Notification No.:CSR/39/19 DATED 18.10.2019

UNIVERSITY OF CALCUTTA

Faculty of Engineering and Technology

Electrical Engineering

Department of Applied Physics

A. Regulation for 4-year 8-semester B. Tech. course

(with effect from the academic year 2018 – 2019)

<table>
<tr><td>01</td><td colspan="2">Department of Applied Physics under the Faculty of Engineering and Technology, University of Calcutta shall provide instructions leading towards the 4-year, 8-semester B. Tech. degree in Electrical Engineering. The course is of four (4) years duration comprised of eight (8) Semesters, each Semester being of six (6) months' duration.</td></tr>
<tr><td>02</td><td colspan="2">Eligibility for Admission</td></tr>
<tr><td></td><td>(a)</td><td>Category-1: For admission in the first semester of 4-Year B. Tech. course in Electrical Engineering stream, the candidates must have passed Class XII Examinations in the 10+2 format under West Bengal Council of Higher Secondary Education or equivalent with Physics, Chemistry, Mathematics securing an average of at least 60% marks (or equivalent grade) in these subjects and qualified through West Bengal Joint Entrance Examination (JEE).</td></tr>
<tr><td></td><td>(b)</td><td>Category-2: For admission of the B.Sc. (Hons.) qualified students to the third semester of the B.Tech. course, the candidates must have passed B.Sc. Honours in Physics in 10+2+3 format from a UGC recognized University in India. The selection will be strictly based on merit as adopted and invoked time to time by University of Calcutta.
The 'Category-2' students must have to attend and pass Workshop Practice and Engineering Drawing subjects additionally arranged in the THIRD/FOURTH Semester curriculum. However, no credit points will be awarded and will not be included for SGPA calculation. In the final mark sheet, it will be mentioned that he/she has qualified Workshop Practice and Engineering Drawing.
The duration of study for students admitted in the third semester will be of 6 semesters (starting from third Semester) in three academic years.</td></tr>
<tr><td>03</td><td colspan="2">The award of the said B. Tech. Degree will be conferred to students who are successful in all of the eight (8) (for Category-1) / six (6) (for category-2) Semester examinations.</td></tr>
<tr><td>04</td><td colspan="2">Attendance: A student must attend 75% of the theoretical and laboratory/practical classes in order to fill up the form for the Semester examinations.</td></tr>
</table>

05 Credit distribution among different courses:

The credit distribution among different topics of the entire program is as follows:

Sl. No.	Topic	Credits of the EE Curriculum
1.	Humanities and Social Sciences including Management	10.5
2.	Basic Sciences	25
3.	Engineering Sciences including workshop, drawing, basics of electrical/mechanical/computer etc.	19.5
4.	Professional Core Subjects	65
5.	Professional Electives Subjects relevant to chosen specialization/branch	15
6.	Open Electives from other technical and/or emerging subjects	12
7.	Project work, general viva-voce and seminar	11
8.	Mandatory Courses [Environmental Sciences, Induction Program, Indian Constitution, Essence of Indian Knowledge Tradition, internship in industry or elsewhere.]	Non-credit
	Total	**158**

(a) A student has to take/opt four (4) subjects/course from the list of Humanities and Social Sciences including Management (HSMC) course, five (5) subjects/course from the list of Professional Elective Course (PEC) and four (4) subject/course from the list of open elective course (OEC).

(b) A student has to go through Mandatory Course (MC) which is Non-credit (NC) course. Mandatory Course (MC) may/will include (but not all) Environmental Sciences, Induction Program, Indian Constitution, Essence of Indian Knowledge Tradition. Mandatory Courses (MC) may also include Summer Internship during summer vacation, attendance of workshop, industrial training etc.

06 B.Tech. Degree with Honours

A student will be eligible to get undergraduate degree with Honours or additional minor engineering if he/she completes an additional 20 credits. The student must have to earn these 20 credits through MOOC and/or SWAYAM each of 8 week duration throughout the 8 semester program. Any student completing any course through MOOC and/or SWAYAM will have to submit an appropriate certificate to earn corresponding credit.

07 Credit based Evaluation

(a) The credit based examination system will be followed for all Semester examinations. Each course shall have a certain number of credits assigned to it depending upon the academic load of the course assessed on the basis of *weekly contact Hours* of lecture, tutorial and laboratory classes, assignments or field study and/or self study.

The number of credits of a course in a semester shall ordinarily be calculated as under:

(i) Lecture (L)/Tutorial (T): One lecture hour per week shall normally be assigned one credit. One hour of tutorial per week shall be assigned one credit. For determining the credits of a theory course, lectures and tutorials shall be added.

(ii) Practical (P): One laboratory Hours per week shall be assigned half (0.5) credit. Each paper shall carry Credit (C) according to number of Hours allotted per week and as indicated in the following table:

Weightage for	No. of Hours/week	Credit (C) assigned
Theoretical	1	1
Tutorial	1	1
Practical	1	(0.5)

The course credits for each course shall be given as L-T-P. For example, 3-1-0 will mean that it is a lecture based course and has 3 lectures, 1 tutorial, and no practical assigned to it. Similarly, a course with 0-0-3 means that it is a practical course with 3 Hours of practical work. Credits will be assigned to seminar, dissertation, project etc. under the practical course head.

The 4-year course will cover a total of 158 credits. Marks assigned to each theoretical papers will be of 100, while the same for each laboratory/practical papers will be of 50. Credit points of theoretical and practical papers including project work, design, General Viva Voce, seminar presentation etc. will be provided in Course Structures separately. There will be two components of evaluation of theoretical papers: i) Sessional assessment 30% i.e. 30 marks ii) End Semester examination 70% i.e. 70 marks.

(b) **The Sessional assessment components of theory papers are:**

Serial No	Mode of evaluation	Marks
01	Mid-semester written examination (MSE)	20
02	Teacher’s assessment (TA): Active participation in routine classes, assignments.	10

(c) End semester examination (ESE):
Written examination of 03 hours duration consisting of subjective and objective questions following the Course Objectives (CO) of the course as mentioned in the detail syllabus.

(d) **Evaluation in Laboratory/ practical papers:**

Serial No	Type of evaluation	Marks
01	Sessional components (timely submission of report copies, participation in laboratory classes)	30
02	End semester viva examination	20

(e) Eligibility of success/failure in a Semester Examination and continuation of course:

(i) On the basis of total marks (TA+MSE+ESE) secured in each paper, **Grade (G)** and **Grade Point (GP)** shall be awarded to a student.

The equivalence between grades, grade points and the percentage marks is given by:

Percentage (%) of marks	Grade (G)	Grade Point (GP)
≥ 90	E	10
89 – 80	A	9
79 - 70	B	8
69 - 60	C	7
59 - 50	D	6
< 50	F	0

At the end of each Semester examination, a Grade-Sheet showing the Semester performance (Semester Grade Sheet) indicated by **SGPA** will be issued to the successful students. However, SGPA will not be calculated for those candidates who fail to earn all the credits in that Semester.

The performance of a candidate in n^{th} Semester examination, who earns all the credits of that semester, will be indicated by the '**Semester Grade Point Average' (SGPA), 'S_n'** to be computed as:

$$SGPA\,[S_n\ ] = \frac{\sum_k [C_k\ GP_k]}{\sum_k C_k}$$

where 'k' denotes the number of courses in a particular semester

and $\sum_k C_k$ denotes the total credits of a particular semester and GP_k is the grade point obtained in k^{th} courses. The Semester Grade Sheet should have the following basic information: The merit list will be prepared on the basis of the total marks obtained.

Paper	Details of courses with code	Full Marks	Marks obtained	Credit obtained	Grade	Grade Point	SGPA	Remarks

(ii) A student has to secure at least 50% marks i.e. Grade-D in a paper to quality a theoretical/practical paper.

(iii) A student has to secure at least 50% marks i.e. Grade-D in all papers in a semester in order to pass that semester examination. Such candidates will be called successful candidates and will be allowed to join classes in the next semester.

(iv) If a student fails to qualify in some papers with accumulated credits more than 8, he/she will not be allowed to continue his/ her studies to the next semester classes. The candidate has to seek re-admission in the same semester in next academic session to continue the program, and will eventually face a year loss.

(v) If a student fails to qualify in some papers with accumulated credit of 8 or less in a semester but qualifies in other papers, he/she will be allowed to continue to the next Semester, provided that total of such backlog credits within the entire course period of

		eight semesters is 24 or less at any point of time. [Example: In the *first and second* Semesters, one has to earn at least 21 - 8= 13 credits and 22-8=14 credits respectively; this may vary in other Semesters]. (vi) **Special supplementary examinations** will be arranged within 3 months of publication of the results of **s*emester 7 and 8***, only for the unsuccessful candidates of category (iv). Students who fails to earn the requisite credits (as mentioned in category (iv)) in special supplementary examination/s will have to appear the same examination/s in the next academic session. (vii) Each theory and practical paper of the end semester examination will be evaluated by internal examiner(s). Project, Seminar and General Viva-voce examinations will be evaluated by a board of examiners consisting of at least two (02) internal examiners and at least one (01) external experts.
08		After the semester examination, the successful candidates shall join classes in the next semester as per university notification on commencement of classes.
09	(a)	**Eligibility for a Degree:** On completion of the B.Tech course, the overall performance of a candidate will be assessed by the '**Cumulative Grade Point Average' (CGPA)** to be computed as: $$CGPA = \frac{\sum_n [C_n S_n]}{\sum_n C_n}$$ where, $C_n = \sum_k C_k$ and $\sum_n C_n$ denotes total credits of all the semesters.
	(b)	A student needs to qualify in all the theoretical and practical papers to qualify for award of the B. Tech. Degree in Electrical Engineering. **'**Category 1' student has to pass all the theoretical and practical papers of 8-Semesters in maximum of 6 consecutive year from admission to obtain B. Tech degree in corresponding course 'Category 2' student has to pass all the theoretical and practical papers of 6-Semesters in maximum of 5 consecutive years to obtain B. Tech degree.
	(c)	A consolidated Grade-Sheet, showing the overall performance of a candidate during B. Tech program indicated by **CGPA**, will be issued only to those successful students who have passed all the theoretical and practical papers of all of the 8 semesters (for Category -1 student) or 6 semesters (for Category -2 student). The consolidated grade sheet shall consist of two components. The first component will have the information of the final Semester as follows:

Paper	Details of courses	Full Marks	Marks obtained	Credit obtained	Grade	Grade Point	SGPA	Remarks

The second component will have a **summary** of all the semesters having the following basic information in two tables:

Semester	Total credit	Credit obtained	SGPA	Full marks	Marks obtained	Cumulative statement	
						Total credit	
						CGPA	
						Full marks (Total)	
						Marks obtained	
						Result	#

Mandatory Course (MC) and Honours Status

Name and code of MC/Workshop/Drawing	Semester	Qualified/Not qualified	Honours
			With/without Honours

The hash (#) in the last row of last column will contain the information regarding the final achievement of the candidate in all the examinations. This box will contain only one (1) of the following three (3) information: ‘1st Class’ / ‘2nd Class’ / ‘Failed’.

(d) Candidates securing CGPA at least 7.5 in B. Tech. Examination shall be placed in the First Class and those securing 6.0 or more but less than 7.5 shall be placed in the ‘Second Class’. Candidates securing CGPA less than 6.0 shall be declared ‘Failed’.

(e) The Degree of **“Bachelor of Technology in Electrical Engineering”** from the Department of Applied Physics under the seal of the University shall be awarded to a successful candidate mentioning the grade and class he/she has obtained.

UNIVERSITY OF CALCUTTA
Faculty of Engineering and Technology
Electrical Engineering
Department of Applied Physics

Course structure for 4-Year 8-Semester B. Tech. Degree in Electrical Engineering

Course Structure for 1st SEMESTER

Serial No.	Name	Code	Weekly Load				Credit
			L	T	P	TCH	
1	English	HU101	2	1	0	03	03
2	Physics-I	PH102	2	1	0	03	03
3	Chemistry-I	CH103	2	1	0	03	03
4	Engineering Mathematics-I	MA104	2	1	0	03	03
5	Basic Electrical Engineering	EE105	2	1	0	03	03
6	Language Lab	HU106	0	0	3	03	1.5
7	Physics Lab -I	PH107	0	0	3	03	1.5
8	Chemistry Lab -I	CH108	0	0	3	03	1.5
9	Basic Electrical Engineering Lab	HU101	0	0	3	03	1.5
	TOTAL		10	5	11	27	21

Course Structure for 2nd Semester

Serial No.	Name	Code	Weekly Load				Credit
			L	T	P	TCH	
1	Physics-II	PH201	2	1	0	03	03
2	Engineering Mathematics-II	MA202	2	1	0	03	03
3	Engineering Mechanics	ME203	2	1	0	03	03
4	Basic computer Science and Engineering	CS204	2	1	0	03	03
5	Basic Electronics	BE205	2	1	0	03	03
6	Physics Lab –II	PH206	0	0	2	02	01
7	Workshop Practice	ME207	0	0	3	03	1.5
8	Engineering Drawing	ME208	0	0	3	03	1.5
9	Computer Programming Lab	CS209	0	0	3	03	1.5
	Basic Electronics Lab	BE210 ET 205	0	0	3	03	1.5
	TOTAL		10	5	14	29	**22**

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Course Structure for 3rd SEMESTER

Serial No.	Name	Code	Weekly Load				Credit
			L	T	P	TCH	
1	Circuit Theory	PCC- EE301	3	0	0	3	3
2	Analog Electronic	PCC- EE 302	3	0	0	3	3
3	Electrical Machines–I	PCC- EE 303	3	1	0	4	4
4	Electromagnetic Fields	PCC- EE 304	3	0	0	3	3
5	Electrical and Electronic Measuring Instruments	*PCC-EE 305*	3	0	0	3	3
7	Electrical Machines-I Laboratory	LC- EE 306	0	0	3	3	1.5
8	Electrical and Electronic Measurements Laboratory	LC- EE 307	0	0	3	3	1.5
9	Circuit Theory Laboratory	LC- EE 308	0	0	3	3	1.5
	TOTAL		15	1	12	28	20.5

Course Structure for 4th SEMESTER

Serial No.	Name	Code	Weekly Load				Credit
			L	T	P	TCH	
1	Digital Electronics	PCC-EE 401	3	0	0	3	3
2	Power Systems–I	PCC-EE 402	3	0	0	3	3
3	Control Systems	PCC-EE 403	3	0	0	3	3
4	Signals and Systems	PCC-EE404	2	1	0	3	3
5	Mathematics–III	BSC 405	3	0	0	3	3
6	Analog and Digital Electronics Laboratory	LC-EE 406	0	0	4	4	2
7	Power Systems-I Laboratory	LC-EE 407	0	0	3	3	1.5
8	Control Systems Laboratory	LC-EE 408	0	0	3	3	1.5
9	Industrial Training	MC-EE 409					0
	TOTAL						20

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Course Structure for 5th SEMESTER

Serial No.	Name	Code	Weekly Load				Credit
			L	T	P	TCH	
1	Electrical Machines–II	PCC-EE 501	3	1	0	4	4
2	Power Electronics	PCC-EE 502	3	0	0	3	3
3	Microprocessors	PCC-EE 503	3	0	0	3	3
4	Professional Elective-I	PEC-EE 504	3	0	0	3	3
5	Open Elective-I	OEC-EE 505	3	0	0	3	3
6	Electrical Machines-II Laboratory	LC-EE 506	0	0	3	3	1.5
7	Electronics Design Laboratory	LC-EE 507	1	0	3	5	2.5
8	Microprocessors Laboratory	LC-EE 508	0	0	3	3	1.5
9	Attending workshop / seminar	MC-EE 509					0
	TOTAL						21.5

Course Structure for 6th SEMESTER

Serial No.	Name	Code	Weekly Load				Credit
			L	T	P	TCH	
1	Power Systems–II	PCC-EE 601	3	0	0	3	3
2	Computer Programming	PCC-EE 602	2	0	2	4	3
3	Electrical Drives	PEC-EE 603	3	0	0	3	3
4	Professional Elective-II	PEC-EE 604	3	0	0	3	3
5	Open Elective-II	OEC-EE 605	3	0	0	3	3
6	HS-II	HSMC- EE 606	3	0	0	3	3
7	Power Electronics and Drives Laboratory	LC-EE 607	0	0	3	3	1.5
8	Power Systems- II Laboratory	LC-EE 608	0	0	3	3	1.5
9	Internship	MC-EE 609					0
	TOTAL						21

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Course Structure for 7th SEMESTER

Serial No.	Name	Code	Weekly Load				Credit
			L	T	P	TCH	
1	Professional Elective-III	PEC-EE 701	3	0	0	3	3
2	Professional Elective-IV	PEC-EE 702	3	0	0	3	3
3	Open Elective-III	OEC-EE 703	3	0	0	3	3
4	Open Elective -IV	OEC-EE 704	3	0	0	3	3
5	HS-III	HSMC 705	3	0	0	3	3
6	Project Stage-I	PROJ-EE 706	0	0	6	6	3
	TOTAL						18

Course Structure for 8th SEMESTER

Serial No.	Name	Code	Weekly Load				Credit
			L	T	P	TCH	
1	Professional Elective-V	PEC-EE 801	3	0	0	3	3
2	Project Stage-II	PROJ-EE 802	0	0	16	16	8
3	Seminar	SEM-EE 803					2
4.	General Viva-voce	GEV-EE 804					1
	TOTAL						14

UNIVERSITY OF CALCUTTA
Faculty of Engineering and Technology
Electrical Engineering
Department of Applied Physics

Detailed Syllabus: 3rd SEMESTER

THEORETICAL PAPERS

Course PCC-EE 301: Electrical Circuit Analysis

Course Outcomes:

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

CO1	Realise and apply network theorems for the analysis of electrical circuits.
CO2	Understand the network graph and topology.
CO3	Understand about the different filters for electrical circuits.
CO4	Obtain an introductory idea about the synthesis and analyze two port network.

Module 1: Network Theorems (8 Hours)

Generalized mesh and nodal analysis, Duality of network. Network theorems: analysis with dependent and independent sources, current and voltage sources, network minimization, numerical examples.

Module 2: Electrical Circuit Analysis Using Laplace Transforms (8 Hours)

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.

Module 3: Two Port Network and Network Functions (12 Hours)

Two Port Networks, terminal pairs, relationship of two port variables, impedance parameters, Admittance parameters, transmission parameters and hybrid parameters, interconnections of two port networks. Determination of incidence matrix, cut-set matrix, loop matrix and mesh matrix of large networks.

Module 4: Filters (8 Hours)

Filter classification, Low-pass, high-pass, band-pass and band-stop filter, Passive filters, advantage of active filters, Transfer function approximation: Butterworth, Chebychev and other approximations, realization of active filters, all pass filter, characteristic impedance of active filters.

Module 5: Introduction to Network synthesis (4 Hours)

Driving point impedance and admittance functions, positive reality concept. realizability conditions, Hurwitz and Sturm tests, general energy functions, two-elements realizability requirements, canonical realization methods, transfer-function synthesis.

Text/References:

1. M.E. Van Valkenburg, “Network Analysis”, Prentice Hall, 2006.
2. D. Roy Choudhury, “Networks and Systems”, New Age International Publications, 1998.
3. W.H. Hayt and J.E. Kemmerly, “Engineering Circuit Analysis”, McGraw Hill Education, 2013.
4. C.K. Alexander and M.N.O. Sadiku, “Electric Circuits”, McGraw Hill Education,2004.
5. K.V.V. Murthy and M.S. Kamath, “Basic Circuit Analysis”, Jaico Publishers, 1999.

Course PCC-EE 302: Analog Electronic Circuits

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

CO1	Understand the characteristics of transistors and MOSFETs.
CO2	Understand and analyse the various rectifier and amplifier circuits.
CO3	Understand the sinusoidal and non-sinusoidal oscillators.
CO4	Understand the functioning of OP-AMP in linear and non-linear applications.

Module1: BJT circuits (8 Hours)
Structure and I-V characteristics of a BJT; BJT as a switch. BJT as an amplifier: Darlington pair, small-signal model, biasing circuits, current mirror; common-emitter, common-base and common-collector amplifiers; Small signal equivalent circuits, high-frequency equivalent circuits

Module 2: MOSFET circuits (8 Hours)
MOSFET structure and I-V characteristics. MOSFET as a switch. MOSFET as an amplifier: small-signal model and biasing circuits, common-source, common-gate and common-drain amplifiers; small signal equivalent circuits-gain, input and output impedances, trans-conductance, high frequency equivalent circuit.

Module 3: Differential, multi-stage and operational amplifiers (10 Hours)
Differential amplifier; power amplifier; direct coupled multi-stage amplifier; internal structure of an operational amplifier, ideal op-amp, non-idealities in an op-amp (Output offset voltage, input bias current, input offset current, slew rate, gain band width product)

Module 4: Linear and Non-linear applications of op-amp (14 Hours)
Idealized analysis of op-amp circuits. Inverting and non-inverting amplifier, differential amplifier, instrumentation amplifier, integrator, active filter, voltage regulator, oscillators (Wein bridge and phase shift). Analog to Digital Conversion. Hysteretic Comparator, Zero Crossing Detector, Square-wave and triangular- wave generators. Precision rectifier, peak detector. Monoshot; Oscillators, Multivibrators: monostable, astable, bistable.

Text/References:
1. A. S. Sedra and K. C. Smith, "Microelectronic Circuits", New York, Oxford University Press,1998.
2. J. V. Wait, L. P. Huelsman and G. A. Korn, "Introduction to Operational Amplifier theory and applications", McGraw Hill U.S.,1992.
3. J. Millman and A. Grabel, "Microelectronics", McGraw Hill Education,1988.
4. P. Horowitz and W. Hill, "The Art of Electronics", Cambridge University Press,1989.
5. P. R. Gray, R. G. Meyer and S. Lewis, "Analysis and Design of Analog Integrated Circuits", John Wiley & Sons, 2001.
6. . R. F. Coughlin and F. F. Drisckoll, "Opamp and Linear Integrated Circuits, PHIL, India.
7. R. Gayakwad, "Opamp and Linear Integrated Circuits, PHIL, India.
8. L. Nashelsky and R. Boylestad, "Electronics Devices and Circuit Theory", Pearson Education.

Course PCC-EE 303: Electrical Machines-I

Course Outcomes:

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

CO1	Understand the basics of electromechanical energy conversion.
CO2	Understand the working principles dc machines, their configurations and operations.
CO3	Understand the working principles of single-phase transformer.
CO4	Understand the working principles of three phase, special and metering transformer.

