge. Breakdown in pure and commercial liquids, Solid dielectrics and composite dielectrics, intrinsic breakdown, electromechanical breakdown and thermal breakdown, Partial discharge, applications of insulating materials. [12]
2. **Generation of High Voltages:** Generation of high voltages, generation of high D. C. and A.C. voltages, generation of impulse voltages, generation of impulse currents, tripping and control of impulse generators. [7]
3. **Measurements of High Voltages and Currents:** Peak voltage, impulse voltage and high direct current measurement method, cathode ray oscillographs for impulse voltage and current measurement, measurement of dielectric constant and loss factor, partial discharge measurements. [7]
4. **Lightning and Switching Over-voltages:** Charge formation in clouds, Stepped leader, Dart leader, Lightning Surges. Switching over-voltages, Protection against over-voltages, Surge diverters, Surge modifiers. [7]
5. **High Voltage Testing of Electrical Apparatus and High Voltage Laboratories:** Various standards for HV Testing of electrical apparatus, IS, IEC standards, Testing of insulators and bushings, testing of isolators and circuit breakers, testing of cables, power transformers and some high voltage equipment, High voltage laboratory layout, indoor and outdoor laboratories, testing facility requirements, safety precautions in H. V. Labs. [7]

*Assignments based on numerical tutorials are required to be submitted.

Outcome: At the end of the course, the student will demonstrate

- Understand the basic physics related to various breakdown processes in solid, liquid and gaseous insulating materials.
- Knowledge of generation and measurement of D. C., A.C., & Impulse voltages. Knowledge of tests on H. V. equipment and on insulating materials, as per the standards.
- Knowledge of how over-voltages arise in a power system, and protection against these over-voltages.

Text Books:

1. M. S. Naidu and V. Kamaraju, "High Voltage Engineering", McGraw Hill Education, 2013.
2. C. L. Wadhwa, "High Voltage Engineering", New Age International Publishers, 2007.

Reference Books:

1. D. V. Razevig (Translated by Dr. M. P. Chourasia), "High Voltage Engineering Fundamentals", Khanna Publishers, 1993.
2. E. Kuffel, W. S. Zaengl and J. Kuffel, "High Voltage Engineering Fundamentals", Newnes Publication, 2000.

EE 23.408 **Wind Energy System** **Total Lectures: 40**

3-0-0-3

Objective: This course provides an overview of the wind turbine as a system, including the influence of the wind resource and external factors that impact the wind energy enterprise.

Pre-requisite: Basic of Electrical Engineering

1. **History:** early wind power, technical development, influence of society and science. **Winds:** physical background, energy content, variation in time and in space, geographical resource distribution, influence of terrain, measurement methods, statistical analysis. [7]

2. **Turbines:** free flow, principles of drag and lift, aerodynamics, design of turbine blades, horizontal and vertical axis wind turbines, Betz' and Glauert's turbine theories, the BEM method. [9]
   Mechanics: static and dynamic loads (oscillations), rotor dynamics, solid mechanics, mechanical modelling, aeroelasticity.

3. **Electric generation:** synchronous/ asynchronous generators, winding/ permanent magnetised generators, constant/ variable speed, transformers, power electronics, power converters. [8]

4. **Design:** horizontal and vertical axis wind turbines, blades, control mechanisms, drive train, tower, nacelle, foundation, choice of materials, manufacture, adaptation to different climates [8]
   Control: control targets, system modelling, control strategies (pitch and stall regulation), hardware.
   Systems: wind power parks, transports, erection, grid connection, operation, maintenance.

5. **Economy:** financing, investment, costs during the life time of a wind turbine, value of wind energy, business and market overview. [8]
   Society: environmental issues, law, forms of government support, technical aspects of environment. Small scale wind power: technology, economy, paths of development.

*Assignments based on numerical tutorials are required to be submitted.

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

- calculate and analyze wind resource and energy production for a wind turbine from wind speed distribution, wind shear and power curve
- Analyze wind turbine components and compare various design configurations.
- compute performance characteristics of the main components of the wind turbine.

Text Books:

1. Freris L.L., Wind Energy Conversion Systems, Prentice Hall 1990.
2. Spera D.A., Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering, ASME Press, NY 1994.

Reference Books:

1. Johnson, G.L., Wind Energy Systems, Prentice Hall, 1985.
2. Manwell, James F.; McGovan, Jon G.; Rogers, Anthony L.**Wind energy explained : theory, design and application** ed.: Chichester: Wiley, 2009.
3. J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, 1986.