Module 1: Electromechanical energy conversion principle (8 Hours)

Electromechanical energy conversion principle, singly excited magnetic system and doubly excited magnetic system, physical concept of torque production; electromagnetic torque and reluctance torque. Concept of General terms pertaining to Rotating Machines**:** Electrical & mechanical degree, pole pitch, coil, generated EMF in full pitched coil, distribution factor, pitch factor, MMF of a coil, MMF of single-phase distributed winding, MMF waveform of commutator machines.

Module 2: DC Machines (10 Hours)

DC Machines: Brief overview, building up of a self excited shunt generator, causes of inability to build up, armature reaction and compensating winding, commutation and interpole winding, problem in the parallel operation of over compound generator and equaliser connection, Principle of motor operation, speed control, torque in a motor and motor stability.

Module 3: Single phase transformer (8 Hours)

Brief introduction, equivalent circuit and phasor diagram, performance analysis, efficiency, regulation, polarity test, parallel operation.

Module 4: Three phase and Special transformers (12 Hours)

Three phase transformer: constructional features, insulation, operation, group connection, parallel operation, testing. Special transformer: Auto transformer, Scott, V-V connection, three winding transformer, tap changers, Earthing transformer, Pulse transformer; Welding transformer, their operation and uses.

Module 5: Instrument transformers (4 Hours)

Current transformers and potential transformers – their construction and characteristics, phasor diagrams, different errors, testing of CT and PT, metering and protection CT.

Text/References

1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery”, New York, McGraw Hill Education.
2. R. C. Kloeffler, R. M. Kerchner, J. L. Brenneman, “Direct Current Machinery”, The Macmillan Company.
3. A.E. Clayton and N. N. Hancock, “Performance and design of DC machines”, CBS Publishers.
4. M. G. Say, “Performance and design of AC machines”, CBS Publishers.
5. C.I. Hubert, “Electric Machines: Theory, Operating Applications and Control”, Pearson
6. A. F. Puchstein and T.C. Lloyd, “Alternating Current Machines”, John Wiley & Sons, Inc.
7. D. V. Richardson, “Rotating electric machinery and transformer technology”, Prentice-Hall Inc.
8. H. Cotton, “Advanced Electrical Technology”, Pitman Publishing.
9. V. Del Toro, “Basic electric machines”, Prentice-Hall Inc.
10. I. L. Kosow, “Electric Machinery & Transformers”, PHI.

11. G. S. Brosan and J. T. Hayden, "Advanced Electrical Power and Machinary", Pitman Publishing.
12. S. K. Sen, "Electrical Machinary", Khanna Publishers.

Course PCC-EE 304: Electromagnetic Fields

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

CO1	Understand the operations of vector calculus and basic laws of electromagnetism and propagation of EM waves.
CO2	Understand the electric and magnetic fields for simple configurations under static conditions.
CO3	Analyse time varying electric and magnetic fields.
CO4	Understand Maxwell's equation in different forms and different media.

Module 1: Review of Vector Calculus (6 Hours)
Vector algebra-addition, subtraction, scalar and vector multiplications, triple products, rectangular, cylindrical and spherical coordinate systems, Vector calculus-differentiation, partial differentiation, integration, vector operator del, gradient, divergence and curl; integral theorems of vectors. Conversion of a vector from one coordinate system to another.

Module 2: Static Electric Field (6 Hours)
Coulomb's law, Electric field intensity, Electrical field due to point charges. Line, Surface and Volume charge distributions. Gauss law and its applications. Absolute Electric potential, Potential difference, Calculation of potential differences for different configurations. Electric dipole, Electrostatic Energy and Energy density.

Module 3: Conductors, Dielectrics and Capacitance (6 Hours)
Current and current density, Ohms Law in Point form, Continuity of current, Boundary conditions of perfect dielectric materials. Permittivity of dielectric materials, Capacitance, Capacitance of a two-wire line, Poisson's equation, Laplace's equation, Solution of Laplace and Poisson's equation, Application of Laplace's and Poisson's equations.

Module 4: Static Magnetic Fields (6 Hours)
Biot-Savart Law, Ampere Law, Magnetic flux and magnetic flux density, Scalar and Vector Magnetic potentials. Steady magnetic fields produced by current carrying conductors.

Module 5: Magnetic Forces, Materials and Inductance (6 Hours)
Force on a moving charge, Force on a differential current element, Force between differential current elements, Nature of magnetic materials, Magnetization and permeability, Magnetic boundary conditions, Magnetic circuits, inductances and mutual inductances.

Module 6: Time Varying Fields and Maxwell's Equations (6 Hours)
Faraday's law for Electromagnetic induction, Displacement current, Point form of Maxwell's equation, Integral form of Maxwell's equations, Motional Electromotive forces. Boundary Conditions.

Module 7: Electromagnetic Waves (6 Hours)

Derivation of Wave Equation, 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.

Text/References:

1. M. N. O. Sadiku, "Elements of Electromagnetics", Oxford University Publication,2014.
2. Pramanik, "Electromagnetism-Problems with solution", Prentice Hall India, 2012.
3. G. W. Carter, "The electromagnetic field in its engineering aspects", Longmans, 1954.
4. W. J. Duffin, "Electricity and Magnetism", McGraw Hill Publication, 1980.
5. E. G. Cullwick, "The Fundamentals of Electromagnetism", Cambridge University Press, 1966.
6. D. Popovic, "Introductory Engineering Electromagnetics", Addison-Wesley Educational Publishers, International Edition, 1971.
7. W. Hayt, "Engineering Electromagnetics", McGraw Hill Education, 2012.
8. D. J. Griffiths, "Introduction to Electrodynamics", Cambridge University Press.
9. M. Spiegel, S. Lipschutz, D. Spellman, "VECTOR ANALYSIS: Schaum's Outlines Series", McGraw Hill.

Course PCC-EE 305: Electrical and Electronic Measuring Instruments

Course Outcomes:

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

CO1	Understand basic functioning of electrical indicating instruments.
CO2	Understand the principle of PMMC, Dynamometer, Induction, Electrostatic instruments.
CO3	Learn about the basic principles of measurements of resistance, voltage, current, power, energy, frequency and power factor measurement using bridges and electrical instruments.
CO4	Learn about electronic measurements using function generators, oscilloscopes, multimeters.

Module 1: Principles of Electrical Measurements (10 Hours)

Standards of measurements and their classification, types of electrical instruments,. General features of electrical measuring instruments: controlling, damping, and balancing of moving systems, measurement of resistance, Wheatstone bridge, Kelvin Double bridge, Megger, ammeter voltmeter method.

Module 2: AC Bridges and Indicating Instruments (10 Hours)

Measurement of capacitance and inductance using AC bridges; AC and DC potentiometers, vibration galvanometer, permanent magnet moving coil, moving iron, induction type and electrodynamic instruments for measuring voltage, current.

Module 3: Measurement of Electrical Power and Energy (8 Hours)

Watt meters: measurement of single phase and three phase power, Measurement of energy, Single Phase and Three Phase induction watt-hour meters, power factor meters, frequency meters.

Module 4: Electronic instruments: (12 Hours)

Cathode ray oscilloscope, DSO, Oscilloscope Controls, Oscilloscope Probes, storage oscilloscope, Digital instruments, Digital Voltmeters, digital phase and frequency meter, True R.M.S Voltmeter, Peak Response Voltmeter, Electronic Ohmmeters, Q-meter, Function generators.

Text/References:

1. Golding and Widdis, "Electrical Measurements & Instruments", ISSAC Pitmax and Sons
2. M. B. Stout, "Electrical Measurements", Prentice Hall International
3. A. D. Helfric, W.D. Cooper, "Modern Electronic Instrumentation and Measurement Techniques", Dorling Kindersly Pvt. India Ltd.
4. D. A. Bell, "Electronic Instrumentation and Measurements", Oxford Higher Education
5. M. M. S. Anand, "Electronic Instruments and Instrumentation Technology", PHIL

PRACTICAL PAPERS

Course LC-EE 306: Electrical Machines–I Laboratory

Course Outcomes:

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

CO1	Tests on single phase transformer.
CO2	Tests on DC machines in motoring and generating mode.
CO3	Tests on three phase and special transformers.
CO4	Tests with Instrument transformers.

List of Experiments

1. Perform open circuit test on a single-phase transformer to find the core loss at rated voltage.
2. Perform short circuit test on a single-phase transformer to find the copper loss at rated current.
3. Find out equivalent circuit parameters of single-phase transformer.
4. Polarity and group connection tests of three phase transformers
5. Perform Scott connection test.
6. Familiarization of 3-point and 4-point starter terminals.
7. Perform tests of dc series machine.
8. Perform tests of dc shunt machine.
9. Perform Swinburne test on dc shunt machine to determine its efficiency.

Course LC-EE 307: Electrical and Electronic Measurements Laboratory

Course Outcomes:

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

CO1	Measure of electrical quantities by electrical and electronic method.
CO2	Use of Oscilloscope to measure various parameters
CO3	Calibration of Instruments.

List of Experiments

1. Measurement of Low resistance by Kelvin Double bridge
2. Measurement of unknown capacitance by Ac bridge method
3. Measurement of unknown voltage, current and frequency by using oscilloscope.
4. Calibration of Wattmeter

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Department of Applied Physics

Course LC-EE 308: Circuit Theory Laboratory

Course Outcomes:

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

CO1	Understand about the transient response of different circuits
CO2	Understand about the two port network parameters
CO3	Understand about the filters

List of Experiments

1. To study the voltage divider circuit.
2. Study the transient response of a RC series circuit.
3. Study the transient response of a RL series circuit.
4. Study the transient response of a RLC series circuit.
5. To study the calculation of Z parameter.
6. To study the calculation of Y parameter.
7. Study the transient response of a parallel RLC series circuit.
8. To study the design and operation of low pass filter.
9. To study the design and operation of high pass filter.
10. To study the design and operation of band pass filter.

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Department of Applied Physics

Detailed Syllabus: 4th SEMESTER

THEORETICAL PAPERS

Course PCC-EE 401: Digital Electronics

Course Outcomes:

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

CO1	Understand working of logic families and logic gates.
CO2	Apply and Design of Combinational and Sequential logic circuits.
CO3	Understand the process of Analog to Digital conversion and Digital to Analog conversion.
CO4	Realize the use of memories and logic devices for implementing the logical problems.

Module 1: Fundamentals of Digital Systems and logic families (8 Hours)

Digital signals, digital circuits, AND, OR, NOT, NAND, NOR and Exclusive-OR operations, Boolean algebra, examples of IC gates, number systems-binary, signed binary, octal hexadecimal number, binary arithmetic, one's and two's complements arithmetic, codes, error detecting and correcting codes, characteristics of digital lCs, digital logic families, TTL, Schottky TTL and CMOS logic, interfacing CMOS and TTL, Tri-state logic.

Module 2: Combinational Digital Circuits (8 Hours)

Standard representation for logic functions, K-map representation, simplification of logic functions using K- map, minimization of logical functions. Don't care conditions, Multiplexer, DeMultiplexer/Decoders, Adders, Subtractors, BCD arithmetic, carry look ahead adder, serial adder, ALU, digital comparator, parity checker/generator, code converters, priority encoders, decoders/drivers for display devices.

Module 3: Sequential circuits and systems (8 Hours)

A 1-bit memory, the circuit properties of Bistable latch, the clocked SR flip flop, J- K-T and D-Types flip flops, applications of flip flops, shift registers, applications of shift registers, serial to parallel converter, parallel to serial converter, ring counter, sequence generator, ripple(Asynchronous) counters, synchronous counters, counters design using flip flops, asynchronous sequential counters, applications of counters.

Module 4: A/D and D/A Converters (8 Hours)

Digital to analog converters: weighted resistor/converter, R-2R Ladder D/A converter, specifications for D/A converters, examples of D/A converter ICs, sample and hold circuit, analog to digital converters: quantization and encoding, parallel comparator A/D converter, successive approximation A/D converter, counting A/D converter, dual slope A/D converter, Flash type A/D converter, A/D converter using voltage to frequency and voltage to time conversion, specifications of A/D converters, example of A/D Converter ICs.

Module 5: Semiconductor memories and Programmable logic devices (8 Hours)

Memory organization and operation, expanding memory size, classification and characteristics of memories, sequential memory, read only memory (ROM), read and write memory (RAM), content addressable memory (CAM), charge coupled device (CCD) memory, commonly used memory chips, ROM as a PLD, programmable logic array (PLA), programmable array logic (PAL), complex programmable logic devices (CPLDS), field programmable gate array (FPGA).

Text/References:

1. A. P. Malvino and DP Leach, “Digital Principles and Applications”, McGraw Hill Education.
2. R. Tokheim, “Digital Electronics: Principles and Applications”, McGraw Hill Education.
3. M. M. Mano, "Digital logic and Computer design", Pearson Education India,2016.
4. H. Taub and D. Schilling, “Digital Integrated Electronics”, McGraw Hill Education
5. A. K. Sharma, "Programmable Logic Handbook: PLDs, CPLDs and FPGAs", McGraw Hill Education.

Course PCC-EE 402: Power Systems-I

Course Outcomes:

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

CO1	Understand the concepts of power systems and various power system components.
CO2	Analyse fault currents for different types of faults.
CO3	Understand the generation of over-voltages and insulation coordination.
CO4	Understand basic concepts of relay and switchgear with their applications in protections.

Module1: Basic Concepts (6 Hours)

Evolution of Power Systems and Present-Day Scenario, Structure of a power system: Bulk Power Grids and Micro-grids, Generation: Conventional and Renewable Energy Sources. Distributed Energy Resources, Energy Storage Transmission and Distribution Systems: Line diagrams, transmission and distribution voltage levels and topologies (meshed and radial systems). Synchronous Grids and Asynchronous (DC) interconnections, Review of Three-phase systems, Analysis of simple three-phase circuits, balanced network, symmetrical components, unbalanced networks, delta - star transformation, Power Transfer in AC circuits and Reactive Power.

Module2: Power System Components (14 Hours)

Overhead Transmission Lines and Cables: Electrical and Magnetic Fields around conductors, Corona. Parameters of lines and cables, Capacitance and Inductance calculations for simple configurations, Travelling-wave Equations, Sinusoidal Steady state representation of Lines: Short, medium and long lines. Losses in a transmission line, Lossless line: equation, voltage and current distribution, characteristics, uses of transmission line as circuit elements. Power Transfer, Voltage profile and Reactive Power, Surge Impedance Loading, Series and Shunt Compensation of transmission lines.

Synchronous Machines: Steady-state performance characteristics. Operation when connected to infinite bus. Real and Reactive Power Capability Curve of generators. Typical waveform under balanced terminal short circuit conditions – steady state, transient and sub-transient equivalent circuits. Loads: Types, Voltage and Frequency Dependence of Loads. Per-unit System and per-unit calculations.

Module 3: Relays and Switchgear (6 Hours)

Relays: Torque equation of an induction relay, Construction, principle of operation, characteristics and application of non-directional over current and earth fault relays, Operation of Induction Disc and Cup type relays, non-directional and directional relays, and different connection schemes, Protection schemes (Over-current, directional, distance protection, differential protection).

Switchgear: Types of Circuit Breakers, Circuit breaker: arc formation, quenching, restriking voltage, and recovery voltage; circuit breaker rating; tripping of circuit breakers by relays, ACB, OCB, Attributes of Protection schemes, Back-up Protection.

Module 4: Fault Analysis (10 Hours)
Method of Symmetrical Components (positive, negative and zero sequences), Balanced and Unbalanced Faults, Representation of generators, lines and transformers in sequence networks, Computation of Fault Currents, Neutral Grounding.

Module5: Over-voltages and Insulation Requirements (4 Hours)
Generation of Over-voltages: Lightning and Switching Surges. Protection against Over-voltages, Insulation Coordination, Propagation of Surges, Voltages produced by traveling surges, Bewley Diagrams.

Text/References:
1. J. Grainger and W.D. Stevenson, "Power System Analysis", McGraw Hill Education,1994.
2. O.I. Elgerd, "Electric Energy Systems Theory", McGrawHillEducation,1995.
3. A. R. Bergen and V. Vittal, "Power System Analysis", Pearson EducationInc.,1999.
4. D.P. Kothari and I. J. Nagrath, "Modern Power System Analysis", McGraw Hill Education, 2003.
5. B.M. Weedy, B.J.Cory, N. Jenkins, J. Ekanayake and G. Strbac, "Electric Power Systems", Wiley, 2012.
6. G S Brosan and J T Hayden "Advanced Electrical Power and Machines" Pitmann, London, 1966
7. "Art and Science of Protective Relaying" C R Mason, Wiley, 2015

Course PCC-EE 403: Control Systems

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

CO1	Understand the modelling of linear-time-invariant systems using transfer function and state-space representations.
CO2	Understand the concept of stability and its assessment for linear-time invariant systems.
CO3	Analyse and Design simple feedback controllers.
CO4	Understand basic concepts of optimal control with non-linear system.

Module1: Introduction to control problem (4 Hours)
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 algebra, signal flow graph.

Module2: Time Response Analysis (10 Hours)
Standard test signals. Time response of first and second order systems for standard test inputs.
Application of initial and final value theorem. Design specifications for second-order systems based on the time-response. Concept of Stability. Routh-Hurwitz Criteria. Relative Stability analysis. Root-Locus technique. Construction of Root-loci.

Module 3: Frequency-response analysis (6 Hours)
Relationship between time and frequency response, Polar plots, Bode plots. Nyquist stability criterion.
Relative stability using Nyquist criterion–gain and phase margin. Closed-loop frequency response.

Module 4: Introduction to Controller Design (8 Hours)
Stability, steady-state accuracy, transient accuracy, disturbance rejection, insensitivity and robustness of control systems. Root-loci method of feedback controller design. Design specifications in frequency-domain. Frequency-domain methods of design. Application of Proportional, Integral and Derivative Controllers, Lead and Lag compensation in designs. Analog and Digital implementation of controllers.

Module 5: State variable Analysis (10 Hours)
Concepts of state variables. State space model. Diagonalization of State Matrix. Solution of state equations. Eigen values and Stability Analysis. Concept of controllability and observability. Pole-placement by state feedback. Discrete-time systems. Difference Equations. State-space models of linear discrete-time systems. Stability of linear discrete-time systems.

Module 6: Introduction to Optimal Control and Nonlinear Control (4 Hours)
Performance Indices. Regulator problem, Tracking Problem. Nonlinear system– Basic concepts and analysis.

Text/References:
1. M. Gopal, "Control Systems: Principles and Design", McGraw Hill Education,1997.
2. B. C. Kuo, "Automatic Control System", Prentice Hall, 1995.
3. K. Ogata, "Modern Control Engineering", Prentice Hall, 1991.
4. I. J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International, 2009
5. R. T. Stefani, B. Shahian, C. J. Savant, and G. H. Hostetter, "Design of Feedback Control Systems", Oxford University Press.
6. N.S. Nise, "Control Systems Engineering", Willey Publications.

Course PCC-EE 404: Signals and Systems
Course Outcomes:
At the end of this course, students will demonstrate the ability to

CO1	Understand the concepts of continuous time and discrete time systems.
CO2	Analyze systems in complex frequency domain.
CO3	Understand different transformation techniques.
CO4	Understand sampling theorem and its implications.

Module 1: Introduction to Signals and Systems (8 Hours)
Signal properties: periodicity, absolute integrability, determinism and stochastic character. Some special signals of importance: the unit step, the unit impulse, the sinusoid, the complex exponential, some special time-limited signals; continuous and discrete time signals, continuous and discrete amplitude signals. System properties: linearity: additivity and homogeneity, shift-invariance, causality, stability, realizability. Examples.

Module 2: Behavior of continuous and discrete-time LTI systems (12 Hours)
Impulse response and step response, convolution, input-output behavior with aperiodic convergent inputs, cascade interconnections. Characterization of causality and stability of LTI systems. System representation through differential equations and difference equations. State-space Representation of systems. State-Space Analysis, Multi-input, multi-output representation. State Transition Matrix and

its Role. Periodic inputs to an LTI system, the notion of a frequency response and its relation to the impulse response.

Module 3: Fourier, Laplace and z-Transforms (14 Hours)
Fourier series representation of periodic signals, Wave form Symmetries, Calculation of Fourier Coefficients. Fourier Transform, convolution/multiplication and their effect in the frequency domain, magnitude and phase response, Fourier domain duality. The Discrete-Time Fourier Transform (DTFT) and the Discrete Fourier Transform (DFT). Parseval's Theorem. Review of the Laplace Transform for continuous time signals and systems, system functions, poles and zeros of system functions and signals, Laplace domain analysis, solution to differential equations and system behavior. The z-Transform for discrete time signals and systems, system functions, poles and zeros of systems and sequences, z-domain analysis.

Module 4: Sampling and Reconstruction (6 Hours)
The Sampling Theorem and its implications. Spectra of sampled signals. Reconstruction: ideal interpolator, zero-order hold, first-order hold. Aliasing and its effects. Relation between continuous and discrete time systems. Introduction to the applications of signal and system theory: modulation for communication, filtering, feedback control systems.

Text/References:
1. V. Oppenheim, A. S. Willsky and S. H. Nawab, “Signals and systems”,Prentice Hall India, 1997.
2. J. G. Proakis and D. G. Manolakis, “Digital Signal Processing: Principles, Algorithms, and Applications”, Pearson, 2006.
3. H. P. Hsu, “Signals and systems”, Schaum’s series, McGraw Hill Education,2010.
4. S. Haykin and B.V. Veen, “Signals and Systems”, John Wiley and Sons,2007.
5. V. Oppenheim and R. W. Schafer, “Discrete-Time Signal Processing”, Prentice Hall, 2009.
6. M. J. Robert “Fundamentals of Signals and Systems”, McGraw Hill Education,2007.
7. B. P. Lathi, “Linear Systems and Signals”, Oxford University Press,2009.
8. S. K. Mitra,” Signals and Systems”, Oxford University Press.

Course BSC405: Mathematics-III

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

CO1	Develop the concept of probability, probability distribution and bivariate distribution.
CO2	Develop the concept of Basic statistics and applied statistics.
CO3	Develop the concept of Calculus of variation.

Module 1: Probability and Distributions (14 Hours)
Probability spaces, conditional probability, independence; Discrete random variables, Independent random variables, the multinomial distribution, Poisson approximation to the binomial distribution, infinite sequences of Bernoulli trials, sums of independent random variables; Expectation of Discrete Random Variables, Moments, Variance of a sum, Correlation coefficient, Chebyshev's Inequality. Continuous random variables and their properties, distribution functions and densities, normal exponential and gamma densities. Bivariate distributions and their properties, distribution of sums and quotients, conditional densities, Bayes' rule.