EE 23.409 **Smart Grid** **Total Lectures: 40**
3-0-0-3

Objective:
- This course aims to equip the students to understand the change in electricity power business from conventional sectors to smart grid sectors.
- To understand and analyze the basic architecture of smart grid and functions of its various components like renewables generation, measurement and communication system etc.

Pre-requisite: Basic of Electrical Engineering

1. **The Traditional Power Generation and Transmission System**: Introduction, Power System reliability and quality, Voltage profile of power system, Power transfer Through radial feeder, Power system stability and control, Protection system, SCADA System. [8]
2. **Smart Grid:** Introduction, Characteristics of Smart Grid, Traditional Grid Versus Smart Grid, Evolution of Smart Grid, Components of Smart Grid, The Environmental Impacts of Smart Grid, Technologies Required for Smart Grid. [8]
3. **Renewable Energy Integration:** Introduction, Solar Energy, Wind Energy, Distributed Energy Resources Integration Challenges, Forecasting and Scheduling, Impacts of Renewable Energy into the Grid. [8]
4. **Smart Grid Communications and Measurement Technology:** Communication, Measurement and Monitoring Technologies, Wide Area Monitoring Systems (WAMS), Phasor Measurement Units (PMU) ,Smart Appliances, Advanced Metering Infrastructure (AMI),Communication Protocols. [8]
5. **Smart Meter:** Details Description of Smart Meter, Benefits of Smart Meter, Technical Configurations of Smart Meter, Components of Smart Meter Network in Distribution System, and Characteristics of smart meters. [8]

*Assignments based on numerical tutorials are required to be submitted.

Outcome: At the end of this course, students will demonstrate the ability to
- Understand the difference between conventional grid and smart grid.
- Understand the integration necessity and challenges of renewable in conventional grid system.
- Understand the operation of communication and measurement technology in modern grid context.

Text Books:
1. Momoh James., "Smart Grid Fundamentals of Design and Analysis", John Wiley &Sons, Inc., Hoboken, New Jersey, 4th Edition, 2012.
2. Bollen, Math and Hassan F, "Integration of Distributed Generation in the Power System", IEEE press, 2011.

Reference Books:
1. Shawkat Ali A. B. M., "Smart Grids Opportunities, Developments and Trends", Springer Verlag, London, 4th Edition, 2013.
2. Chowdhury S., Crossley P. "Microgrids and Active Distribution Networks" The Institution of Engineering and Technology, UK, 3rd Edition, 2009.
3. James Momoh, Smart Grid: Fundamentals of Design and Analysis, IEEE Computer Society Press (2012).

EE 23.410 **Energy Storage Systems** **Total Lectures: 40**
3-0-0-3

Objective:
- To enable the student to understand the need for energy storage, devices and technologies available and their applications

Pre-requisite: Basic of Electrical Engineering

1. **Electrical Energy Storage Technologies:** Characteristics of electricity, Electricity and the roles of EES, High generation cost during peak-demand periods, Need for continuous and flexible supply, Long distance between generation and consumption, Congestion in power grids, Transmission by cable. [8]

2. **Needs for Electrical Energy Storage:** Emerging needs for EES, More renewable energy, less fossil fuel, Smart Grid uses The roles of electrical energy storage technologies, The roles from the viewpoint of a utility, The roles from the viewpoint of consumers, The roles from the viewpoint of generators of renewable energy. [8]

3. **Features of Energy Storage System:** Classification of EES systems, Mechanical storage systems, Pumped hydro storage (PHS), Compressed air energy storage (CAES), Flywheel energy storage (FES),Electrochemical storage systems, Secondary batteries, Flow batteries, Chemical energy storage, Hydrogen (H_2),Synthetic natural gas (SNG). [8]

4. **Types of Electrical Energy Storage Systems:** Electrical storage systems, Double-layer capacitors (DLC), Superconducting magnetic energy storage (SMES), Thermal storage systems, Standards for EES, Technical comparison of EES technologies. [8]

5. **Applications:** Present status of applications, Utility use (conventional power generation, grid operation & service), Consumer use (uninterruptable power supply for large consumers), New trends in applications, Renewable energy generation, Smart Grid, Smart Micro grid, Smart House, Electric vehicles, Management and control hierarchy of storage systems, Internal configuration of battery storage systems, External connection of EES systems . [8]

*Assignments based on numerical tutorials are required to be submitted.

Outcome: After completion of this course, the student will be able to
- analyze the characteristics of energy from various sources and need for storage
- classify various types of energy storage and various devices used for the purpose
- Identify various real time applications.

Text Books:
1. James M. Eyer, Joseph J. Iannucci and Garth P. Core, “Energy Storage Benefits and Market Analysis”, Sandia National Laboratories, 2004.
2. The Electrical Energy Storage by IEC Market Strategy Board.