Module 2: Introduction to Statistics (16 Hours)

Measures of Central tendency: Moments, skewness and Kurtosis - Probability distributions: Binomial, Poisson and Normal-evaluation of statistical parameters for these three distributions, Correlation and regression–Rank correlation, Curve fitting by the method of least squares-fitting of straight lines, second degree parabolas and more general curves. Test of significance: Large sample test for single proportion, difference of proportions, single mean, difference of means, and difference of standard deviations, test for single mean, difference of means and correlation coefficients, test for ratio of variances- Chi-square test for goodness off it and independence of attributes.

Module 7: Calculus of variation (10 Hours)
Functions of complex variable and conformal transformation: Analytical complex function: Cauchy-Rieman differential equations, harmonic function, line integral of complex function, Cauchy's integral theorem, derivative of analytical function, modulus and real value theorem, Residue and Cauchy's residue theorem; Definite integrals by the method of residue; Jordan's lemma, Mapping of complex functions: Conformal mapping, critical point of transformation.

Text/References:
1. M.R. Spiegel, "Schaum's outline of Theory and Problems of Probability and Statistics", McGraw Hill.
2. R. A. Johnson, I. Miller, J.Freund, " Miller & Freund's Probability and Statistics for Engineers", Pearson.
3. C.W. Therrien & M. Tummala," Probability and Random processes for electrical and computer engineers", CRC Press.
4. R.A. Johnson & D. W. Wichern, "Applied multivariate statistical analysis", PHI
5.A.S. Gupta,"Calculus of variation with applications", PHI
6.M.L.Krasnov, G.K. Makarenko and A.I. Kiselev,"Problems and excersizes in the calculus of variations", MIR Publication

PRACTICAL PAPERS

Course LC-EE 406: Analog and Digital Electronics Laboratory

Course Outcomes:

At the end of this course, students will have the ability to

CO1	Exercise the operation of 4-bit adder and subtractor, encoder and decoder, multiplexer and demultiplexer.
CO2	Study the application of different Flip-flops, 4 Bit Shift Register and Counters.
CO3	Experiment and application of analog electronic circuits, 8 Bit ADC and DAC.
CO4	Develop test electronic circuits using experiment boards with simulation.

List of Experiments

1. Characteristics of BJT, MOSFET
2. Applications of Op Amp: Adder, Subtractor, Differentiator, Integrator, Instrumentation Amplifier, Active filters
3. Applications of 555 timer: monostable, bistable and astable multivibrator
4. Simulation of Electronics circuits, idea of PCB design
5. Tests on Oscillators
6. Zero Crossing Detector (ZCD)
7. Analog to Digital Converter (ADC)
8. Digital to Analog Converter (DAC)
9. 16:1 Multiplexer circuit

10. Demultiplexer 1:16 circuit
11. Flip-flop: a) JK, b) SR
12. Counter: a) Ring, b) Jhonson
13. Adder: a) Half, b) Full
14. Subtractor

Course LC-EE407: Power Systems–I Laboratory

Course Outcomes:

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

CO1	Vsualize various power system components.
CO2	Realise and analyse about the transmission line parameters with two port networking concept and Ferranti effect.
CO3	Design and develop a protection scheme with the study of various relay operating characteristics.
CO4	Realise the implications of V curves of grid connected synchronous machines.

List of Experiments

1. To draw single line diagram of entire power system with different components.
2. To study Ferranti Effect in a HV transmission line with variable sending end voltages and variable line lengths.
3. Determination of ABCD constants of short, medium and long transmission line.
4. To study the characteristic non directional, directional over current relay with different PSM and TSM settings.
5. To study the characteristic over voltage and under voltage relay.
6. Design and implement a protection scheme using any one relay.
7. To draw the V-curves of Synchronous machine and its consequences.

Course LC-EE 408: Control Systems Laboratory

Course Outcomes:

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

CO1	Realize the basic control system concept using MATLAB.
CO2	Analyse about the time responses of different order and type of control system.
CO3	Analyse about the frequency responses of different control systems.
CO4	Design a the controller for DC motor and servo motor operation.

List of Experiments

1. Familiarization of basic control system functions and blocks using MATLAB and SIMULINK toolbox.
2. Simulation of step response and impulse response for different 'order' and ‘Type’ of systems with unity feedback using MATLAB.
3. Determination of step and impulse response of second order systems and determination of transient response specifications.
4. Determination of root locus, Bode plot, polar plot and Nyquist plot using MATLAB functions for different system.
5. Design of PID controller of a plant using MATLAB.
6. Determination of transfer function from state space and vice-versa using MATLAB.
7. Transfer function realization using analog circuit modules.
8. Study of servo position control system.

9. Study of armature control and field control of DC motor.

Detailed Syllabus: 5th SEMESTER

THEORETICAL PAPERS

Course PCC-EE 501: Electrical Machines–II

Course Outcomes:

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

CO1	Understand the concepts of rotating magnetic fields.
CO2	Understand the operation of different ac machines.
CO3	Analyse performance characteristics of different ac machines.
CO4	Understand the concepts of special machines.

Module 1: Three phase Induction Machines (18 Hours)

Polyphase induction machine: Brief overview, construction, rotating magnetic field, simplified theory with constant flux, equivalent circuit, vector diagram, torque slip curve, power slip curve, effects of rotor resistance; frequency changer, circle diagram, performance calculations using circle diagram, performance test, starting, braking. Stability issues, crawling and cogging, high torque motors, harmonic torque, speed control methods, single phasing, rotor circuit unbalance, commissioning tests, relevant IS specifications, selection of motors. Induction generators: operating principle, implications and uses.

Module2: Synchronous Generator (10 Hours)

Synchronous Generator: principle of operation, construction, windings; excitation systems, emf equation, generated emf of 3-phase generator, pitch factor, distribution factor, different reactances, armature reaction, equivalent circuit, regulation: synchronous impedance method, old AIEE method, Potier reactance method. Parallel operation of synchronous generators, Synchronising techniques, phasor diagram, synchronizing current, torque, Load - frequency curve.

Module 3: Synchronous Motor (6 Hours)

Synchronous motor: starting, phasor diagram, characteristics, torque-angle relationship, uses. Synchronous condenser: steady state operation, uses.
Salient pole machine: two reaction theory, direct axis and quadrature axis reactances, phasor diagram, Torque-angle characteristic.

Module 4: Fractional Horse Power and Special Motors (8 Hours)

Single-phase induction Motor, BLDC, SRM, PMSM, Stepper Motor: constructional features, principle of operation and applications.

Text/References:

1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery", New York, McGraw Hill Education.
2. M. G. Say, "Performance and design of AC machines", CBS Publishers.
3. C.I. Hubert, "Electric Machines: Theory, Operating Applications and Control", Pearson
4. A. F. Puchstein and T.C. Lloyd, "Alternating Current Machines", John Wiley & Sons, Inc.
5. D. V. Richardson, "Rotating electric machinery and transformer technology", Prentice-Hall Inc.
6. H. Cotton, "Advanced Electrical Technology", Pitman.
7. V. Del Toro, "Basic electric machines", Prentice-Hall Inc.

8. I. L. Kosow, “Electric Machinery & Transformers”, PHI
9. A.S. Langsdorf, “Alternating current machines”, McGraw Hill Education, 1984.
10. P. C. Sen, “Principles of Electric Machines and Power Electronics”, John Wiley & Sons, 2007.
11. G.S. Brosan and J. T. Hayden,”Advanced Electrical Power and Machinary”, Pitman
12. S.K.Sen, “Electrical Machinary”, Khanna Publishers

Course PCC-EE 502: Power Electronics

Course Outcomes:

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

CO1	Understand the power electronics devices.
CO2	Understand and analyse uncontrolled rectifier circuits.
CO3	Understand and analyse the operation of DC-AC, DC-DC converters.
CO4	Understand the operation of power supply.

Module 1: Power switching devices (6 Hours)

Diode, Thyristor, MOSFET, IGBT: I-V Characteristics; Firing circuit for thyristor; Voltage and current commutation of a thyristor; Gate drive circuits for MOSFET and IGBT.

Module 2: Thyristor rectifiers (8 Hours)

Single-phase half-wave and full-wave rectifiers, Single-phase full-bridge thyristor rectifier with R-load and highly inductive load; Three-phase full-bridge thyristor rectifier with R-load and highly Inductive load; Input current wave shape and power factor.

Module 3: DC-DC buck and boost converter (12 Hours)

Elementary chopper with an active switch and diode, concepts of duty ratio and average voltage, classification of choppers, Power circuit of a buck converter, analysis and waveforms at steady state, duty ratio control of output voltage. Power circuit of a boost converter, analysis and waveforms at steady state, relation between duty ratio and average output voltage.

Module 4: Voltage source inverter (12 Hours)

Single-phase: Power circuit of single-phase voltage source inverter, switch states and instantaneous output voltage, Square wave operation of the inverter, concept of average voltage over a switching cycle, bipolar sinusoidal modulation and unipolar sinusoidal modulation, modulation index and output voltage

Three-phase: Power circuit of a three-phase voltage source inverter, switch states, instantaneous output voltages, average output voltages over a sub-cycle, three-phase sinusoidal modulation.

Module 5: Power Supply (4 Hours)

Introduction to auxiliary power supply, linear power Supply, regulated power supply, switch mode power supply (SMPS), practical design examples

Text/References:

1. M. H. Rashid, “Power electronics: circuits, devices, and applications”, Pearson Education India, 2009.
2. N. Mohan and T. M. Undeland, “Power Electronics: Converters, Applications and Design”, John Wiley & Sons, 2007.
3. R. W. Erickson and D. Maksimovic, “Fundamentals of Power Electronics”, Springer Science & Business Media, 2007.

4. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India,2009.
5. M. Ramamoorty: "An Introduction to Thyristors and Their Applications", Macmillan Press Limited.
6. B.D. Bedford, Richard G. Hoft:, "Principles of Inverter Circuits", John Wiley & Sons Inc
7. R. Ramshaw: "Power Electronics: Thyristor Controlled Power Electric Motors", Chapman and Hall publication
8. S. Maniktala, "Switching power supplies A-Z", Newnes publication

Course PCC-EE 503: Microprocessors

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

CO1	Understand the basic concept and architecture of Microprocessors.
CO2	Do assembly language programming with clear understanding of algorithms.
CO3	Develop knowledge of interfacing of peripherals like I/O, A/D, D/A, timer etc.
CO4	Develop systems using microprocessor and understand microcontroller.

Module 1: 8085 Microprocessor Architecture (8 Hours)
Microprocessor Architecture-8085 microprocessor CPU architecture, pin diagram, temporary registers, ALU, timing and control unit, machine cycles, bus interfacing, memory maps, special function registers, stack memory.

Module 2: Data transfer techniques (4 Hours)
Data transfer techniques: Programmed data transfer, concept of interrupt, Insterrupts of 8085, interrupt priority, interrupt driven data transfer, 8259 programmeble interrupt controller, DMA transfer, 8257 DMA controller.

Module 3: Interfacing issues (8 Hours)
Interfacing- Basic principles of interfacing memory and I/O devices, 8255A programmable peripheral interface, Interfacing of D/A and A/D converter, Concept of serial data transfer, 8251 USART; concept of timer and counter, 8253 programmable timer interval IC.

Module 4: Instruction set and programming (14 Hours)
Programming of 8085 mocroprocessors: Addressing modes, instruction set, assembly language programming, simple numerical operations, data sorting examples, block data movement.

Module 5: 8051 microcontroller introductions (6 Hours)
Microcontroller- 8051 basics, architecture, Internal RAM, SFR area, Instruction set and basic interfacing programes.

Text/References:
1. R. S. Gaonkar, Microprocessor Architecture: Programming and Applications with the 8085", Penram International Publishing,1996
2. D. A. Patterson and J. H. Hennessy, "Computer Organization and Design: The Hardware/Software interface", Morgan Kaufman Publishers,2013.
3. D. V. Hall, "Microprocessors & Interfacing", McGraw Hill Higher Education, 1991.

4. B. Ram, “Fundamentals of Microprocessors & Microcontrollers”, Dhanpat Rai Publications.
5. M. A. Mazidi, J. G. Mazidi and R. D. McKinlay, “The 8051 Microcontroller and Embedded Systems: Using Assembly and C”, Pearson Education, 2007.
6. K. J. Ayala, “8051Microcontroller”, Delmar Cengage Learning, 2004.

Course PEC-EE 504: Professional Elective-I

Out of the subjects mentioned in professional elective courses, only one has to select for study. For details please see professional elective course portion.

Course OEC-EE 505: Open Elective -I

Out of the subjects mentioned in open elective courses, only one has to select for study. For details please see open elective course portion.

PRACTICAL PAPERS

Course LC-EE 506: Electrical Machines–II Laboratory

Course Outcomes:

At the end of this course, students will have the ability to

CO1	Visualise the operation and study the characteristics of induction machines.
CO2	Analyse the starting method of three phase induction machines.
CO3	Realise the synchronization and parallel operation features of synchronous machines.
CO4	Realise the operation and characteristics of synchronous machines.

List of Experiments

1. Study of no-load and blocked rotor test of three phase and single phase induction motor.
2. Load test on induction motor to find percentage slip, power factor, H.P. output and efficiency and draw the circle diagram.
3. Study of induction machine as a frequency changer.
4. Perform load test on three phase alternator to determine the voltage regulation of alternator.
5. Perform parallel operation of alternator with infinite bus using synchroscope and lamp method to synchronize the machine with the bus system.

Study of V-curves of synchronous machines.

Course LC-EE 507: Electronics Design Laboratory

Course Outcomes:

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

CO1	Understand the practical issues related to practical implementation of applications using electronic circuits.
CO2	Choose appropriate components, software and hardware platforms.
CO3	Design a Printed Circuit Board, get it made and populate/solder it with components.
CO4	Work as a team with other students to implement an application.

List of Experiments

1. Basic concepts on measurements;
2. Noise in electronic systems;
3. Sensors and signal conditioning circuits;
4. Introduction to electronic instrumentation and PC based data acquisition;
5. Analog Electronic system design;
6. Interfacing of analog and digital systems,
7. Embedded systems, Electronic system design employing microcontrollers, CPLDs, and FPGAs;
8. PCB design and layout; System assembly considerations.

Group projects involving electronic hardware (Analog, Digital, mixed signal) leading to implementation of an application.

Course LC-EE 508: Microprocessors Laboratory

Course Outcomes:

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

CO5	Understand to use the basic operation of 8085 microprocessor kit.
CO6	Understand about arithmetic operation and algorithm development.
CO7	Understand about interfacing for the relay operation, and stepper motor control using microcontroller.
CO8	Understand the display operation with a real time clock using microcontroller.

List of Experiments

1. Addition of x number of 8 bit numbers: x may be two or any higher integer number
2. Addition of x number of 16 bit numbers: x may be two or any higher integer number
3. Subtraction of two 8 bit numbers
4. Multiplication of two 8 bit numbers
5. Division of two 8 bit numbers
6. Identification of I/O ports
7. Arrangement of 10 bytes of data in ascending and descending order by sorting algorithm
8. On and OFF control of relay for protection purposes
9. Making of Real Time Clock using microcontroller
10. Interfacing of Stepper motor using microcontroller

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Detailed Syllabus: 6th SEMESTER

THEORETICAL PAPERS

Course PCC-EE 601: Power Systems–II

Course Outcomes:

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

CO1	Use numerical methods to analyses power system in steady state.
CO2	Understand stability constraints in a synchronous grid.
CO3	Understand methods to control the voltage, frequency and power flow.
CO4	Understand the monitoring and control of a power system.
CO5	Understand the basics of power system economics.

Module 1: Power Flow Analysis (10 Hours)

Review of the structure of a Power System and its components.

Analysis of Power Flows: Formation of Bus Admittance Matrix. Real and reactive power balance equations at anode. Load and Generator Specifications, Application of numerical methods for solution of non-linear algebraic equations- Gauss Seidel and Newton-Raphson methods for the solution of the power flow equations, Computational Issues in Large-scale Power Systems.

Module 2: Stability Constraints in synchronous grids (10 Hours)

Swing Equations of a synchronous machine connected to an infinite bus, Power angle curve, Description of the phenomena of loss of synchronism in a single-machine infinite bus system, Following a disturbance like a three-phase fault, Analysis using numerical integration of swing equations (using methods like Forward Euler, Runge-Kutta 4th order methods), as well as the Equal Area Criterion, Impact of stability constraints on Power System Operation, Effect of generation rescheduling and series compensation of transmission lines on stability.

Module 3: Control of Frequency and Voltage (10 Hours)

Turbines and Speed-Governors, Frequency dependence of loads, Droop Control and Power Sharing, Automatic Generation Control, Generation and absorption of reactive power by various components of a Power System. Excitation System Control in synchronous generators, Automatic Voltage Regulators, Shunt Compensators, Static VAR compensators and STATCOMs, Tap Changing Transformers. Power flow control using embedded dc links, phase shifters.

Module 4: Fault Analysis: its necessity, contributors to fault current, symmetrical faults, consideration of load current, fault current calculations using computer in n-bus system, current limiting reactors, construction, operation, rating, placement in power system, protection, asymmetrical fault: sequence networks for generators, single line to ground, double line to ground, and line to line fault, sequence network for transformer and transmission line, analysis of a complete power system, Computer aided calculations; Application of fault analysis in power system co-ordination using different power system software. (18 Hr)

Text/References:

1. J. Grainger and W.D. Stevenson, “Power System Analysis”, McGrawHillEducation,1994.
2. O. I. Elgerd, “Electric Energy Systems Theory”, McGraw Hill Education,1995.
3. A. R. Bergen and V. Vittal, “Power System Analysis”, Pearson EducationInc.,1999.

4. D. P. Kothari and I. J. Nagrath, "Modern Power System Analysis", McGraw Hill Education,2003.
5. B. M. Weedy, B.J. Cory, N. Jenkins, J. Ekanayake and G. Strbac, "Electric Power Systems", Wiley, 2012.
6. E W Kimbark "Power System Stability" IEEE Press, Wiley Interscience, NY
7. Prabha Kundur "Power System Stability and Control" McGraw Hill Education

Course PCC-EE 602: Computer Programming

Course Outcomes:

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

CO1	Understanding of windows environment using VB.Net
CO2	Design and development of GUI in windows with custom made requirements
CO3	The fundamentals of Python programming.
CO4	Application of various Python libraries for customised hardware and software based system developments.

Lectures with laboratory Demonstrations:

Module 1: Introduction to Visual basic (8 hour)

Fundamentals of GUI development using VB.Net, Concepts of object, method and event in VB.Net, Utilisation of various tools, Components and References, basic concept of event handling, I/O File handling and data handling.

Module 2: Visual basic Programming (10 hour)

Learn to develop program in windows environment, simple display program, Key board and mouse interactive program, Reading and writing I/O files, handling of other windows program - like reading and writing Excel file, Excel plotting, interfacing of USB/COM ports, development of net based application in client/server mode.

Module 3: Introduction to Python libraries (10 hour)

Python Types, Expressions, Strings, Lists, Tuples, Python memory model (names, mutable and immutable values), List operations, Regular Expressions, Python Functions, Abstract Data types, Classes and Objects in Python, Exception handling, Handling files, Python Scientific/Statistical/Machine Learning Libraries.

Module 4: Python programming (12 hour)

Python Programming: Object based program using multi threading, I/O handling of files, Printing and display using timer operation, program for handling of interfacing of cameras, program to develop machine learning based applications.

Text/References:

1. D. Kuhlman,"A Python Book: Beginning Python, Advanced Python, and Python Exercises".
2. R. L. Halterman, "Learning To Program With Python",
3. C. H. Swaroop, "A Byte of Python",www.ebshelf.com
4. S. Holzner,"Visual Basic .Net Programming"- Black Book
5. S. Holzner,"Visual Basic 6 Programming"- Black Book
6. H. Schildt, " Java: The Complete Reference", Rupa Publication

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Course PCC-EE 603: Electrical Drives

Course Outcomes:

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

CO1	Understand the fundamentals of Electric drives.
CO2	Understand the operation and control schemes of DC motor drives.
CO3	Understand the operation and control schemes of AC motor drives.
CO4	Understand the drives for Traction system.

Module 1: Introduction of Electrical drives (4 Hours)

Dynamics of electrical drives, closed loop control, selection of motor power ratings. Different components of drive: speed measurement, torque measurement, current measurement, phase locked loop.

Module 2: DC motor drive: (12 Hours)

DC motor characteristics, braking, speed control methods of DC motor. Contactor based DC motor speed control, Controlled rectifier-based DC motor drive, Chopper fed DC Drive.

Module 3: Induction and Synchronous Motor Drive (14 Hours)

Induction motor characteristics, NEMA classification, Braking, Different methods of speed control: voltage control, frequency control, Variable Voltage variable frequency Control, rotor resistance control, slip power recovery control: Static Scherbius drive, Static Kramer drive, VSI: 120 and 180 degree mode of conduction, CSI, Cycloconverter used in AC drive.

Module 4: Traction Drive (10 Hours)

General overview of traction and Indian traction services, Different drives for different electrical motors and their different operating modes: Electrical traction service, nature of traction load, braking. Introduction to PLC based Drives and its applications in industry.

Text/References:

1. G. K. Dubey, “Power Semiconductor Controlled Drives”, PrenticeHall,1989.
2. R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control”, Prentice Hall, 2001.
3. G. K. Dubey, “Fundamentals of Electrical Drives”, CRC Press ,2002.
4. W. Leonhard, “Control of Electric Drives”, Springer Science & Business Media, 2001.
5. P.C. Sen, “Thyristor Dc Drives”, John Wiley, NY.
6. B.K. Bose, “Modern Power Electronics and AC Drives”, PHI.

Course PEC-EE 604: Professional Elective-II

Out of the subjects mentioned in professional elective courses, only one has to select for study. For details pl. see professional elective course portion.

Course OEC-EE 605: Open Elective-II

Out of the subjects mentioned in open elective courses, only one has to select for study. For details pl. see open elective course portion.

Course HSMC 606: HS-II

Out of the subjects mentioned in humanities, social science including management courses (HSMC), only one will be offered for study. For details pl. see HSMC portion.

PRACTICAL PAPERS

Course LC-EE 607: Power Electronics and Drives Laboratory

Course Outcomes:

At the end of this course, students will have the ability to

CO1	Get exposure to power semiconductor devices, like Diodes, Power BJT, Power MOSFET etc. and their basic characteristics.
CO2	Study different types of converters, chopper and inverters circuits with different types of loads.
CO3	Applications of converters, choppers in DC and AC drive.
CO4	Get exposure to power electronics circuit simulation software as well as to analyse the control features of both ac and dc drives.

List of Experiments

1. Study the V-I characteristics of SCR, DIAC and TRIAC
2. Study the V-I Characteristics of an enhancement MOSFET and calculate different parameters.
3. Familiarization of Diode-Resistance and Diode-Resistance-Capacitance firing circuit of an SCR.
4. Study load voltage waveforms of single-phase controlled bridge converter for different types of load.
5. Application of single-phase inverter to drive ac machine.
6. Study of chopper circuits for different types of load.
7. Study of different types of converter circuits using simulation software.
8. Application of VFD to drive 3 phase ac machine along with Numeric relay and PLC.
9. Application of DC converters to drive DC loads.

Course LC-EE 608: Power Systems-II Laboratory

Course Outcomes:

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

CO1	Understand the real power flow issues in HVAC lines with various line length and loading conditions.
CO2	Understand the reactive power flow profiles in HVAC lines with various line length and loading conditions.
CO3	Understand the IDMT characteristics of over current and earth fault relays.
CO4	Understand the concept of power system load flow and fault analysis through simulation.

List of Experiments

1. To study the power flow characteristics with different line length of HVAC Transmission line.

2. To study the voltage profile variation with different loadings and with different line lengths of HVAC Transmission line.
3. To study the reactive power profile with different loadings and with different line lengths of HVAC Transmission line.
4. To study the IDMT characteristic of directional and non-directional over current and earth fault relay.
5. To simulate load flow and fault analysis schemes using ETAP software

Detailed Syllabus: 7th SEMESTER

THEORETICAL PAPERS

Course PEC-EE 701: Professional Elective-III

Out of the subjects mentioned in professional elective courses, only one has to select for study. For details pl. see professional elective course portion.

Course PEC-EE 702: Professional Elective-IV

Out of the subjects mentioned in professional elective courses, only one has to select for study. For details pl. see professional elective course portion.

Course OEC-EE 703: Open Elective-III

Out of the subjects mentioned in open elective courses, only one has to select for study. For details pl. see open elective course portion.

Course OEC-EE 704: Open Elective-IV

Out of the subjects mentioned in open elective courses, only one has to select for study. For details pl. see open elective course portion.

Course HSMC-705: HS-III

Out of the subjects mentioned in humanities, social science including management courses (HSMC), only one will be offered for study. For details please see HSMC portion.

Course PROJ-EE 706: Project Stage-I

Course Outcomes:

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

CO1	Survey and study of published literature on the assigned topic.
CO2	Understand the working out a preliminary approach to the problem relating to the assigned topic.
CO3	Conduct preliminary Analysis/Modeling/Simulation/Experiment/ Design/Feasibility.
CO4	Prepare a written report and power point presentation on the study.

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Detailed Syllabus: 8th SEMESTER

THEORETICAL PAPERS

Course PEC-EE 801: Professional Elective-V

Out of the subjects mentioned in professional elective courses, only one has to select for study. For details pl. see professional elective course portion.

Course PROJ-EE 802: Project Stage-II

Course Outcomes:

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

CO1	Review and finalization of published literature on the assigned topic.
CO2	Understand the Working out a in depth Approach to the Problem relating to the assigned topic.
CO3	Conduct in depth Analysis/Modeling/Simulation/Experiment/ Design/Feasibility and Final development of product/process, testing, results, conclusions and future directions.
CO4	Prepare a Written Report and power point Presentation on the Study.

Course PROJ-EE 803: Seminar

Course Outcomes:

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

CO1	Learn about the engineering society through the societal developments with life-long learning
CO2	Learn about the ethics of engineering
CO3	Learn to communicate and to analyse the engineering problems using modern tools

Course PROJ-EE 804: General Viva-Voce

Course Outcomes:

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

CO1	Learn applications of acquired knowledge towards the engineering society
CO2	Learn about the importance of life-long learning.
CO3	Learn to communicate and to analyse the overall engineering problems

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PROFESSIONAL ELECTIVE COURSES

Subject Code	Subject Title
PE01	Line Commutated and Active PWM Rectifiers
PE02	Electrical Machine Design (AB, SC)
PE03	Power System Protection (JNB, AB)
PE04	HVDC Transmission Systems
PE05	Electromagnetic Waves (Field Theory)
PE06	Industrial Electrical Systems
PE07	Digital Signal Processing (NM)
PE08	Computer Architecture
PE09	Computational Electromagnetics
PE10	Wind and Solar Energy Systems
PE11	Electrical and Hybrid Vehicles
PE12	Power Quality and FACTS
PE13	Digital Control Systems (NM, AB, KDS)
PE14	Control Systems Design
PE15	Power System Dynamics and Control
PE16	Advanced Electric Drives
PE17	Electrical Energy Conservation and Auditing
PE18	High Voltage Engineering
PE19	Power Station and Substation Practice (JNB)

Detailed Syllabus

Course PE01: Line Commutated and Active PWM Rectifiers

Course Outcomes:

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

CO1	Analyse controlled rectifier circuits.
CO2	Understand the operation of line-commutated rectifiers– 6 pulse and multi-pulse configurations.
CO3	Understand the operation of PWM rectifiers–operation in rectification and regeneration modes and lagging, leading and unity power factor mode.

Module 1: Diode rectifiers with passive filtering (6 Hours)

Half-wave diode rectifier with RL and RC loads;1-phase full-wave diode rectifier with L, C and LC filter;3-phase diode rectifier with L, C and LC filter; continuous and discontinuous conduction, input current waveshape, effect of source inductance; commutation overlap.

Module 2: Thyristor rectifiers with passive filtering (6Hours)
Half-wave thyristor rectifier with RL and RC loads;1-phase thyristor rectifier with L and LC filter;3-Phase thyristor rectifier with L and LC filter; continuous and discontinuous conduction, input current wave shape.

Module 3: Multi-Pulse converter (6 Hours)
Review of transformer phase shifting, generation of 6-phase ac voltage from 3-phase ac, 6-pulse Converter and12-pulse converters with inductive loads, steady state analysis, commutation overlap, Notches during commutation.

Module 4: Single-phase ac-dc single-switch boost converter (6 Hours)
Review of dc-dc boost converter, power circuit of single-switch ac-dc converter, steady state analysis, unity power factor operation, closed-loop control structure.

Module 5: Ac-dc bidirectional boost converter (6 Hours)
Review of 1-phase inverter and 3-phase inverter, power circuits of 1-phase and 3-phase ac-dc boost converter, steady state analysis, operation at leading, lagging and unity power factors. Rectification and regenerating modes. Phasor diagrams, closed-loop control structure.

Module 6: Isolated single-phase ac-dc flyback converter (10 Hours)
Dc-dc flyback converter, output voltage as a function of duty ratio and transformer turns ratio. Power Circuit of ac-dc flyback converter, steady state analysis, unity power factor operation, closed loop control structure.

Text/References:
1. G. De, “Principles of Thyristorised Converters”, Oxford & IBH Publishing Co,1988.
2. J. G. Kassakian, M. F. Schlecht and G. C.Verghese, “Principles of Power Electronics”, Addison-Wesley, 1991.
3. L. Umanand, “Power Electronics: Essentials and Applications”, Wiley India, 2009.
4. N. Mohan and T. M. Undeland, “Power Electronics: Converters, Applications and Design”, John Wiley & Sons, 2007.
5. R. W. Erickson and D. Maksimovic, “Fundamentals of Power Electronics”, Springer Science & Business Media, 2001.

Course PE-EE02: Electrical Machine Design

Course Outcomes:

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

CO1	Understand the fundamental aspects of Electrical Machine Design.
CO2	Understand the design aspects of DC machines.
CO3	Understand the design aspects of Transformer, Induction machines.
CO4	Use software tools to design calculations.

Module 1: Introduction (4 Hours)

Major considerations in electrical machine design, electrical engineering materials, space factor, choice of specific electrical and magnetic loadings, thermal considerations, heat flow, temperature rise, rating of machines, design of inductive coil, design of electric heaters.

Module 2: DC Machines (6 Hours)
Rating of dc machine, design of field winding, choice of armature winding, design of armature winding, main dimension, specific magnetic loading, specific electrical, output equation.

Module 3: Transformers (10 Hours)
Sizing of a transformer, main dimensions, kVA output for single-and three-phase transformers, window space factor, overall dimensions, operating characteristics, regulation, no load current, temperature rise in transformers, design of cooling tank, methods for cooling of transformers

Module 4: Induction Motors (10 Hours)
Sizing of an induction motor, main dimensions, length of air gap, rules for selecting rotor slots of squirrel cage machines, design of rotor bars & slots, design of end rings, design of wound rotor, Magnetic leakage calculations, leakage reactance of poly phase machines, magnetizing current, short circuit current, circle diagram, operating characteristics

Module 5: Computer-aided Design (CAD) (10 Hours)
Introduction to Auto-CAD, Auto-CAD based design, analysis and synthesis of various electrical machines. Introduction to FEM based machine design.

Text/References:
1. A.K. Sawhney, "A Course in Electrical Machine Design", Dhanpat Raiand Sons,1970.
2. M.G. Say, "Theory & Performance & Design of A.C. Machines", ELBS London.
3. S.K. Sen, "Principles of Electrical Machine Design with computer programmes", Oxford and IBH Publishing, 2006.
4. K. L. Narang, "A Text Book of Electrical Engineering Drawings", Satya Prakashan, 1969.
5. A. Shanmugasundaram, G. Gangadharan and R.Palani, "Electrical Machine Design Data Book", New AgeInternational,1979.
6. K. M.V. Murthy, "Computer Aided Design of Electrical Machines", B.S. Publications,2008.
7. Nicola Bianchi, "Electrical Machine Analysis Using Finite Elements", CRC.

Course PE03: Power System Protection
Course Outcomes:
At the end of this course, students will demonstrate the ability to

CO1	Understand the different protection systems for transformer.
CO2	Understand the different protection systems for motor and generator.
CO3	Understand the different protection systems for transmission line
CO4	Understand the basic principles of digital protection.

Module 1: Transformer protection (10 Hours)
Over-current and earth-fault, Restricted earth fault, Merz Price differential protection scheme, Biased differential schemes, magnetising inrush current protection schemes: harmonic restraint, Harmonic blocking, Buchholz relay construction and protection.

Module 2: Generator protection (10 Hours)
Over-current and earth-fault schemes, differential schemes, protection against stator unbalance, rotor earth fault, failure of excitation, failure of prime mover, temperature protection, protection for generator transformer unit, Under-frequency and df/dt relays,

Module 3: Motor protection (6 Hours)
Under voltage, Over-voltage, Single phasing, phase reversal and thermal overload protection of motors, earth fault.

Module 4: Transmission line protection (8 Hours)
Basic principle of operation of Transmission line protection, basic concepts of distance relays, types of distance relays and their characteristics, graded schemes and relay coordination, bus bar protection.

Module 5: Modern relaying technology (6 Hours)
Pilot wire and carrier current protection, Introduction to Static relays, Microprocessor relays and Numerical relays.

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

Course PE04: HVDC Transmission Systems

Course Outcomes:

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

CO1	Understand the advantages of dc transmission over ac transmission.
CO2	Understand the operation of Line Commutated Converters and Voltage Source Converters.
CO3	Understand the control strategies used in HVDC transmission system.
CO4	Understand the improvement of power system stability using an HVDC system.

Module 1: DC Transmission Technology (4 Hours)
Comparison of AC and DC Transmission (Economics, Technical Performance and Reliability). Application of DC Transmission. Types of HVDC Systems. Components of a HVDC system. Line Commutated Converter and Voltage Source Converter based systems.

Module 2: Analysis of Line Commutated and Voltage Source Converters (10 Hours)
Line Commutated Converters (LCCs): Six pulse converter, Analysis neglecting commutation overlap, harmonics, Twelve Pulse Converters. Inverter Operation. Effect of Commutation Overlap.

Expressions for average dc voltage, AC current and reactive power absorbed by the converters. Effect of Commutation Failure, Misfire and Current Extinction in LCC links.

Voltage Source Converters (VSCs): Two and Three-level VSCs. PWM schemes: Selective Harmonic Elimination, Sinusoidal Pulse Width Modulation. Analysis of a six-pulse converter. Equations in the rotating frame. Real and Reactive power control using a VSC.

Module 3: Control of HVDC Converters: (10 Hours)

Principles of Link Control in a LCC HVDC system. Control Hierarchy, Firing Angle Controls–Phase-Locked Loop, Current and Extinction Angle Control, Starting and Stopping of a Link. Higher level Controllers Power control, Frequency Control, Stability Controllers. Reactive Power Control. Principles of Link Control in a VSC HVDC system: Power flow and dc Voltage Control. Reactive Power Control/AC voltage regulation.

Module 3: Components of HVDC systems: (8 Hours)

Smoothing Reactors, Reactive Power Sources and Filters in LCC HVDC systems DC line: Corona Effects. Insulators, Transient Over-voltages. DC line faults in LCC systems. Dc line faults in VSC systems. DC breakers. Monopolar Operation. Ground Electrodes.

Module 4: Stability Enhancement using HVDC Control (4 Hours)

Basic Concepts: Power System Angular, Voltage and Frequency Stability. Power Modulation: basic principles–synchronous and asynchronous links. Voltage Stability Problem in AC/DC systems.

Module 5: MT DC Links (4 Hours)

Multi-Terminal and Multi-Infeed Systems. Series and Parallel MT dc systems using LCCs. MT dc systems using VSCs. Modern Trends in HVDC Technology. Introduction to Modular Multi-level Converters.

Text/References:

1. K. R. Padiyar, “HVDC Power Transmission Systems”, New Age International Publishers, 2011.
2. J. Arrillaga, “High Voltage Direct Current Transmission”, Peter Peregrinus Ltd., 1983.
3. E. W. Kimbark, “Direct Current Transmission”, Vol.1, Wiley-Interscience, 1971.

Course PE 05: Electromagnetic waves

Course Outcomes:

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

CO1	Analyse transmission lines and estimate voltage and current at any point on transmission line for different load conditions.
CO2	Provide solution to real life plane wave problems for various boundary conditions.
CO3	Analyse the field equations for the wave propagation in special cases such as lossy and low loss dielectric media.
CO4	Visualize TE and TM mode patterns of field distributions in a rectangular wave-guide.
CO5	Understand and analyse radiation by antennas.

Module 1: Transmission Lines (6 Hours)
Introduction, Concept of distributed elements, Equations of voltage and current, Standing waves and impedance transformation, Lossless and low-loss transmission lines, Power transfer on a transmission line, Analysis of transmission line in terms of admittances, Transmission line calculations with the help of Smith chart, Applications of transmission line, Impedance matching using transmission lines.

Module 2: Maxwell's Equations (6 Hours)
Basic quantities of Electromagnetics, Basic laws of Electromagnetics: Gauss's law, Ampere's Circuitallaw, Faraday's law of Electromagnetic induction. Maxwell's equations, Surface charge and surface current, Boundary conditions at media interface.

Module 3: Uniform Plane Wave (7 Hours)
Homogeneous unbound medium, Wave equation for time harmonic fields, Solution of the wave equation, Uniform plane wave, Wave polarization, Wave propagation in conducting medium, Phase velocity of a wave, Power flow and Poynting vector.

Module 4: Plane Waves at Media Interface (7 Hours)
Plane wave in arbitrary direction, Plane wave at dielectric interface, Reflection and refraction of waves at dielectric interface, Total internal reflection, Wave polarization at media interface, Brewster angle, Fields and power flow at media interface, Lossy media interface, Reflection from conducting boundary.

Module 5: Wave guides (7 Hours)
Parallel plane wave guide: Transverse Electric (TE) mode, transverse Magnetic (TM) mode, Cut-off frequency, Phase velocity and dispersion. Transverse Electromagnetic (TEM) mode, Analysis of waveguide-general approach, Rectangular wave guides.

Module 6: Antennas (7 Hours)
Radiation parameters of antenna, Potential functions, Solution for potential functions, Radiations from Hertz dipole, Near field, Far field, Total power radiated by a dipole, Radiation resistance and radiation pattern of Hertz dipole, Hertz dipole in receiving mode.

Text/Reference Books
1. R. K. Shevgaonkar, "Electromagnetic Waves", Tata McGraw Hill, 2005.
2. D. K. Cheng, "Field and Wave Electromagnetics", Addison-Wesley, 1989.
3. M. N. O. Sadiku, "Elements of Electromagnetics", Oxford University Press, 2007.
4. C. A. Balanis, "Advanced Engineering Electromagnetics", John Wiley & Sons, 2012.
5. C. A. Balanis, "Antenna Theory: Analysis and Design", John Wiley & Sons, 2005.

Course PE06: Industrial Electrical Systems

Course Outcomes:

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

CO1	Understand the electrical wiring systems for residential, commercial and industrial consumers, representing the systems with standard symbols and drawings, SLD.
CO2	Understand various components of industrial electrical systems.
CO3	Analyze and select the proper size of various electrical system components.

Module 1: Electrical System Components (8 Hours)
LT system wiring components, selection of cables, wires, switches, distribution box, metering system, Tariff structure, protection components- Fuse, MCB, MCCB, ELCB, inverse current characteristics, symbols, single line diagram (SLD) of a wiring system, Contactor, Isolator, Relays, MPCB, Electric shock and Electrical safety practices.

Module 2: Residential and Commercial Electrical Systems (8 Hours)
Types of residential and commercial wiring systems, general rules and guidelines for installation, load calculation and sizing of wire, rating of main switch, distribution board and protection devices, earthing system calculations, requirements of commercial installation, deciding lighting scheme and number of lamps, earthing of commercial installation, selection and sizing of components.

Module 3: Illumination Systems (6 Hours)
Understanding various terms regarding light, lumen, intensity, candle power, lamp efficiency, specific consumption, glare, space to height ratio, waste light factor, depreciation factor, various illumination schemes, Incandescent lamps and modern luminaries like CFL, LED and their operation, energy saving in illumination systems, design of a lighting scheme for a residential and commercial premises, flood lighting.

Module 4: Industrial Electrical Systems I (8 Hours)
HT connection, industrial substation, Transformer selection, Industrial loads, motors, starting of motors, SLD, Cable and Switchgear selection, Lightning Protection, Earthing design, Power factor correction – kVAR calculations, type of compensation, Introduction to PCC, MCC panels. Specifications of LT Breakers, MCB and other LT panel components.

Module 5: Industrial Electrical Systems II (6 Hours)
DG Systems, UPS System, Electrical Systems for the elevators, Battery banks, Sizing the DG, UPS and Battery Banks, Selection of UPS and Battery Banks.

Module 6: Industrial Electrical System Automation (6 Hours)
Study of basic PLC, Role of in automation, advantages of process automation, PLC based control system design, Panel Metering and Introduction to SCADA system for distribution automation.

Text/Reference Books
1. S. L. Uppal and G. C. Garg, “Electrical Wiring, Estimating & Costing”, Khanna publishers, 2008.
2. K. B. Raina, “Electrical Design, Estimating & Costing”, New age International, 2007.
3. S. Singh and R. D. Singh, “Electrical estimating and costing”, Dhanpat Rai and Co., 1997.
4. Website for IS Standards.
5. H. Joshi, “Residential Commercial and Industrial Systems”, McGraw Hill Education, 2008.

Course PE07: Digital Signal Processing

Course Outcomes:

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

CO1	Represent signals mathematically in continuous and discrete-time and in the frequency domain.
CO2	Understand the Discrete-Fourier Transform (DFT) and the FFT algorithms.
CO3	Design digital filters for various applications.

CO4	Apply digital signal processing for the analysis of real-life signals.

Module 1: Discrete-time signals and systems (8 Hours)
Discrete time signals and systems: Sequences; representation of signals on orthogonal basis; Representation of discrete systems using difference equations, Sampling and reconstruction of signals-aliasing; Sampling theorem and Nyquist rate.

Module 2: Discrete Fourier Transform (10 Hours)
Frequency Domain Analysis, Discrete Fourier Transform (DFT), Properties of DFT, Convolution of signals, Fast Fourier Transform Algorithm, Parseval's Identity, Implementation of Discrete Time Systems.

Module 3: Design of Digital filters (12 Hours)
Design of FIR Digital filters: Window method, Park-McClellan's method. Design of IIR Digital Filters: Butterworth, Chebyshev and Elliptic Approximations; Low-pass, Band-pass, Band-stop and High-pass filters. Effect of finite register length in FIR filter design. Parametric and non-parametric spectral estimation. Introduction to multi-rate signal processing.

Module 4: Applications of Digital Signal Processing (10 Hours)
Convolution and Correlation Functions and Power Spectra, Stationary Processes, Optimal filtering using ARMA Model, Linear Mean-Square Estimation, Wiener Filter, Wavelet Transform.

Text/Reference Books:
1. S. K. Mitra, "Digital Signal Processing: A computer-based approach", McGraw Hill, 2011.
2. V. Oppenheim and R.W. Schafer, "Discrete Time Signal Processing", Prentice Hall, 1989.
3. J. G. Proakis and D.G.Manolakis, "Digital Signal Processing: Principles, Algorithms And Applications", PrenticeHall,1997.
4. L. R. Rabiner and B. Gold, "Theory and Application of Digital Signal Processing", Prentice Hall, 1992.
5. J. R. Johnson, "Introduction to Digital Signal Processing", Prentice Hall, 1992.
6. D. J. DeFatta, J. G. Lucas and W. S. Hodgkiss, "Digital Signal Processing", John Wiley & Sons, 1988.

Course PE08: Computer Architecture

Course Outcomes:

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

CO1	Understand the concepts of microprocessors, their principles and practices.
CO2	Write efficient programs in assembly language of the 8086 family of microprocessors.
CO3	Organize a modern computer system and be able to relate it to real examples.
CO4	Develop the programs in assembly language for 80286, 80386 and MIPS processors in real and protected modes.
CO5	Implement embedded applications using ATOM processor.

Module 1: Introduction to computer organization (6 Hours)

Architecture and function of general computer system, CISC Vs RISC, Data types, Integer Arithmetic - Multiplication, Division, Fixed and Floating-point representation and arithmetic, Control unit operation, Hardware implementation of CPU with Micro instruction, microprogramming, System buses, Multi-bus organization.

Module 2: Memory organization (6 Hours)
System memory, Cache memory-types and organization, Virtual memory and its implementation, Memory management unit, Magnetic Hard disks, Optical Disks.

Module 3: Input–output Organization (8 Hours)
Accessing I/O devices, Direct Memory Access and DMA controller, Interrupts and Interrupt Controllers, Arbitration, Multilevel Bus Architecture, Interface circuits - Parallel and serial port. Features of PCI and PCI Express bus.