Reference Books:
1. Jim Eyer, Garth Core, “Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide, Report”, Sandia National Laboratories, Feb 2010.
2. Rahn C. D. and Wang C., “Battery Systems Engineering” First Edition, Wiley, 2013.
3. Moseley P. T., and Garche J., “Electrochemical Energy Storage for Renewable Sources and Grid Balancing”, Elsevier Science, 2014.

EE 23.411 **Industrial Automation and Control** **Total Lectures: 40**
3-0-0-3

Objective: This course facilitates the students to get a comprehensive exposure to the working principles of actuators, sensors, different type of controllers and industrial communication in the field of industrial automation system.

Pre-requisite: Basic of Electrical Engineering

1. **Overview:** Structure & components Industrial Automation systems. Architectural levels of Industrial controls. [8]
2. **Actuators & sensors:** Servomotors, Stepper motors, Process I/O systems. Local & remote I/O systems. [8]
3. **Controllers:** Different types of controllers, Single loop and Multiloop controllers and their tunning, Direct controllers and their tunning, Direct Digital Controllers, Software implementation of Multiloop Controllers. Distributed Control Systems. [8]
4. **Supervisory Controllers:** Functionally of Supervisory Control Level, Process Optimization, Recipe Management Material. Tracking. Man-machine interfaces. [8]
5. **Industrial Communication Systems:** Characteristic features of industrial networks. Low level networks and their features, Field bus architecture. Performance aspects of Industrial Automation Systems. [8]

*Assignments based on numerical tutorials are required to be submitted.

Outcome: The students shall develop an insightful knowledge on actuators, sensors, different controllers and tuning of different controllers used in industries.

Text Books:
1. Terry Bartlet, Industrial Control Electronics Devices, Systems & Applications, Thomson Delmar Learning, 3rd Edition, 2006.
2. John W. Webb, Ronald A. Reis, Programmable Logic Controllers: Principles and Applications, PHI New Delhi, 5th Edition, 2009.

Reference Books:
1. John G. Webster, The Measurement Instrumentation and Sensors Handbook, Springer Science & Business Media, 1999.
2. Richard Zurawski, Industrial Communication Technology Handbook, CRC Press, 2nd Edition, 2017.

EE 23.412 **Advanced Electric Drives** **Total Lectures: 40**

3-0-0-3

Objective: This course aims to equip the students to understanding the advance electric drive system and their controls.

Pre-requisite: Electrical Drives and Control

1. **Power Converters for AC Drives :** [10]
   PWM control of inverter, selected harmonic elimination, space vector modulation, current control of VSI, three level inverter, different topologies, SVM for three level inverter, diode rectifier with boost chopper, PWM converter as line side rectifier, current fed inverters with self-commutated devices, control of CSI, H-bridge as a 4-Q drive.
2. **Induction Motor and Synchronous Motor Drives:** [12]
   Different transformations and reference frame theory, modeling of induction machines, voltage fed inverter control, v/f control, vector control, direct torque and flux control (DTC), modeling of synchronous machines, open loop v/f control, vector control, direct torque control, CSI fed synchronous motor drives.
3. **Permanent magnet motor drives:** [6]
   Introduction to various PM motors, BLDC and PMSM drive configuration, comparison, block diagrams, speed and torque control in BLDC and PMSM.
4. **Switched reluctance motor drives:** [6]
   Evolution of switched reluctance motors, various topologies for SRM drives, comparison, closed loop speed and torque control of SRM.
5. **DSP based motion control:** [6]
   Use of DSPs in motion control, various DSPs available, realization of some basic blocks in DSP for implementation of DSP based motion control.

*Assignments based on numerical tutorials are required to be submitted.

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

- Understand the operation of power electronic converters and their control strategies.
- Understand the vector control strategies for AC motor drives
- Understand the implementation of the control strategies using digital signal processors.

Text Books:

1. B. K. Bose, “Modern Power Electronics and AC Drives”, Pearson Education, Asia, 2003.
2. P. C. Krause, O. Wasynczuk and S. D. Sudhoff, “Analysis of Electric Machinery and Drive Systems”, John Wiley & Sons, 2013.

Reference Books:

1. H. A. Taliyat and S. G. Campbell, “DSP based Electromechanical Motion Control”, CRC press, 2003.
2. R. Krishnan, “Permanent Magnet Synchronous and Brushless DC motor Drives”, CRC Press, 2009.
3. Boldea, Ion, and Syed A. Nasar. Electric drives. CRC press, 2016.