Module 4:16 and 32 microprocessors (8 Hours)
80x86Architecture, IA–32 and IA–64, Programming model, Concurrent operation of EU and BIU, Real mode addressing, Segmentation, Addressingmodesof80x86, Instruction set of 80x86, I/O addressing in 80x86.

Module 5: Pipelining (8 Hours)
Introduction to pipelining, Instruction level pipelining (ILP), compiler techniques for ILP, Data hazards, Dynamic scheduling, Dependability, Branch cost, Branch Prediction, Influence on instruction set.

Module 6: Different Architectures (8 Hours)
VLIW Architecture, DSP Architecture, SoC architecture, MIPS Processor and programming.

Text/Reference Books
1. V. Carl, G. Zvonko and S. G. Zaky, "Computer organization", McGraw Hill, 1978.
2. B. Breyand C. R. Sarma, "The Intel microprocessors", Pearson Education, 2000.
3. J. L. Hennessy and D. A. Patterson, "Computer Architecture A Quantitative Approach", Morgan Kauffman, 2011.
4. W. Stallings, "Computer organization", PHI, 1987.
5. P. Barryand P. Crowley, "Modern Embedded Computing", Morgan Kaufmann, 2012.
6. N. Mathivanan, "Microprocessors, PC Hardware and Interfacing", Prentice Hall, 2004.
7. Y. C. Lieuand G. A.Gibson, "Microcomputer Systems: The 8086/8088 Family", Prentice Hall India, 1986.
8. J. Uffenbeck, "The 8086/8088 Design, Programming, Interfacing", Prentice Hall, 1987.
9. B. Govindarajalu, "IBMPC and Clones", Tata McGraw Hill,1 991.
10. P. Able, "8086 Assembly Language Programming", Prentice Hall India.

Course PE09: Computational Electromagnetics

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

CO1	Understand the basic concepts of electromagnetics.
CO2	Understand computational techniques for computing fields.

CO3	Organize a modern computer system and be able to relate it to real examples.
CO4	Apply the techniques to simple real-life problems.

Module 1: Introduction (6 Hours)
Conventional design methodology, Computer aided design aspects–Advantages. Review of basic fundamentals of Electrostatics and Electromagnetics. Development of Helmhotz equation, energy transformer vectors-Poynting and Slepian, magnetic Diffusion-transients and time-harmonic.

Module 2: Analytical Methods (6 Hours)
Analytical methods of solving field equations, method of separation of variables, Roth's method, integral methods-Green's function, method of images.

Module 3: Finite Difference Method (FDM) (7 Hours)
Finite Difference schemes, treatment of irregular boundaries, accuracy and stability of FD solutions, Finite-Difference Time-Domain (FDTD) method-Uniqueness and convergence.

Module 4: Finite Element Method (FEM) (7 Hours)
Overview of FEM, Variational and Galerkin Methods, shape functions, lower and higher order elements, vector elements, 2D and 3D finite elements, efficient finite element computations.

Module 5: Special Topics (7 Hours)
{Background of experimental methods-electrolytic tank, R-C network solution, Field plotting (graphical method)}, hybrid methods, coupled circuit-field computations, electromagnetic-thermal and electromagnetic-structural coupled computations, solution of equations, method of moments, Poisson's fields.

Module 6: Applications (7 Hours)
Low frequency electrical devices, static / time-harmonic / transient problems in transformers, rotating machines, actuators. CAD packages.

Text/Reference Books
1. P. P. Silvester and R. L. Ferrari "Finite Element for Electrical Engineers", Cambridge University press, 1996.
2. M. N. O. Sadiku, "Numerical Techniques in Electromagnetics", CRC press, 2001.

Course PE10: Wind and Solar Energy Systems

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

CO1	Understand the energy scenario and the consequent growth of the power generation from renewable energy sources.
CO2	Understand the basic physics of wind and solar power generation.
CO3	Understand the power electronic interfaces for wind and solar generation.
CO4	Understand the issues related to the grid-integration of solar and wind energy systems.

Module 1: Physics of Wind Power: (5 Hours)

History of wind power, Indian and Global statistics, Wind physics, Betz limit, Tip speed ratio, stall and pitch control, Wind speed statistics-probability distributions, Wind speed and power-cumulative Distribution functions.

Module 2: Wind generator topologies:(12 Hours)
Review of modern wind turbine technologies, Fixed and Variable speed wind turbines, Induction Generators, Doubly-Fed Induction Generators and their characteristics, Permanent-Magnet Synchronous Generators, Power electronics converters. Generator-Converter configurations, Converter Control.

Module 3: The Solar Resource:(3 Hours)
Introduction, solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability.

Module 4: Solar photo voltaic:(8 Hours)
Technologies-Amorphous, mono crystalline, poly crystalline; V-I characteristics of a PV cell, PV module, array, Power Electronic Converters for Solar Systems, Maximum Power Point Tracking (MPPT) algorithms. Converter Control.

Module 5: Network Integration Issues:(8 Hours)
Overview of grid code technical requirements. Fault ride-through for wind farms-real and reactive Power regulation, voltage and frequency operating limits, solar PV and wind farm behavior during grid disturbances. Power quality issues. Power system interconnection experiences in the world.

Text/References:
1. T. Ackermann, “Wind Power in Power Systems”, John WileyandSonsLtd.,2005.
2. G. M. Masters, “Renewable and Efficient Electric Power Systems”, John WileyandSons,2004.
3. S. P. Sukhatme, “Solar Energy: Principles of Thermal Collection and Storage”, McGraw Hill, 1984.
4. H. Siegfried and R.Waddington, “Grid integration of wind energy conversion systems” John Wiley and Sons Ltd.,2006.
5. G. N. Tiwari and M. K. Ghosal, “Renewable Energy Applications”, Narosa Publications,2004.
6. J. A. Duffie and W.A. Beckman, “Solar Engineering of Thermal Processes”, John Wiley & Sons,1991.

Course PE11: Electrical and Hybrid Vehicles

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

CO1	Understand the models to describe hybrid vehicles and their performance.
CO2	Understand the different possible ways of energy storage.
CO3	Understand the different strategies related to energy storage systems.
CO4	Understand the issues related to the grid-integration of solar and wind energy systems.

Module 1: Introduction (10 Hours)
Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

Module 2: Electric Trains (10 Hours)
Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

Module 3: Energy Storage (10 Hours)
Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system:
Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems.

Module 5: Energy Management Strategies (9 Hours)
Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.
Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

Text/References:
1. C. Mi, M.A. Masrur and D.W.Gao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", John Wiley & Sons, 2011.
2. S. Onori, L.Serrao and G. Rizzoni,"Hybrid Electric Vehicles: Energy Management Strategies", Springer,2015.
3. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", CRC Press,2004.
4. T. Denton, "Electric and Hybrid Vehicles", Routledge, 2016.

Course PE12: Power Quality and FACTS

Course Outcomes:

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

CO1	Understand the characteristics of ac transmission and the effect of shunt and series reactive compensation.
CO2	Understand the working principles of FACTS devices and their operating characteristics.
CO3	Understand the basic concepts of power quality.

CO4	Understand the working principles of devices to improve power quality.

Module 1: Transmission Lines and Series/Shunt Reactive Power Compensation (4 Hours)
Basics of AC Transmission. Analysis of uncompensated AC transmission lines. Passive Reactive Power Compensation. Shunt and series compensation at the mid-point of an AC line. Comparison of Series and Shunt Compensation.

Module 2: Thyristor-based Flexible AC Transmission Controllers (FACTS) (6 Hours)
Description and Characteristics of Thyristor-based FACTS devices: Static VAR Compensator (SVC), Thyristor Controlled Series Capacitor (TCSC), Thyristor Controlled Braking Resistor and Single Pole Single Throw (SPST) Switch. Configurations/Modes of Operation, Harmonics and control of SVC and TCSC. Fault Current Limiter.

Module 3: Voltage Source Converter based (FACTS) controllers (8 Hours)
Voltage Source Converters (VSC): Six Pulse VSC, Multi-pulse and Multi-level Converters, Pulse-Width Modulation for VSCs. Selective Harmonic Elimination, Sinusoidal PWM and Space Vector Modulation. STATCOM: Principle of Operation, Reactive Power Control: Type I and Type II controllers, Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC): Principle of Operation and Control. Working principle of Interphase Power Flow Controller. Other Devices: GTO Controlled Series Compensator. Fault Current Limiter.

Module 4: Application of FACTS (4 Hours)
Application of FACTS devices for power-flow control and stability improvement. Simulation example of power swing damping in a single-machine infinite bus system using a TCSC. Simulation example of voltage regulation of transmission mid-point voltage using a STATCOM.

Module 5: Power Quality Problems in Distribution Systems (4 Hours)
Power Quality problems in distribution systems: Transient and Steady state variations in voltage and frequency. Unbalance, Sags, Swells, Interruptions, Wave-form Distortions: harmonics, noise, notching, dc-offsets, fluctuations. Flicker and its measurement. Tolerance of Equipment: CBEMA curve.

Module 6: DSTATCOM (8 Hours)
Reactive Power Compensation, Harmonics an Unbalance mitigation in Distribution Systems using DSTATCOM and Shunt Active Filters. Synchronous Reference Frame Extraction of Reference Currents. Current Control Techniques in for DSTATCOM.

Module 7: Dynamic Voltage Restorer and Unified Power Quality Conditioner (6 Hours)
Voltage Sag/Swell mitigation: Dynamic Voltage Restorer–Working Principle and Control Strategies. Series Active Filtering. Unified Power Quality Conditioner (UPQC): Working Principle. Capabilities and Control Strategies.

Text/References
1. N. G. Hingorani and L.Gyugyi, “Understanding FACTS: Concepts and Technology of FACTS Systems”, Wiley-IEEE Press, 1999.
2. K. R. Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age International(P) Ltd. 2007.
3. T. J. E. Miller, “Reactive Power Control in Electric Systems”, John Wiley and Sons, New York, 1983.

4. R. C. Dugan, “Electrical Power Systems Quality”, McGraw Hill Education, 2012.
5. G. T. Heydt, “Electric Power Quality”, Starsina Circle Publications, 1991

Course PE13: Digital Control Systems

Course Outcomes:

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

CO1	Obtain discrete representation of LTI systems.
CO2	Analyze stability of open loop and closed loop discrete-time systems.
CO3	Design and analyze digital controllers.
CO4	Design state feedback and output feedback controllers.

Module1: Discrete Representation of Continuous Systems (6 Hours)

Basics of Digital Control Systems. Discrete representation of continuous systems. Sample and hold circuit. Mathematical Modelling of sample and hold circuit. Effects of Sampling and Quantization. Choice of sampling frequency. ZOH equivalent.

Module2: Discrete System Analysis (6 Hours)

Z-Transform and Inverse Z Transform for analyzing discrete time systems. Pulse Transfer function. Pulse transfer function of closed loop systems. Mapping from s-plane to z plane. Solution of Discrete time systems. Time response of discrete time system.

Module 3: Stability of Discrete Time System (4 Hours)

Stability analysis by Jury's test. Stability analysis using bilinear transformation. Design of digital control system with dead beat response. Practical issues with dead beat response design.

Module 4: State Space Approach for discrete time systems (10 Hours)

State space models of discrete systems, State space analysis. Lyapunov Stability. Controllability, reachability, Reconstructibility and observability analysis. Effect of pole zero cancellation on the controllability & observability.

Module5: Design of Digital Control System (8 Hours)

Design of Discrete PID Controller, Design of discrete state feedback controller. Design of set point tracker. Design of Discrete Observer for LTI System. Design of Discrete compensator.

Module6: Discrete output feedback control (8 Hours)

Design of discrete output feedback control. Fast output sampling (FOS) and periodic output feedback controller design for discrete time systems.

Text/References

1. K. Ogata, "Digital Control Engineering", Prentice Hall, Englewood Cliffs, 1995.
2. M. Gopal, "Digital Control Engineering", Wiley Eastern, 1988.
3. G. F. Franklin, J. D. Powell and M. L. Workman, "Digital Control of Dynamic Systems", Addison-Wesley, 1998.
4. B. C. Kuo, "Digital Control System", Holt, Rinehart and Winston,1980.

Course PE14: Control Systems Design

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

CO1	Understand various design specifications.
CO2	Design controllers to satisfy the desired design specifications using simple controller structures (P, PI, PID, compensators).
CO3	Design controllers using the state-space approach.

Module1: Design Specifications (6 Hours)
Introduction to design problem and philosophy. Introduction to time domain and frequency domain. Design specification and its physical relevance. Effect of gain on transient and steady state response. Effect of addition of pole on system performance. Effect of addition of zero on system response.

Module 2: Design of Classical Control System in the time domain (8 Hours)
Introduction to compensator. Design of Lag, lead lag-lead compensator in time domain. Feedback and Feed forward compensator design. Feedback compensation. Realization of compensators.

Module 3: Design of Classical Control System in frequency domain (8 Hours)
Compensator design in frequency domain to improve steady state and transient response. Feedback and Feed forward compensator design using bode diagram.

Module 4: Design of PID controllers (6 Hours)
Design of P, PI, PD and PID controllers in time domain and frequency domain for first, second and third order systems. Control loop with auxiliary feedback–Feed forward control.

Module 5: Control System Design in state space (8 Hours)
Review of state space representation. Concept of controllability & observability, effect of pole zero cancellation on the controllability & observability of the system, pole placement design through state feedback. Ackerman's Formula for feedback gain design. Design of Observer. Reduced order observer. Separation Principle.

Module 6: Nonlinearities and its effect on system performance (3 Hours)
Various types of non-linearities. Effect of various non-linearities on system performance. Singular points. Phase plot analysis.

Text/References
1. N. Nise, "Control system Engineering", John Wiley,2000.
2. I. J. Nagrath and M. Gopal, "Control system engineering", Wiley, 2000.
3. M. Gopal, "Digital Control Engineering", Wiley Eastern, 1988.
4. K. Ogata, "Modern Control Engineering", Prentice Hall, 2010.
5. B. C. Kuo, "Automatic Control system", Prentice Hall, 1995.
6. J. J. D'Azzo and C. H. Houpis, "Linear control system analysis and design (conventional and modern)", McGraw Hill, 1995.
7. R. T. Stefani and G. H. Hostetter, "Design of feedback control Systems", Saunders College Pub, 1994.

Course PE15: Power System Dynamics and Control

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

CO1	Understand the problem of power system stability and its impact on the system.
CO2	Analyze linear dynamical systems and use of numerical integration methods.
CO3	Model different power system components for the study of stability.
CO4	Understand the methods to improve stability

Module 1: Introduction to Power System Operations (4 Hours)
Introduction to power system stability, Power System Operations and Control, Stability problems in Power System, Impact on Power System Operations and control.

Module 2: Analysis of Linear Dynamical System and Numerical Methods (4 Hours)
Analysis of dynamical System, Concept of Equilibrium, Small and Large Disturbance Stability, Modal Analysis of Linear System, Analysis using Numerical Integration Techniques, Issues in Modeling: Slow and Fast Transients, Stiff System.

Module 3: Modeling of Synchronous Machines and Associated Controllers (12 Hours)
Modeling of synchronous machine: Physical Characteristics, Rotor position dependent model, D-Q Transformation, Model with Standard Parameters, Steady State Analysis of Synchronous Machine, Short Circuit Transient Analysis of a Synchronous Machine, Synchronization of Synchronous Machine to an Infinite Bus, Modeling of Excitation and Prime Mover Systems. Physical Characteristics and Models, Excitation System Control, Automatic Voltage Regulator. Prime Mover Control Systems. Speed Governors.

Module 4: Modeling of other Power System Components (8 Hours)
Modeling of Transmission Lines and Loads, Transmission Line Physical Characteristics, Transmission Line Modeling, Load Models-induction machine model, Frequency and Voltage Dependence of Loads, Other Subsystems–HVDC and FACTS controllers, Wind Energy Systems.

Module 5: Stability Analysis (8 Hours)
Angular stability analysis in Single Machine Infinite Bus System, Angular Stability in multi-machine systems–Intra-plant, Local and Inter-area modes. Frequency Stability: Centre of Inertia Motion. Load Sharing: Governor droop. Single Machine Load Bus System: Voltage Stability. Introduction to Torsional Oscillations and the SSR phenomenon, Stability Analysis Tools: Transient Stability Programs, Small Signal Analysis Programs.

Module 6: Enhancing System Stability (4 Hours)
Planning Measures, Stabilizing Controllers (Power System Stabilizers), Operational Measures-Preventive Control, Emergency Control.

Text/Reference Books
1. K. R. Padiyar, "Power System Dynamics, Stability and Control", B. S. Publications, 2002.
2. P. Kundur, "Power System Stability and Control", Mc GrawHill, 1995.
3. P. Sauerand M.A. Pai, "Power System Dynamics and Stability", Prentice Hall, 1997.

Course PE16: Advanced Electric Drives

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

CO1	Understand the operation of power electronic converters and their control strategies.
CO2	Understand the vector control strategies for ac motor drives.
CO3	Understand the implementation of the control strategies using digital signal processors

Module 1: Power Converters for AC drives (10 Hours)
PWM control of inverter, selected harmonic elimination, space vector modulation, current control of VSI, three level inverter, Different topologies, SVM for 3 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-Qdrive.

Module 2: Induction motor drives (10 Hours)
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).

Module 3: Synchronous motor drives (6 Hours)
Modeling of synchronous machines, open loop v/f control, vector control, direct torque control, CSI fed synchronous motor drives.

Module 4: Permanent magnet motor drives (6 Hours)
Introduction to various PM motors, BLDC and PMSM drive configuration, comparison, block diagrams, Speed and torque control in BLDC and PMSM.

Module 5: Switched reluctance motor drives (6 Hours)
Evolution of switched reluctance motors, various topologies for SRM drives, comparison, Closed loop speed and torque control of SRM.

Module 6: DSP based motion control (6 Hours)
Use of DSPs in motion control, various DSPs available, realization of some basic blocks in DSP for implementation of DSP based motion control.

Text /References:
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.
3. H. A. Taliyat and S. G. Campbell, “DSP based Electromechanical Motion Control”, CRC press, 2003.
4. R. Krishnan, “Permanent Magnet Synchronous and Brushless DC motor Drives”, CRC Press, 2009.

Course PE17: Electrical Energy Conservation and Auditing

Course Outcomes:

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

CO1	Understand the current energy scenario and importance of energy conservation.
CO2	Understand the concepts of energy management.
CO3	Understand the methods of improving energy efficiency in different electrical systems.
CO4	Understand the concepts of different energy efficient devices.

Module 1: Energy Scenario (6 Hours)

Commercial and Non-commercial energy, primary energy resources, commercial energy production, final energy consumption, energy needs of growing economy, long term energy scenario, energy pricing, energy sector reforms, energy and environment, energy security, energy conservation and its importance, restructuring of the energy supply sector, energy strategy for the future, air pollution, climate change. Energy Conservation Act-2001 and its features.

Module 2: Basics of Energy and its various forms (7 Hours)

Electricity tariff, load management and maximum demand control, power factor improvement, selection & location of capacitors, Thermal Basics-fuels, thermal energy contents of fuel, temperature & pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity & heat transfer, units and conversion.

Module 3: Energy Management & Audit (6 Hours)

Definition, energy audit, need, types of energy audit. Energy management (audit) approach-understanding energy costs, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements, fuel & energy substitution, energy audit instruments. Material and Energy balance: Facility as an energy system, methods for preparing process flow, material and energy balance diagrams.

Module 4: Energy Efficiency in Electrical Systems (7 Hours)

Electrical system: Electricity billing, electrical load management and maximum demand control, power factor improvement and its benefit, selection and location of capacitors, performance assessment of PF capacitors, distribution and transformer losses. Electric motors: Types, losses in induction motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, energy saving opportunities with energy efficient motors.

Module 5: Energy Efficiency in Industrial Systems (8 Hours)

Compressed Air System: Types of air compressors, compressor efficiency, efficient compressor operation, Compressed air system components, capacity assessment, leakage test, factors affecting the performance and savings opportunities in HVAC, Fans and blowers: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities. Pumps and Pumping System: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities. Cooling Tower: Types and performance evaluation, efficient system operation, flow control strategies and energy saving opportunities, assessment of cooling towers.

Module 6: Energy Efficient Technologies in Electrical Systems (8 Hours)

Maximum demand controllers, automatic power factor controllers, energy efficient motors, soft starters with energy saver, variable speed drives, energy efficient transformers, electronic ballast, occupancy sensors, energy efficient lighting controls, energy saving potential of each technology.

Text/Reference Books

1. Guide books for National Certification Examination for Energy Manager/Energy Auditors Book-1, General Aspects (available online)
2. Guide books for National Certification Examination for Energy Manager/Energy Auditors
3. Book-3, Electrical Utilities (available online)
4. S. C. Tripathy, "Utilization of Electrical Energy and Conservation", McGraw Hill, 1991.
5. Success stories of Energy Conservation by BEE, New Delhi (www.bee-india.org)

Course PE18: High Voltage Engineering

Course outcomes:

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

CO1	Understand the basic physics related to various breakdown processes in solid, liquid and gaseous insulating materials.
CO2	Knowledge of generation and measurement of D.C., A.C., & Impulse voltages.
CO3	Knowledge of tests on H.V. equipment and on insulating materials, as per the standards.
CO4	Knowledge of how over-voltages arise in a power system, and protection against these over- voltages.

Module 1: Breakdown in Gases (8 Hours)

Ionization processes and de-ionization processes, Types of Discharge, Gasesas insulating materials, Breakdown in Uniform gap, non-uniform gaps, Town send's theory, Streamer mechanism, Corona discharge.

Module 2: Breakdown in liquid and solid Insulating materials (7 Hours)

Breakdown in pure and commercial liquids, Solid dielectrics and composite dielectrics, intrinsic breakdown, electromechanical breakdown and thermal breakdown, Partial discharge, applications of insulating materials.

Module 3: Generation of High Voltages (7 Hours)

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.

Module 4: Measurements of High Voltages and Currents (7 Hours)

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.

Module 5: Lightning and Switching Over-voltages (7 Hours)

Charge formation in clouds, Stepped leader, Dart leader, Lightning Surges. Switching over-voltages, Protection against over-voltages, Surge diverters, Surge modifiers.

Module 6: High Voltage Testing of Electrical Apparatus and High Voltage Laboratories (7 Hours)

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.

Text/Reference 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.
3. D. V. Razevig (Translated by Dr. M. P. Chourasia), "High Voltage Engineering Fundamentals", Khanna Publishers, 1993.
4. E. Kuffel, W. S. Zaengl and J. Kuffel, "High Voltage Engineering Fundamentals", Newnes Publication, 2000.
5. R. Arora and W. Mosch "High Voltage and Electrical Insulation Engineering", John Wiley & Sons, 2011.
6. Various IS standards for HV Laboratory Techniques and Testing

Course PE19: Power Station and Substation Practice

Course outcomes:

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

CO1	Learn principle of operation, layout of different types, process flow diagrams and process loops of power plants.
CO2	Study different types of substations, their equipment, arrangement, metering safety issues.
CO3	Understand the concept of power system tariff and digital metering
CO4	Understand SMART metering, power exchange concept and demand side management

Module 1: Power Station Engineering (12 Hours)

Power Station Engineering: Thermal power station: thermodynamic cycle, Fuels, surface-to-volume ratio, process flow diagram, different subsystems, operation of equipment: furnace, superheater, reheater, LP heater, HP heater, boiler, feed pump, condenser, turbine, condensate pump, deaerator, ID, FD and PA fan. Unit control room, a few automatic control loops. Nuclear, hydel and Non-conventional power station: principle of operation and layout.

Module 2: Substation Engineering (16 Hours)

Substation Engineering: Substation classification, equipments, layout, busbar arrangement, busbar material, use of current limiting reactors, Grounding: types, grounding practice, Substation automation: metering and protection. UPS used in substations. Overhead line insulators: materials, types, insulators in strings, string efficiency. Protection against surges: lighting arrester.

Module 3: Power System Economics and Management (12 Hours)

Power system Tariff: Its need and structure, block rate, two part and multirate tariff, Availability Based Tariff (ABT), basic principle, areas of use and achievements in restructured power system, demand and maximum demand, tri-vector meter; digital metering: active, reactive and apparent energy, introduction to SMART metering, economics of power factor improvement; instruments and techniques. Basic Pricing Principles: Generator cost curves, utility functions, power exchanges, spot pricing, electricity market models, demand side-management, transmission and distributions charges, ancillary services, regulatory framework.

Text/Reference Books

1. Nagrath & Kothery, "Power System Engineering" , Tata McGraw Hill
2. Elements of power system analysis, C.L. Wadhwa, New Age International.
3. Power System Analysis, John Grainger, William Stevenson Jr., McGraw Hill
4. Power System Analysis and Design, J. Duncan Glover, Mulukutla S. Sarma, Thomas Overbye, Cengage Learning.
5. Electrical Power System, Subir Roy, Prentice Hall
6. Electric Power transmission & Distribution, S.Sivanagaraju, S.Satyanarayana, Pearson Education.
7. A Text book on Power system Engineering, Soni, Gupta, Bhatnagar&Chakrabarti, DhanpatRai& Co.
8. Electric Power distribution system Engineering, T. Gonen, CRC Press.

UNIVERSITY OF CALCUTTA
Faculty of Engineering and Technology
Electrical Engineering
Department of Applied Physics

OPEN ELECTIVE COURSES

Open elective courses at a glance

Subject code	Course Title
OE01	Electronic Devices
OE02	Data Structures and Algorithms
OE03	VLSI circuits
OE04	Image Processing
OE05	Analog and Digital Communication
OE06	Strength of Materials
OE07	Fluid Machinery
OE08	Embedded Systems
OE09	Automobile Engineering
OE10	Wavelet Transforms
OE11	Modern Manufacturing Processes
OE12	Power Plant Engineering
OE13	Computer Networks
OE14	Internet of Things
OE15	Transducer and measurement systems
OE16	Process Control instrumentation
OE17	Non-destructive evaluation and biomedical Instrumentation
OE18	Introduction to Robotics
OE19	Machine Learning Techniques

Detailed Syllabus

Course OE01: Electronic Devices

Course Outcomes:

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

CO1	Understand the principles of semiconductor Physics
CO2	Understand and utilize the mathematical models of semiconductor junctions and MOS transistors for circuits and systems

Module 1: Introduction to Semiconductor Physics (20 Hours)

Review of Quantum Mechanics, Electrons in periodic Lattices, E-k diagrams. Energy bands in intrinsic and extrinsic silicon; Carrier transport: diffusion current, drift current, mobility and resistivity; sheet resistance, design of resistors, Generation and recombination of carriers; Poisson and continuity equation P-N junction characteristics, I-V characteristics, and small signal switching models; Avalanche breakdown, Zener diode, Schottky diode Bipolar Junction Transistor, I-V characteristics, Ebers-Moll Model, MOS capacitor, C-V characteristics, MOSFET, I-V characteristics, and small signal models of MOS transistor, LED, photodiode and solar cell;

Module 2: Integrated circuit fabrication process (20 Hours)

Integrated circuit fabrication process: oxidation, diffusion, ion implantation, photolithography, etching, chemical vapor deposition, sputtering, twin-tub CMOS process.

Text /Reference Books:

1. G. Streetman, and S. K. Banerjee, “Solid State Electronic Devices,” 7th edition, Pearson,2014.
2. D. Neamen, D. Biswas "Semiconductor Physics and Devices," McGraw-Hill Education
3. S. M. Sze and K. N. Kwok, “Physics of Semiconductor Devices,” 3rd edition, John Wiley & Sons, 2006.
4. C.T. Sah, “Fundamentals of solid-state electronics,” World Scientific Publishing Co. Inc, 1991.
5. Y. Tsividis and M. Colin, “Operation and Modeling of the MOS Transistor,” Oxford Univ. Press, 2011.

Course OE02: Data Structures and Algorithms

Course Outcomes

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

CO1	For a given algorithm student will able to analyze the algorithms to determine the time and computation complexity and justify the correctness.
CO2	For a given problem of Stacks, Queues and linked list student will able to implement it and analyze the same to determine the time and computation complexity.
CO3	Student will able to write an algorithm Selection Sort, Bubble Sort, Insertion Sort Quick Sort, Merge Sort, Heap Sort and compare their performance in term of Space and Time complexity.
CO4	Student will able to implement Graph search and traversal algorithms and determine the time and computation complexity.

Module1: Introduction: **(8 Hours)**

Basic Terminologies: Elementary Data Organizations, Data Structure Operations: insertion, deletion, traversal etc.; Analysis of an Algorithm, Asymptotic Notations, Time-Space trade off.

Searching: Linear Search and Binary Search Techniques and their complexity analysis.

Module 2: Stacks and Queues (12 Hours)

ADT Stack and its operations: Algorithms and their complexity analysis, Applications of Stacks: Expression Conversion and evaluation –corresponding algorithms and complexity analysis. ADT queue, Types of Queue: Simple Queue, Circular Queue, Priority Queue; Operations on each types of Queues: Algorithms and their analysis.

Module 3: Linked Lists: **(12 Hours)**

Singly linked lists: Represent at ion in memory, Algorithms of several operations: Traversing, Searching, Insert ion into, Deletion from linked list; Linked representation of Stack and Queue, Header nodes, Doubly linked list : operations on it and algorithmic analysis; Circular Linked Lists: all operations their algorithms and the complexity analysis.

Trees: Basic Tree Terminologies, Different types of Trees: Binary Tree, Threaded Binary Tree, Binary Search Tree, AVL Tree; Tree operations on each of the trees and their algorithms with complexity analysis. Applications of Binary Trees. B Tree, B+ Tree: definitions, algorithms and analysis.

Module 4: Sorting and Hashing: **(8 Hours)**
Objective and properties of different sorting algorithms: Selection Sort, Bubble Sort, Insertion Sort, Quick Sort, Merge Sort, Heap Sort; Performance and Comparison among all the methods, Hashing.

Graph: Basic Terminologies and Representations, Graph search and traversal algorithms and complexity analysis.

Text /Reference Books:

1. Ellis Horowitz, Sartaj Sahni, "Fundamentals of Data Structures", Computer Science Press.
2. Algorithms, Data Structures, and Problem Solving with C++", Illustrated Edition by Mark Allen Weiss, Addison-Wesley Publishing Company.
3. "How to Solve it by Computer", 2nd Impression by R.G. Dromey, Pearson Education.

Course OE03: VLSI circuits

Course Outcomes

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

CO1	Design different CMOS circuits using various logic families along with their circuit layout
CO2	Use tools for VLSI IC design.
CO3	To understand the fabrication process of CMOS technology

Design of digital circuits: Review of CMOS design techniques, CMOS inverter and basic gates, comparison with other logic families, static vs dynamic logic, delay calculation, logical effort, driving large capacitive loads.
The Wiring Network: Elmore delay calculation, lumped and distributed RC lines; delay in long lines-buffers and buffer placement.
Design Automation: Custom vs semi-custom circuit partitioning, placement and routing/ floorplanning; algorithms for physical design.
The MOS Device: Small Signal and Large Signal equivalent circuit; MOS device modeling; MOS SPICE models; SPICE simulation of MOS circuits.

MOS Components and Sub-circuits: MOS Switch; MOS Diode/Active resistors; MOS Capacitors; Switched Capacitor Resistor; Current Sinks and Sources; Current Mirrors; Current and Voltage reference; Bandgap reference; SPICE Simulation examples.

CMOS Amplifiers: Inverters **-** Characteristics and properties as amplifiers; Differential amplifiers; Cascade Amplifiers; Output Amplifiers; Gilbert cell; Frequency response characteristics; SPICE simulation examples.

Switched capacitors circuit: General considerations; Switched capacitor integrators; first and second order switched capacitor filter circuits.

References:

Course OE04: Image Processing

Course Outcomes

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

CO1. Mathematically represent the various types of images and analyze them.

2. Process these images for the enhancement of certain properties or for optimized use of the resources.

3. Develop algorithms for image compression and coding

Syllabus

Module 1: Digital Image Fundamentals (10 Hours)

Elements of visual percept ion, image sensing and acquisition, image sampling and quantization, basic relationships between pixels – neighborhood, adjacency, connectivity, distance measures. Image Enhancements and Filtering-Gray level transformations, histogram equalization and specifications, pixel-domain smoothing filters – linear and order-statistics, pixel-domain sharpening filters – first and second derivative, two-dimensional DFT and its inverse, frequency domain filters – low-pass and high-pass.

Module 2: Color Image Processing (8 Hours)

Color models–RGB, YUV, HSI; Color transformations– formulation, color complements, color slicing, tone and color corrections; Color image smoothing and sharpening; Color Segmentation. Image Segmentation- Detection of discontinuities, edge linking and boundary detect ion, thresholding – global and adaptive, region-based segmentation.

Module 3: Wavelets and Multi-resolution image processing (10 Hours)

Uncertainty principles of Fourier Transform, Time-frequency localization, continuous wavelet transforms, wavelet bases and multi-resolution analysis, wavelets and Sub band filter banks, wavelet packets. Image Compression-Redundancy–inter-pixel and psycho-visual; Lossless compression – predictive, entropy; Lossy compression-predictive and transform coding; Discrete Cosine Transform; Still image compression standards–JPEG and JPEG-2000.

Module 4: Fundamentals of Video Coding (12 Hours)

Inter-frame redundancy, motion estimation techniques – full-search, fast search strategies, forward and backward motion predict ion, frame classification – I, P and B; Video sequence hierarchy–Group of pictures, frames, slices, macro-blocks and blocks; Elements of a video encoder and decoder; Video coding standards – MPEG and H.26X, Video Segmentation-Temporal segmentation–shot boundary detection, hard-cuts and soft-cuts; spatial segmentation–motion-based; Video object detection and tracking.

Text/Reference Books:

1. R.C. Gonzalez and R.E. Woods, Digital Image Processing, Second Edition, Pear son Education 3rd edit ion 2008

2. Anil Kumar Jain, Fundamentals of Digital Image Processing, Prentice Hall of India.2nd edit ion 2004

3. Murat Tekalp, Digital Video Processing" Prentice Hall, 2nd edit ion 2015

Course OE05: Analog and Digital Communication

Course Outcomes:

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

CO1	Analyze and compare different analog modulation schemes for their efficiency and bandwidth
CO2	Analyze the behavior of a communication system in presence of noise

CO3	Investigate pulsed modulation system and analyze their system performance
CO4	Analyze different digit al modulation schemes and can compute the bit error performance

Module 1: Review of signals and systems (10 Hours)
Frequency domain representation of signals, Principles of Amplitude Modulation Systems- DSB, SSB and VSB modulations. Angle Modulation, Representation of FM and PM signals, Spectral characteristics of angle modulated signals.

Review of probability and random process. Gaussian and white noise characteristics, Noise in amplitude modulation systems, Noise in Frequency modulation systems. Pre-emphasis and Deemphasis, Threshold effect in angle modulation.

Module 2: Various modulation schemes (8 Hours)
Sampling process. Pulse Amplitude and Pulse code modulation (PCM), Differential pulse code modulation. Delta modulation, Noise considerations in PCM, Time Division multiplexing, Digital Multiplexers.

Module 3: Detection Theory (12 Hours)
Optimum detection of signals in noise, Coherent communication with waveforms- Probability of Error evaluations. Baseband Pulse Transmission- Inter symbol Interference and Nyquist criterion. Pass band Digital Modulation schemes- Phase Shift Keying, Frequency Shift Keying, Quadrature Amplitude Modulation, Continuous Phase Modulation and Minimum Shift Keying.

Module 4: Digital Modulation tradeoffs (10 Hours)
Optimum demodulation of digital signals over band- limited channels- Maximum likelihood sequence detection (Viterbi receiver). Equalization Techniques. Synchronization and Carrier Recovery for Digital modulation.

Text/Reference Books:
1. Haykin S., "Communications Systems", John Wiley and Sons, 2001.
2. Proakis J. G. and Salehi M., "Communication Systems Engineering", Pearson Education, 2002.
3. Taub H. and Schilling D.L., "Principles of Communication Systems", Tat a McGraw Hill, 2001.
4. Wozencraft J. M. and Jacobs I. M., ``Principles of Communication Engineering", John Wiley, 1965.
5. Barry J. R., Lee E. A. and Messerschmitt D. G., ``Digital Communication", Kluwer Academic Publishers, 2004.
6. Proakis J.G., ``Digital Communications", 4th Edition, McGraw Hill, 2000.

Course OE06: Strength of Materials
Course Outcomes:
At the end of this course students will demonstrate the ability to

CO1	recognise various types loads applied on machine components of simple geometry and understand the nature of internal stresses that will develop within the components
CO2	evaluate the strains and deformation that will result due to the elastic stresses developed within the materials for simple types of loading
CO3	understand the nature of stresses developed in simple geometries such as bars,

	cantilevers, beams, shafts, cylinders and spheres for various types of simple loads
CO4	calculate the elastic deformation occurring in various simple geometries for different types of loading

Module 1: Deformation in solids (8 Hours)
Hooke's law, stress and strain- tension, compression and shear stresses-elastic constants and their relations- volumetric, linear and shear strains- principal stresses and principal planes- Mohr's circle.

Module 2: Beams and types transverse loading on beams (8 Hours)
shear force and bend moment diagrams- Types of beam supports, simply supported and over-hanging beams, cantilevers. Theory of bending of beams, bending stress distribution and neutral axis, shear stress distribution, point and distributed loads.

Module 3: Moment of inertia (8 Hours)
About an axis and polar moment of inertia, deflection of a beam using double integration method, computation of slopes and deflection in beams, Maxwell's reciprocal theorems.

Module 4: stresses and deformation (16 Hours)
Torsion, stresses and deformation in circular and hollow shafts, stepped shafts, deflection of shafts fixed at both ends, stresses and deflect ion of helical springs. Axial and hoop stresses in cylinders subjected to internal pressure, deformation of thick and thin cylinders, deformation in spherical shells subjected to internal pressure.

Text Books:
1 Egor P. Popov, Engineering Mechanics of Solids, Prentice Hall of India, New Delhi, 2001.
2 R. Subramanian, Strength of Materials, Oxford University Press, 2007.
3 Ferdinand P. Been, Russel Johnson Jr and John J. Dewole, Mechanics of Materials, Tata McGraw Hill Publishing Co. Ltd., New Delhi 2005.

Course OE07: Fluid Machinery
Course Outcomes:
At the end of this course students will demonstrate the ability to

CO1	learn about the application of mass and momentum conservation laws for fluid flows
CO2	understand the importance of dimensional analysis
CO3	obtain the velocity and pressure variations in various types of simple flows
CO4	analyze the flow in water pumps and turbines

Module 1: Fundamentals of fluid (9 Hours)
Definition of fluid, Newton's law of viscosity, Units and dimensions-Properties of fluids, mass density, specific volume, specific gravity, viscosity, compressibility and surface tension, Control volume- application of continuity equation and momentum equation, Incompressible flow, Bernoulli's equation and its applications.

Module 2: Fluid flow solution (9 Hours)
Exact flow solutions in channels and ducts, Couette and Poisuielle flow, laminar flow through circular conduits and circular annuli- concept of boundary layer – measures of boundary layer thickness – Darcy Weisbach equation, friction factor, Moody's diagram.

Module 3: Dimensional analysis (6 Hours)

Need for dimensional analysis–methods of dimension analysis–Similitude–types of similitude Dimensionless parameters: application of dimensionless parameters–Model analysis.

Module 4: Operation of pump (8 Hours)

Euler's equation – theory of Rotodynamic machines – various efficiencies – velocity components at entry and exit of the rotor, velocity triangles – Centrifugal pumps, working principle, work done by the impeller, performance curves – Cavitation in pumps- Reciprocating pump–working principle.

Module 5: Operation of Turbine (8 Hours)

Classification of water turbines, heads and efficiencies, velocity triangles- Axial, radial and mixed flow turbines- Pelton wheel, Francis turbine and Kaplan turbines, working principles – draft tube-Specific speed, unit quantities, performance curves for turbines – governing of turbines.

References

Course OE08: Embedded Systems

Course Outcomes

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

CO1	Suggest design approach using advanced controllers to real-life situations
CO2	Design interfacing of the systems with other data handling / processing systems
CO3	Appreciate engineering constraints like energy dissipation, data exchange speeds etc.

Module 1: Embedded system Hardware and Simulator (8 Hours)

Basics architecture of PIC microcontroller, PWM generation, basics architecture of Arduino hardware and operation, Raspberry PI hardware concept and its operation, AVR Microcontroller basics, fundamental of Compiler, concept of simulator and emulator.

Module 2: Data Acquisition System (8 Hours)

Concept of data acquisition system using external ADC, using microcontroller based ADC, Concept of generation of sampling rate, over sampling and under sampling, use of interrupt based data acquisition, principle of voltage and current sampling.

Module 3: Interfacing of Display and Keyboard (8 Hours)

Interfacing concept of two and three digit 7 segment display, display code generation for 7 segment display, refresh rate, concept of three and half digit and four and half digit display. Interfacing of 16x2 LCD, its code generation. Interfacing of 4x4 keyboard, interfacing of computer keyboard.

Module 4: Communication and remote controller design (8 Hours)

Serial communication using RS232 protocol at different BAUD rate, flow control principle and parity control. Concept of RS485, I^2C, PS2, CAN, MODBUS SCADA, LAN, Profibus protocols, networking using RS485.

Module 5: Laboratory Practice (8 hours)

Laboratory practice of ADC, Display, Keyboard and remote communication.

Text/Reference Books

1. J.W. Valvano, "Embedded Microcomputer System: Real Time Inter facing", Brooks/Cole,2000.
2. Jack Ganssle, "The Art of Designing Embedded Systems", Newness, 1999.
3. V.K. Madisetti, "VLSI Digital Signal Processing", IEEE Press (NY, USA), 1995.
4. David Simon, "An Embedded Software Primer", Addison Wesley, 2000.
5. K.J. Ayala, "The 8051 Microcontroller: Architecture, Programming, and Applications", PenramIntl, 1996.

Course OE09: Automobile Engineering
Course Outcomes
At the end of the course, students will demonstrate the ability to:

CO1	understand the construction and working principle of various parts of an automobile
CO2	understand the transmission systems of an automobile
CO3	understand the steering and breaking systems of an automobile
CO4	understand the alternative energy source for automobile

Module 1: Basics of automobile (8 Hours)
Types of automobiles, vehicle construction and layouts, chassis, frame and body, vehicle aerodynamics, IC engines-components, function and materials, variable valve timing (VVT).Engine auxiliary systems, electronic injection for SI and CI engines, unit injector system, rotary distributor type and common rail direct injection system, transistor based coil ignition & capacitive discharge ignition systems, turbo chargers (WGT, VGT), engine emission control by 3-way catalytic converter system, Emission norms (Euro & BS).

Module 2: Transmission systems (12 Hours)
Transmission systems, clutch types & construction, gear boxes- manual and automatic gear shift mechanisms, Overdrive, transfer box, flywheel, torque converter, propeller shaft, slip joints, universal joints, differential and rear axle, Hotchkiss drive and Torque tube drive.

Module 3: Steering and Braking system (10 Hours)
Steering geometry and types of steering gear box, power steering, types of front axle, types of suspension systems, pneumatic and hydraulic braking systems, antilock braking system (ABS),electronic brake force distribution (EBD) and traction control.

Module 3: Alternative energy sources (10 Hours)
Alternative energy sources, natural gas, LPG, biodiesel, bio-ethanol, gasohol and hydrogen fuels in automobiles, modifications needed, performance, combust ion & emission characteristics of alternative fuels in SI and CI engines, Electric and Hybrid vehicles, application of Fuel Cells.

Text books:
1. Kirpal Singh, Automobile Engineering, 7th ed., Standard Publishers, New Delhi, 1997.
2. Jain K.K. and Asthana R.B., Automobile Engineering, Tata McGraw Hill, New Delhi, 2002.
3. Heitner J., Automotive Mechanics, 2nd ed., East-West Press, 1999.
4. Heisler H., Advanced Engine Technology, SAE International Publ., USA, 1998.

Course OE10: Wavelet Transforms
Course Outcomes
At the end of the course, students will demonstrate the ability to:

CO1	Understand time- frequency nature of the signals
CO2	Apply the concept of wavelets to practical problems
CO3	Mathematically analyze the systems or process the signals using appropriate wavelet functions

Module 1: Introduction to wavelet transform (20 Hours)

Introduction to time frequency analysis; the how, what and why about wavelets, Short-time Fourier transform, Wigner-Ville transform.; Continuous time wavelet transform, Discrete wavelet transform, tiling of the time-frequency plane and wave packet analysis, Construction of wavelets.

Module 2: Multi-resolution and Multirate signal analysis (20 Hours)
Multi-resolution analysis. Introduction to frames and bi-orthogonal wavelets, Multirate signal processing and filter bank theory, Application of wavelet theory to signal denoising, image and video compression, multi-tone digital communication, transient detection.

Text/Reference Books:

1.Y.T. Chan, Wavelet Basics, Kluwer Publishers, Boston, 1993.
2.I. Daubechies, Ten Lectures on Wavelets, Society for Industrial and Applied Mathematics, Philadelphia, PA, 1992.
3.C. K. Chui, An Introduction to Wavelets, Academic Press Inc., New York, 1992.
4.Gerald Kaiser, A Friendly Guide to Wavelets, Birkhauser, New York, 1995.
5.P. P. Vaidyanathan, Multirate Systems and Filter Banks, Prentice Hall, New Jersey, 1993.
6.A.N. Akansu and R.A. Haddad, Multiresolution signal Decomposition: Transforms, Subbands and Wavelets, Academic Press, Oranld, Florida, 1992.
7.B.Boashash, Time-Frequency signal analysis, In S.Haykin, (editor), Advanced Spectral Analysis, pages 418--517. Prentice Hall, New Jersey, 1991.

Course OE11: Modern Manufacturing Technology
Course Outcomes
At the end of the course, students will demonstrate the ability to:

CO1	provide knowledge on machines and related tools for manufacturing various components
CO2	understand the relationship between process and system in manufacturing domain
CO3	identify t e techniques for the quality assurance of the products and the optimality of the process in terms of resources and time management

Module 1: Tooling for conventional and non-conventional machining processes (12 Hours)
Mould and die design, Press tools, Cutting tools; Holding tools: Jigs and fixtures, principles, applications and design; press tools – configuration, design of die and punch; principles of forging die design.

Module 2: Metrology (16 Hours)
Dimensions, forms and surface measurements, Limits, fits and tolerances; linear and angular measurements; comparators; gauge design; interferometry; Metrology in tool wear and part quality including surface integrity, alignment and testing methods; tolerance analysis in manufacturing and assembly. Process metrology for emerging machining processes such as microscale machining, Inspection and work piece quality.

Module 3: Assembly practices (6 Hours)
Manufacturing and assembly, process planning, selective assembly, Material handling and devices.

Module 4: Manufacturing model and linear programming (16 Hours)
Linear programming, objective function and constraints, graphical method, Simplex and duplex algorithms, transportation assignment, Traveling Salesman problem; Network models: shortest route, minimal spanning tree, maximum flow model- Project networks: CPM and PERT, critical path

scheduling; Production planning & control: Forecasting models, aggregate production planning, materials requirement planning. Inventory Models: Economic Order Quantity, quantity discount models, stochastic inventory models, practical inventory control models, JIT. Simple queuing theory models.

Text Books:
(i) Kalpakjian and Schmid, Manufacturing processes for engineering materials (5th Edition)-Pearson India, 2014.
(ii) Taha H. A., Operations Research, 6th Edition, Prentice Hall of India, 2003.
(iii) Shenoy G.V. and Shrivastava U.K., Operations Research for Management, Wiley Eastern, 1994.

Course OE12: Power Plant Engineering
Course Outcomes
At the end of the course, students will demonstrate the ability to:

CO1	Understand an overview of power plants and the associated energy conversion issues
CO2	Realise the principles of operation of thermal power plants and their economics
CO3	Realise the principles of operation of hydroelectric power plants and their economics
CO4	Realise the principles of operation of nuclear power plants and their economics

Module 1: Thermal power plants (12 Hours)
Coal based thermal power plants, basic Rankine cycle and its modifications, layout of modern coal power plant, super critical boilers, FBC boilers, turbines, condensers, steam and heating rates, subsystems of thermal power plants, fuel and ash handling, draught system, feed water treatment, binary cycles and cogeneration systems

Module 2: Gas turbine power plants (8 Hours)
Gas turbine and combined cycle power plants, Brayton cycle analysis and optimization, components of gas turbine power plants, combined cycle power plants, Integrated Gasifier based Combined Cycle (IGCC) systems.

Module 3: Nuclear energy power plants (10 Hours)
Basics of nuclear energy conversion, Layout and subsystems of nuclear power plants, Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), CANDU Reactor, Pressurized Heavy Water Reactor (PHWR), Fast Breeder Reactors (FBR), gas cooled and liquid metal cooled reactors, safety measures for nuclear power plants.
Module 4: Hydroelectric power plants (10 Hours)
Hydroelectric power plants, classification, typical layout and components, principles of wind, tidal, solar PV and solar thermal, geothermal, biogas and fuel cell power systems Energy, economic and environmental issues, power tariffs, load distribution parameters, load curve, capital and operating cost of different power plants, pollution control technologies including waste disposal options for coal and nuclear plants.

Text Books:
1. Nag P.K., Power Plant Engineering, 3rd ed., Tata McGraw Hill, 2008.
2. El Wakil M.M., Power Plant Technology, Tata McGraw Hill, 2010.
3. Elliot T.C., Chen K and Swanekamp R.C., Power Plant Engineering, 2nd ed., McGraw Hill, 1998.

Course OE13: Computer Networks
Course Outcomes
At the end of the course, students will demonstrate the ability to:

CO1	Explain the functions of the different layer of the OSI Protocol.
CO2	develop an understanding of modern network architectures from a design and performance perspective.
CO3	Introduce the student to the major concepts involved in wide-area networks (WANs), local area networks (LANs) and Wireless LANs (WLANs).
CO4	Provide an opportunity to do network programming

Module1: (8 Hours)
Data communication Components: Representation of data and its flow Networks, Various Connection Topology, Protocols and Standards, OSI model, Transmission Media, LAN: Wired LAN, Wireless LANs, Connecting LAN and Virtual LAN, Techniques for Bandwidth utilization: Multiplexing - Frequency division, Time division and Wave division, Concepts on spread spectrum.

Module2: (10 Hours)
Data Link Layer and Medium Access Sub Layer: Error Detection and Error Correction - Fundamentals, Block coding, Hamming Distance, CRC; Flow Control and Error control protocols - Stop and Wait, Go back – N ARQ, Selective Repeat ARQ, Sliding Window, Piggybacking, Random Access, Multiple access protocols -Pure ALOHA, Slotted ALOHA, CSMA/CD, CDMA/CA

Module3: (6 Hours)
Network Layer: Switching, Logical addressing – IPV4, IPV6; Address mapping – ARP, RARP, BOOTP and DHCP–Delivery, Forwarding and Unicast Routing protocols.

Module4: (10 Hours)
Transport Layer: Process to Process Communication, User Datagram Protocol (UDP), Transmission Control Protocol (TCP), SCTP Congestion Control; Quality of Service, QoS improving techniques: Leaky Bucket and Token Bucket algorithm.

Module5: (6 Hours)
Application Layer: Domain Name Space (DNS), DDNS, TELNET, EMAIL, File Transfer Protocol (FTP), WWW, HTTP, SNMP, Bluetooth, Firewalls, Basic concepts of Cryptography

References
1. Data Communication and Networking, 4th Edition, Behrouz A. Forouzan, McGraw- Hill.
2. Data and Computer Communication, 8th Edit ion, William Stallings, Pearson Prentice Hall India.
1. Computer Networks, 8th Edit ion, Andrew S. Tanenbaum, Pearson New International Edit ion.
2. Internetworking with TCP/IP, Volume 1, 6th Edit ion Douglas Comer, Prentice Hall of India.
3. TCP/IP Illustrated, Volume 1, W. Richard Stevens, Addison-Wesley, United States of America.

Course OE14: Internet of Things
Course Outcomes
At the end of the course, students will demonstrate the ability to:

CO1	Understand internet of Things and its hardware and software components
CO2	Interface I/O devices, sensors & communication modules
CO3	Remotely monitor data and control devices
CO4	Develop real life IoT based projects

Module 1: Introduction to IoT (8 Hours)

Architectural Overview, Design principles and needed capabilities, IoT Applications, Sensing, Actuation, Basics of Networking, M2M and IoT Technology Fundamentals- Devices and gateways, Data management, Business processes in IoT, Everything as a Service (XaaS), Role of Cloud in IoT, Security aspects in IoT.

Module 2: Elements of IoT (9 Hours)
Hardware Components- Computing (Arduino, Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces. Software Components- Programming API's (using Python/Node.js/Arduino) for Communication Protocols-MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP.

Module 3: IoT Application Development (18 Hours)
Solution framework for IoT applications- Implementation of Device integration, Data acquisition and integration, Device data storage- Unstructured data storage on cloud/local server, Authentication, authorization of devices.

Module 4. IoT Case Studies (10 Hours)
IoT case studies and mini projects based on Industrial automation, Transportation, Agriculture, Healthcare, Home Automation

References

1.Vijay Madisetti, Arshdeep Bahga, Ïnternet of Things, "A Hands-on Approach", University Press
2.Dr. SRN Reddy, Rachit Thukral and Manasi Mishra, "Introduction to Internet of Things: A practical Approach", ETI Labs
3.Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press
4.Jeeva Jose, "Internet of Things", Khanna Publishing House, Delhi
5.Adrian McEwen, "Designing the Internet of Things", Wiley
6.Raj Kamal, "Internet of Things: Architecture and Design", McGraw Hill
7.Cuno Pfister, "Getting Started with the Internet of Things", O Reilly Media

Course OE15: **Transducer and measurement systems**
Course Outcomes
At the end of the course, students will demonstrate the ability to:

CO1	Understand the basics of Generalized measurement system
CO2	Apply the basics in Industrial temperature measurement system
CO3	Understand and Analyse Industrial pressure and displacement measurement system
CO4	Understand the basics of Noncontact Measurements

Module 1: Generalized measurement system (10 Hours)
Generalized measurement system components and their functions, Input-output configuration, sensors and transducers, active and passive transducers, static and dynamic characteristics, calibration, errors and their computation.

Module 2: Industrial temperature measurement systems (10 Hours)
Temperature standards, low temperature measurement, filled-in systems, thermocouple, RTD, thermistors, radiation detectors, IC temperature sensors.

Module 3: Industrial pressure and displacement measurement systems (10 Hours)

Basic principle of variable capacitance and inductance transducers, Bourdon tube, strain gages, load cells, LVDT, piezoelectric transducers.

Module 4: Noncontact Measurements (10 hours)
Inductive and optical proximity sensors for rotational speed measurements systems, transmitters, Hall current sensors, current and voltage transformers, ultrasonic transducers, encoders.

Suggested Books:
1. Measurement Systems: Application & design: EO Doebline (Mc Graw Hill)
2. Instrument Trasducers: Neubert (Oxford)
3. Transducers and Instrumentation: DVS Murthy (Prentice Hall India)
4. Indusrial Instrumentation: DC Patranabis

Course OE16: **Process Control instrumentation**
Course Outcomes
At the end of the course, students will demonstrate the ability to:

CO1	Understand the fundamental of process control
CO2	Realise the components of a process control system
CO3	Analyse various sequential process control schemes
CO4	Realise application of computers in continuous process control

Module 1: Fundamental of process control (10 Hours)
Process dynamics, process equation, load variables, self-regulation, control lag, dead time, concept of open and closed loop control, discontinuous control, On-off control, PID control, feedforward control, cascade control, split range control.

Module 2: Components of a process control system (10Hours)
Flapper nozzle system, current and pneumatic transmitters, actuators, control valves, their characteristics, current to pneumatic converters, safety valves.

Module 3: Sequential process control schemes (10 Hours)
Sequential process control using programmable logic controllers: block diagram, centurion, IO modules, isolation, representation of open and -closed contacts, ladder diagram representation, use of timers, counters and sequencing elements in PLC, case studies.

Module 4: Computers in continuous process control (10Hours)
Data loggers, supervisory control, centralized control, and distributed control system (DCS), Components of a DCS and their operation, alarm systems, PI diagram symbols, SCADA in process control.

Suggested Books:
1. Process control instrumentation technology: Curtis D. Johnson (PHI)
2. Process Control : Dipak C. Patranabis
3. Instrument Engineers’ Handbook: Volume II: Bela G. Liptak (CRC Press)

Course OE17: **Non-destructive evaluation and biomedical Instrumentation**
Course Outcomes

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

CO1	Understand basics of Non-destructive evaluation
CO2	Apply the basics of NDE for complex analysis using its advanced study
CO3	Realise the basics of biomedical measurement
CO4	Realise the basics of ECG and its analysis procedures

Module 1: Basics of Non-destructive evaluation (10 Hours)
Basic objectives and advantages of NDE, block diagram of test set up, various probing media, classical NDT methods: Magnetic particle inspection (MPI), penetrant tests (PT), electrified particle inspection (EPI).

Module 2: Advanced NDE methods (10 Hours)
Eddy current test, probe types and configurations, surface gaging; Ultrasonic tests, basic principle of reflection and through transmission technique, probe configuration, pulse echo type ultrasonic tests, display types.

Module 3: Biomedical measurement (10 Hours)
Basic scope and challenges, common biomedical signals: ECG, PPG, EEG, EMG, and EOG: electrophysiology, characteristics and applications; Artifacts and their removals, biomedical amplifiers and signal conditioning.

Module 4: ECG basics and analysis (10 Hours)
Measurement and recording of ECG and EEG waveforms, measurement protocols, interpretations, recorder characteristics, basics of computerized analysis of ECG, heart rate variability, continuous recording and arrhythmia analysis, human health monitoring systems.

Suggested books:
1. Biomedical Measurement and Instrumentation: Leslie Cromwel
2. Medical Instrumentation application and design: John G. Webster
3. Electrical and Magnetic Methods of Non-destructive Testing- Jack Blitz (Springer)
4. Non-destructive testing: Hull and John (MacMilan)

Course OE18: **Robotics and Automation**
Course Outcomes
At the end of the course, students will demonstrate the ability to:

CO1	Understand basics of operation of Robot
CO2	Understand about the Robotic dynamics
CO3	Realise the basics of Robotic Kinematics
CO4	Realise the basics of Robotic motion

Module 1: Basics of Robotics (10 Hours)
Introduction, components and structure of robotics system.

Module 2: Robotics Kinematics (10 Hours)

Kinematics of manipulators, rotation translation and transformation, David – Hastemberg Representation, Inverse Kinematics. Dyamics – modeling using Newton Euler equation.

Module 3: Robot Dynamics (10 Hours)
Linearization of Robot Dynamics – State variable continuous and discrete models.

Module 4: Robotic Motion (10 Hours)
Different types of trajectories and introduction to their generation. Position Control: Independent joint control. Introduction to advanced control for robot application.

Referencs:

Course OE19: **Introduction to Machine Learning Techniques**

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

CO1	Understand basics of Mechatronics
CO2	Understand about the Sensors and transducers for Mechatronics
CO3	Realise the operation of Pneumatic and Hydraulic actuation systems
CO4	Realise the basics of Programmable Logic Controller

Module 1: Types of Machine Learning (8 Hours)
Types of Machine Learning - Supervised (Regression/Classification) and Unsupervised (Pattern Recognition/Clustering), Deep Learning, Reinforcement Learning

Module2: Bias and Variance (10 Hours)
Bias, Variance, Overfitting/Underfitting, Regularization, ROC Curve, Evaluation & Cross-Validation

Module 3: Inductive Learning, Feature & Dimension Reduction (12 Hours)
- PCA, SVM and Kernel Function
- KNN and Decision Tree Algorithms
- Linear Regression & Logistic Regression
- Naive Bayes and Bayesian Networks
- VC Dimension and Ensemble Methods - Bagging, Boosting, Random Forest
- Unsupervised Learning - K Means & Hierarchical Clustering
- Perceptron, Artificial Neural Network (ANN), Backpropagation & Hidden Layer

Module 4: Deep Learning (10 Hours)
Basic of Deep Learning (CNN, RNN, Autoencoders etc.) & Application Area (Computer Vision, NLP)
References:

UNIVERSITY OF CALCUTTA
Faculty of Engineering and Technology
Electrical Engineering
Department of Applied Physics

Humanities, Social Science including Management Courses (HSMC)

HSMC-01	Foundational Course in Humanities (Philosophy)
HSMC-02	Education, Technology and Society
HSMC-03	History of Science and Technology in India
HSMC-04	Political and Economic Thought for a Humane Society
HSMC-05	State, Nation Building and Politics in India
HSMC-06	Engineering Management
HSMC-07	Application of Psychology
HSMC-08	Sociology, Society and Culture
HSMC- 09	Engineering Economics
HSMC-10	Values and Ethics
HSMC-11	Introduction to Women's and Gender Studies
HSMC-12	Making Indian Culture: Epistemic Traditions, Literature and Performative Arts
HSMC-13	Human Relations at Work
HSMC-14	Language and Communication
HSMC-15	Language and Linguistics
HSMC-16	Understanding Society and Culture through Literature
HSMC-17	Fundamentals of Linguistics
HSMC-18	Film Appreciation
HSMC-19	Law and Engineering

Details course

Course code HSMC-01: PHILOSOPHY
Course Outcomes:
At the end of this course, students will demonstrate the ability to

CO1	Develop strong natural familiarity with humanities along with right understanding enabling them to eliminate conflict and strife in the individual and society.
CO2	Understand to relate philosophy to literature, culture, society and lived experience.
CO3	Understand the knowledge about moral and ethics codes.

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Module I: (8 Hours)

The difference between knowledge (Vidya) and Ignorance (Avidya):
a. Upanishads; b. Six systems orthodox and Heterodox Schools of Indian Philosophy.
c. Greek Philosophy:

Module II: Origin of the Universe (12 Hours)

Nasidiya Sukta: "Who really knows?", Brhadaranyaka Upanishad; Chandogya Upanishad: Non-self, Self, real and unreal. Taittiriya Upanishad: Siksha Valli. Plato's Symposium: Lack as the source of desire and knowledge. Socratic method of knowledge as discovery. Language: Word as root of knowledge (Bhartrahari's Vakyapadiyam). Fourteen Knowledge basis as a sources of Vidya: Four

Vedas; Six auxiliary sciences (Vedangas); Purana, Nyaya, Mimamsa and Dharma Sastras.

Module III: Knowledge as Power (8 Hours)
Francis Bacon. Knowledge as both power and self-realization in Bagavad Gita. Knowledge as oppression: M. Foucault. Discrimination between *Rtam* and *Satyam* in Indian Philosophy.

Module IV: Knowledge as Invention (12 Hours)
Modern definition of creativity; scientific activity in the claim that science invents new things at least through technology. Knowledge about the self, transcendental self; knowledge about society, polity and nature. Knowledge about moral and ethics codes. Tools of acquiring knowledge: *Tantrayuktis*, a system of inquiry (Caraka, Sushruta, Kautilya, Vyasa)

References:
1.Copleston, Frederick, History of Philosophy, Vol. 1.Great Britain: Continuum.
2 Hiriyanna, M. Outlines of Indian Philosophy, Motilal Banarsidass Publishers; Fifth Reprint edition (2009)
3 Sathaye, Avinash, Translation of Nasadiya Sukta
4. Ralph T. H. Griffith. The Hymns of the Ṛgveda. Motilal Banarsidass: Delhi: 1973.
5. Raju, P. T. Structural Depths of Indian Thought, Albany: State University of New York Press.
6. Plato, Symposium, Hamilton Press.
7. Kautilya Artha Sastra. Penguin Books, New Delhi.
8. Bacon, Nova Orgum
9. Arnold, Edwin. The Song Celestial.
10. Foucault, Knowledge/Power.
11. Wildon, Anthony, System of Structure.
12. Lele, W.K. The Doctrine of Tantrayukti. Varanasi: Chowkamba Series.
13. Dasgupta, S. N. History of Indian Philosophy, Motilal Banasidas, Delhi.
14. Passmore, John, Hundred Years of Philosophy, Penguin.

Course HSMC-02: Education, Technology and Society

Course Outcomes:

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

CO1	Explore the various ways in which technology has and may in future affect not only the mode of delivery of education but also the very nature of education.
CO2	Understand the requirement of education for becoming an effective member of the society.
CO3	Understand to fulfill the potential of a learner to the fullest without too much thought of an individual's responsibility towards the contemporary society.

Module I: Necessity of Education (18 Hours)
Necessity of education for human life, Impact of education on society. Nature and scope of education (Gurukul to ICT driven), Emotional intelligence Domains of learning, Approaches to learning, Learning outcomes.

Module II: Role of Education (22 Hours)
Role of education in technology advancement. Technology and society; management of technology; technology transfer. Ethical and value implications of education and technology on individual and society.

Reference Books:
1. Bertrand Russel, "Education and Social order".
2. Bower and Hilgard, "Theories of learning".

3. Jan L Harrington, "Technology and Society".

Course HSMC-03: History of Science and Technology in India

Course Outcomes:

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

CO1	Investigate the various ways in which technology has and may in future affect not only the mode of delivery of education but also the very nature of education.
CO2	Understand the requirement of education for becoming an effective member of the society.
CO3	Understand to fulfill the potential of a learner to the fullest without too much thought of an individual's responsibility towards the contemporary society.

Module I: Concepts and Perspectives (8 Hours)

Meaning of History-Objectivity, Determinism, Relativism, Causation, Generalization in History; Moral judgment in history. Science and Technology-Meaning, Scope and Importance, Interaction of science, technology & society, Sources of history on science and technology in India.

Module II: Historiography Of Science And Technology In India (4 Hours)

Technology in pre-historic period, Beginning of agriculture and its impact on technology, Science and Technology during Vedic and Later Vedic times, Science and technology from 1st century AD to C-1200.

Module III: Science and Technology in Medieval India (10 Hours)

Legacy of technology in Medieval India, Interactions with Arabs, Development in medical knowledge, Astronomy and Mathematics: interaction with Arabic Sciences, Science and Technology on the eve of British conquest.

Module IV: Science and Technology in Colonial India (8 Hours)

Science and the Empire, Indian response to Western Science, Growth of techno-scientific institutions.

Module V: Science and Technology in a Post-Independent India (10 Hours)

Science, Technology and Development discourse, Shaping of the Science and Technology Policy, Developments in the field of Science and Technology, Science and technology in globalizing India, Social implications of new technologies like the Information Technology and Biotechnology.

References:

1. G. Kuppuram, Ed., “History of Science and Technology in India”, South Asia Books, 1990.
2. Debiprasad Chattopadhyaya, “History of Science and Technology in Ancient India: The Beginnings”, South Asia Books, 1987.

Course HSMC-04: Political and Economic Thought for a Humane Society

Course Outcomes:

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

CO1	Learn about how societies are shaped by philosophy, political and economic system
CO2	Investigate how different political-economic systems try to fulfill these desires.
CO3	A critique of different systems and their implementations in the past
CO4	Lifelong learning for implementations with possible future direction

	schemes

Module 1: Humane Society (9 Hours)
Considerations for humane society, holistic thought, human being's desires, harmony in self, harmony in relationships, society, and nature, societal systems.

Module 2: Capitalism, Facism and totalitarianism and Communism (12 Hours)
Capitalism – Free markets, demand-supply, perfect competition, laissez-faire, monopolies, imperialism. Liberal democracy. Fascism and totalitarianism. World war I and II. Cold war. Communism – Mode of production, theory of labour, surplus value, class struggle, dialectical materialism, historical materialism, Russian and Chinese models.

Module 3:Welfare states (10 Hours)
Welfare state. Relation with human desires. Empowered human beings, satisfaction. Gandhian thought. Swaraj, Decentralized economy & polity, Community. Control over one's lives. Relationship with nature.

Module 4: Indian civilization (5 Hours)
Essential elements of Indian civilization. Technology as driver of society, Role of education in shaping of society. Future directions.

References :

1. A Nagaraj, M K Gandhi, JC Kumarappa
2. Adam smith, J S Mill
3. Marx, Lenin, Mao, M N Roy
4. M K Gandhi, Schumacher, Kumarappa
5. Pt Sundarlal, R C Mazumdar, Dharampal
6. Nandkishore Acharya, David Dixon, Levis Mumford

Course HSMC-05: State, Nation building and Politics in India
Course Outcomes:
At the end of this course, students will be able to learn about

CO1	the theoretical aspect of the state, its organs, its operationalization aspect, the background.
CO2	philosophy behind the founding of the present political system, broad streams and challenges of national integration and nation-building in India.
CO3	the real understanding of our political system/ process in correct perspective and make them sit up and think for devising ways for better participation in the system.
CO4	Challenges/ problems and issues concerning national integration and nation-building with the aim of developing a future vision for a better India.

Module I: Need of State and politics - (16 Hours)
Understanding the need and role of State and politics. Development of Nation-State, sovereignty, sovereignty in a globalized world. Organs of State – Executive, Legislature, Judiciary. Separation of powers, forms of governmentunitary-federal, Presidential-Parliamentary,

Module II: About India - (12 Hours)

The idea of India.1857 and the national awakening. 1885 Indian National Congress and development of national movement its legacies. Constitution making and the Constitution of India.

Module III: Federal system - (12 Hours)
Goals, objective and philosophy. Why a federal system? National integration and nation-building. Challenges of nation-building – State against democracy (Kothari), New social movements. The changing nature of Indian Political System, the future scenario. What can we do?

References :
1. Sunil Khilnani, The Idea of India. Penguin India Ltd., New Delhi.
2. Madhav Khosla, The Indian Constitution, Oxford University Press. New Delhi, 2012. Brij Kishore Sharma, Introduction to the Indian Constitution, PHI, New Delhi, latest edition.
3. Sumantra Bose, Transforming India: Challenges to the World's Largest Democracy, Picador India, 2013.
4. Atul Kohli, Democracy and Discontent: India's Growing Crisis of Governability, Cambridge University Press, Cambridge, U. K., 1991.
5. M. P. Singh and Rekha Saxena, Indian Politics: Contemporary Issues and Concerns, PHI, New Delhi, 2008, latest edition.
6. Rajni Kothari, Rethinking Democracy, Orient Longman, New Delhi, 2005.

Course code: HSMC- 06: Engineering Management
Course Outcomes:
At the end of this course, students will be able to

CO1	learn about project management and finance through proper planning and decision, efficient production, labour handling etc
CO2	Investigate to become more productive through discipline and walefare schemes
CO3	Realisation about industrial personnel selection and recruitment, promotion, redress of grivences etc.

Module 1: Engineering Management (10 Hours)
Management, administration: planning, decision making, organization and staff, controlling, communication.
Module 2: Industrial relations (12 Hours)
Location of factory: building and plant layout, Material handling: maintenance dept procedure. personnel selection and recruitment, training and placement, transfer and promotion, discipline, redress of grievances.
Module 3: Labour Handling (10 Hours)
Labour turnover: prevention of accident and safety measure, Welfare scheme, Union relation: worker's participation in management. Wage administration, method of wage payment,
Module 4: Production (8 Hours)
projection planning, scheduling, routing of work order, flow chart, inspection and avoidance of waste, time and motion study.

References:

Course code: HSMC- 07: Applications of Psychology
Course Outcomes:
At the end of this course, students will be able to learn about

CO1	aware of the different applications of psychology to everyday issues of life.
CO2	aware of the different social issues, workplace issues, and behavioural issues.
CO3	understand how the knowledge gained from this course can be used in their own personal and professional work life.

Module I: Psychology in industries and organizations - (10 Hours)
Introduction: Nature and fields. Psychology in industries and organizations: Job analysis; fatigue and accidents consumer behavior.

Module II: Psychology and mental health - (12 Hours)
Abnormality, symptoms and causes psychological disorders.

Module III: Psychology and Counseling - (8 Hours)
Need of Counseling, Counselor and the Counselee, Counseling Process, Areas of Counseling.

Module IV: Psychology and social behavior - (10Hours)
Group, group dynamics, teambuilding, Prejudice and stereotypes; Effective Communication, conflict and negotiation.

References :

1. Schultz, D. & Schultz, S.E. (2009). Psychology and Work Today (10th ed.). New Jersey:Pearson/Prentice Hall.
2. Butcher, J. N., Mineka, S., & Hooley, J. M. (2010). Abnormal psychology (14th ed.). New York: Pearson
3. Gladding, S. T. (2014). Counselling: A comprehensive profession. New Delhi: Pearson Education
4. Aronson, E., Wilson, T. D., & Akert, R. M. (2010). Social Psychology (7th Ed.). Upper Saddle River, NJ: Prentice Hall.

Course HSMC-08: Sociology, Society and Culture
Course Outcomes:
At the end of this course, students will be able to learn about

CO1	The interest of the student in social issues and demonstrate both the process and challenge of scientific observation.
CO2	The analysis of social behaviour and social data.
CO3	the understanding of basic concepts and descriptive materials of sociology.
CO4	Tools for identifying the process of idea and a scientific approach for continuing social observation and analysis.

Module I:Sociology as a Science (4 Hours)
Sociology and common Sense. Sociology and current affairs. Sociology as a science. Logic in sociological inquiry. Sociology of action. The field and relevance of sociology. Positivism.

Module II: Society and Culture (8 Hours)
Culture and society. The structure of culture. Cultural Traits and complexes. Subcultures and counter cultures. Cultural integration. Cultural relativism. Real and Ideal culture. Ethnocentrism .Xenocentrism. Cultural lag

Module III: Social Institutions (12 Hours)
The concept of varna. The Caste system: Origin and characteristics (of caste) as a system, Hierarchy based on birth, Religious sanctions on social participation, Caste and subcaste, Caste conflicts, Caste councils, An appraisal of caste system, Prospects of caste in modern India. The Class system: What is social class?, Development of class, Self-identification and class consciousness, Class in itself and class for itself, Class having blue collar status and white collar status, Industrial class, Significance of social class, The future of social classes: From Proletariat to status seekers.

Module IV: Environment and Ecology(10 Hours)
Conceptualising environment. Forest, ecology and society. Common Property Resources and its management. Significance of forest and environment in modern life. Environmental movement with reference to forest and water management.

Module V: Issues of modernity (14 Hours)
Concept of modernity. Tradition Vs Modernity. Globalization: Is globalization new and real?, Has globalization weakened the state?, Has globalization led to cultural homogenisation?, Does globalization lead to a clash of cultures?

References:
1. Gisbert, P. (2011), Fundamental of Sociology, Orient Blackswan Private Ltd.
2. Horton, Paul B. and Hunt, Chester L. (Sixth edition), Sociology, Mc Graw Hill Book Company.
3. Haralambos, M. and Heald, R.M. (26th impression, 2004), Sociology: Themes and Perspectives, Oxford University Press, New Delhi.
4. Betteille, Andre (2014), sociology: essays on Approach & Method, Oxford Uninversity Press, New Delhi.
5. Ahuja, Ram (2006), Indian Social System, Rawat Publications, New Delhi.
6. Guha, Ramchandra (1994), Social Ecology, Oxford University Press, New Delhi.
7. Sundar Nandini, Jeffery Roger and Thin, Neil (2001) Branching out Joint Forest Management in India, Oxford University Press, New Delhi.
8. Dunlap, Riley E. and Micelson, William (2008), Handbook of Environmental Sociology, Rawat Publications, New Delhi.
9. Moore, Francis (2003), Environment and Society, Dominant Publishers, New Delhi.
10. Boman, Z. (1989), Modernity and Holocaust, Cambrdige Polity Press.
11. Baudrilard, J. (1994), The Illusion of the End, Cambridge Polity Press.
12. Jameson, Fredric (2006), Postmodernism OR The Cultural Logic of Late Capitalism, Duke University Press, Durham.
13. Giddens, Anthony (1990), he Consequences of Modernity, Cambridge Polity Press.
14. Gupta, Dipankar (2000), Mistaken Modernity, Harper Collins Publishers, India.

Course HSMC-09: Engineering Economics
Course Outcomes:
At the end of this course, students will be able to

CO1	Basics understanding of role of engineering economics.
CO2	The analysis of various terminologies related to economics
CO3	Design of the mixed economy for various production.
CO4	To manage project and finance related to economic development

Module1: Nature and significance of economics(12 Hours)

Concepts of demand, supply, equilibrium, short and long term analysis, static and dynamic state, macro and micro economics, want and utility, \

Module 2: Marginal analysis (8 Hours)

Cost, money and real cost. Tax and profit, competition, monopoly, distribution.

Module 3: Economic systems(10 Hours)

Capitalism, socialism, mixed economy, Factors of production, national income land labour capital, organization and enterprise. Laws of return, PNP, NNP and national income.

Module 4: Economic development of India (10 Hours)

features, industrialization, labour economics, agriculture, economic planning, banking and international trade.

References:

Course HSMC-10: Values & Ethics

Course Outcomes: After completion of this course, the students will be able to

CO1	Describe the Effects of Technological Growth
CO2	Describe and practice the Ethics of Profession
CO3	Demonstrate the Profession and Human Values
CO4	Comprehend Science, Technology and Engineering as knowledge and as Social and Professional Activities

Detailed Syllabus

Module 1: Profession and Human Values (10 Hours)

a. Values Crisis in contemporary society
b. Nature of values: Value Spectrum of a good life
c. Psychological values: Integrated personality; mental health
d. Societal values: The modern search for a good society, justice, democracy, secularism, rule of law, values in Indian Constitution.
e. Aesthetic values: Perception and enjoyment of beauty, simplicity, clarity

Module 2: Effects of Technological Growth (10 Hours)

a. Rapid Technological growth and depletion of resources, Reports of the Club of Rome. Limits of growth: sustainable development
b. Energy Crisis: Renewable Energy Resources
c. Environmental degradation and pollution. Eco-friendly Technologies. Environmental Regulations, Environmental Ethics
d. Appropriate Technology Movement of Schumacher; later developments

Module 3: Ethics of Profession: (10 Hours)

a. Engineering profession: Ethical issues in Engineering practice,
b. Conflicts between business demands and professional ideals.
c. Social and ethical responsibilities of Technologists. Codes of professional ethics. Whistle blowing and beyond, Case studies.
d. Moral and ethical values: canons of ethics; ethics of virtue; ethics of duty; ethics of responsibility.

Module 4: Human centered Technology (10 Hours)

a. Human centered Technology.
b. Human Operator in Engineering projects and industries. Problems of man, machine, interaction,

c. Impact of assembly line and automation.

References:

1. Stephen H Unger, Controlling Technology: Ethics and the Responsible Engineers, John Wiley & Sons, New York 1994 (2nd Ed)
2. Deborah Johnson, Ethical Issues in Engineering, Prentice Hall, Englewood Cliffs, New Jersey 1991.
3. A N Tripathi, Human values in the Engineering Profession, Monograph published by IIM, Calcutta 1996.
4. Little, William: An Introduction of Ethics (allied Publisher, Indian Reprint 1955)
5. William, K Frankena: Ethics (Prentice Hall of India, 1988)
6. Dr. Awadesh Pradhan: Mahamana ke Vichara. (B.H.U., Vanarasi-2007)

Course HSMC-11: Introduction to Women’s and Gender Studies

Course Outcomes:

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

CO1	The gender concepts, gender role and relations.
CO2	The women's movement both global and national.
CO3	the understanding of basics of gender specific language.
CO4	The gender representation..

Module I: Concepts (10 Hours)

Sex vs. Gender, masculinity, femininity, socialization, patriarchy, public/ private, essentialism, binaryism, power, hegemony, hierarchy, stereotype, gender roles, gender relation, deconstruction, resistance, sexual division of labour.

Module II: Feminist Theory (6 Hours)

Liberal, Marxist, Socialist, Radical, Psychoanalytic, postmodernist, ecofeminist.

Module III: Women’s Movements: Global, National and Local (8 Hours)

Rise of Feminism in Europe and America. Women’s Movement in India.

Module IV: Gender and Language (8 Hours)

Linguistic Forms and Gender. Gender and narratives.

Module V: Gender and Representation (8 Hours)

Advertising and popular visual media. Gender and Representation in Alternative Media. Gender and social media.

Course HSMC-12: Making Indian Culture: Epistemic Traditions, Literature and Performative Arts

Course Outcomes:

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

CO1	The development of an indigenous, Non- European perspective to study the dynamics of Indian Civilization.
CO2	fostering an indigenous perspective that will help in retrieving the dynamics, priorities and insights of Indian civilization disembedding it from the imitation of European model.

CO3	Breaking the disciplinary boundary by taking the recourse to an interdisciplinary approach, and bringing out the totality of Indian civilization.
CO4	Exploring the dynamics of Indian modernity which was lost under the colonial subjugation

Module I: The Vernacular Millennium Topics (12 Hours)
The Emergence of Modern Indian Languages with special reference to Hindi. Bhakha and its regional variations. The Idea of Hindi, Rekhta, Urdu and Hindustani

Module II: Early Modern India: Mughal Period and After Topics (14Hours)
Religious Sects and Indian Islam, Bhakha and Braj Bhasha, Performative Tradition: Poetry and Music Text and Telling

Module III: Colonial and Postcolonial India (14 Hours)
Orientalism and India. Translating India: Language of Command and Command of Language. Colonial Modernity: Renaissance and Nationalism . Postcolonial Critique and Indian Modernity

References:
1. Sunil Kumar,. The Emergence of the Delhi Sultanate
2. Hazari Prasad Drivedi, Nath Sampradaya
3. Dharmveer Bharati, Siddha Sahitya
4. J.L.Mehta , Advanced Study in the History of Medieval India, Vol. III: Medieval Indian Society and Culture.
5. GyanendraPandeya, The Construction of Communalism in Colonial North India
6. William Crooke, The Tribes and Caste of North-Western Provinces of India
7. Dipesh Chakrabarty, Provincializing Europe

Course HSMC-13: Human Relations At Work
Course Outcomes:
At the end of this course, students will be able to learn about

CO1	awareness of human relations at work its relationship with self.
CO2	the processes involved in interaction with people at work.
CO3	the importance of psychological and physical health in maintaining human relations at work and progressing in career.

Module I: Understanding and Managing Yourself (10 Hours)
Human Relations and You: Self-Esteem and SelfConfidence: Self-Motivation and Goal Setting; Emotional Intelligence, Attitudes, and Happiness; Values and Ethics and Problem Solving and Creativity.

Module II: Dealing Effectively with People (12 Hours)
Communication in the Workplace; Specialized Tactics for Getting Along with Others in the Workplace; Managing Conflict; Becoming an Effective Leader; Motivating Others and Developing Teamwork; Diversity and Cross-Cultural Competence.

Module III: Staying Physically Healthy (8 Hours)
Yoga, Pranayam and Exercise: Aerobic and anaerobic.

Module IV: Staying Psychologically Healthy (10 Hours)

Managing Stress and Personal Problems, Meditation. Developing Career Thrust: Getting Ahead in Your Career, Learning Strategies, Perception, Life Span Changes, Developing Good Work Habits.

References :

1. Dubrien, A. J. (2017). Human Relations for Career and Personal Success: Concepts, Applications, and Skills, 11th Ed. Upper Saddle River, NJ: Pearson.
2. Greenberg, J. S. (2017). Comprehensive stress management (14th edition). New York: McGraw Hill.
3. Udai, Y. (2015). Yogasan aur pranayam. New Delhi: N.S. Publications.`

Course HSMC-14: Language and Communication

Course Outcomes:

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

CO1	Comprehend the basic knowledge of communication skills in English through exposure to communication theory and practice.
CO2	Apply the basic grammatical skills, reading skills, vocabulary of the English language through intensive practice.
CO3	Develop listening and writing skills. Able to write Official Letters, Technical report, memo, notice, minutes, agenda, resume, curriculum vitae.
CO4	Apply /illustrate all sets of English Language and Communication skills in creative and effective ways in the professional sphere of their life.

Module 1: Communication Interface in a Globalized World (6 Hours)

a .Definition of Communication & Scope of Communication. b. Process of Communication—Models and Types. c. Verbal—Non-Verbal Communication, Channels of Communication. d. Barriers to Communication & surmounting them. e. Miscommunication

Module 2: Grammar, Vocabulary and Reading (8 Hours)

Functional Grammar and Usage: a. Articles, Prepositions, Verbs, b. Verb-Subject Agreement, c. Comparison of Adjectives, d. Tenses and their Use, e. Transformation of Sentences (Singular-Plural, Active-Passive, Direct-Indirect, Degrees of Comparison), f. Error Correction . Vocabulary and Reading: a. Word origin—Roots, Prefixes and Suffixes, Word Families, Homonyms and Homophones, b. Antonyms and Synonyms, One-word substitution, c. Reading—Purposes and Skills d. Reading Sub-Skills—Skimming, Scanning, Intensive Reading , e. Comprehension Practice (Fiction and Non fictional Prose/Poetry), f. Précis

Module 3: Business writing (12 Hours)

a. Business Communication in the Present-day scenario, b. Business Letters (Letters of Inquiry, Sales Letters, Complaint and Adjustment Letters, Job Application Letters), c. Drafting of a CV and Résumé d. Memo, Notice, Agenda, Minutes of Meetings, Advertisement, e. E-mails (format, types, jargons, conventions), f. Technical Report writing

Module 4: Professional Communication in Practice (16 Hours)

I. Speaking: a. Speaking (Choice of words, Speech Syntax, Pronunciation, Intonation), b. Language Functions/Speech Acts, c. Speaking using Picture Prompts and Audio Visual inputs, d. Conversational Role Plays (including Telephonic Conversation) .II. Power Point Presentation (Non-Technical and Technical Presentation). III. Group Discussion: Principles and Practice. IV. Interviewing Skills (Dos and Don’ts of Interviews and Mock Interview practice)

References:

1.Raymond Murphy. *English Grammar in Use*. 3rd Edn. CUP, 2001.
2. Seidl & McMordie. *English Idioms& How to Use Them*. Oxford:OUP, 1978.

3. Michael Swan. *Practical English Usage*. Oxford:OUP, 1980.
4. Simeon Potter. *Our Language*. Oxford:OUP, 1950.
5. Pickett, Laster and Staples. *Technical English: Writing, Reading & Speaking*. 8th ed. London: Longman, 2001.
6. Joseph, C. J. and Myall. *A Comprehensive Grammar of Current English*. Ed. A. Biswas. Inter University Press, 2015.

Course HSMC-15: Language and Linguistics

Course Outcomes:

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

CO1	Understand of various languages as communication medium
CO2	Analyse the different languages with their communications features
CO3	Analyse the structural differences between languages for communication.
CO4	Realise phase structure, meaning and pragmatics of linguistics

Module I: Language as communication medium (12 Hours)

How do human languages (spoken and signed) differ from means of communication used by other animals?
(a) "Design Features" of human languages.
(b) Innateness and (social) learning —"copying" and the spread of cultural phenomena.
(c) Patterns vs Rules vs Analogies.
(d) What language "Acquisition" and "Transmission" really mean?
(e) Structural complexity of spoken languages — the significance of modularity.
(f) Speaker-Idexicality - language and identity (race/ethnicity, socio-economic, class, gender, age group, education, professional affiliation, etc.)

Module II: Different languages (8 Hours)

Why do human languages differ structurally, despite their architectural Similarities? (Sense of typology). (a) Variation vs transformational evolution.
(b) Word order typology.

Module III: Structure and structure dependence (8 Hours)

(a) Diagnostics for structure; reference, co-reference and anaphoric reference; deixis, demonstratives, tense, pronominal. b) Context; topic, focus, focusing devices.
(b) Thematic role; agent, patient, goal.
(c) Grammatical relation; subject and object.
(d) Case; nominative, accusative.

Module IV: Phrase structure, Meaning, Pragmatic (12 Hours)

(a) X-bar theory; head, complement, specifies.
(b) S as IP and S-bar as CP.
(c) DP analysis of noun phrase.
(d) Syntactic operation; move; relative clause.
(e) Sense and reference and denotation and connotation.
(f) Synonymy, antonym, hyponymy.
(g) Propositions; ambiguity, generic vs specific, definite and indefinite.
(h) Presupposition.
(i) Entailment.
(j) Implicate.

References:

1. Akrnajian, A and Heny, F 1975. An Introduction to the Principles of Transformational Syntax, Cambridge, Mass: MIT Press.
2. Chomsky, N and Halle, Morries 1966. Studies in Language, Harper and Row, publishers. New York
3. Bolinger, D.L. 1980, Language, the Loaded Weapon, London: Longman. Stephen. C. Levenson, 1983 Pragmatics, Cambridge University Press.
4. Song, Jae Jung, 2001 Linguistic Typology. Pearson Education Limited.

Course HSMC-16: Understanding Society and Culture Through Literature
Course Outcomes:

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

CO1	Awareness of various traditions
CO2	Ability to not just understand the diversity found between various traditions but to celebrate them.
CO3	Strengthening of the analytical capability.
CO4	Improvement in language skills and ability of expressing complex ideas.

Module I: Introduction (6 Hours)

Knowledge tradition, what is Literature, Significance of studying literature, how to study society and culture through literature

Module II: Morality (8 Hours)

Various literary pieces will be picked up that would help us to understand morality.

Module III: Dilemma (14 Hours)

Various literary pieces will be picked up that would force us to think about situations where one is faced with a dilemma; where such ethical questions arise that differentiating between right and wrong becomes very difficult. This forces us to re-think our notions of right and wrong and helps us in understanding the various realities of life.

Module IV: Gender (12 Hours)

Various literary pieces will be picked up that questions the current notions of gender, and raises uncomfortable questions, challenging the status-quo, forcing us to think the real meaning of equality and emancipation.

Course HSMC-17: Fundamentals of Linguistics

Course Outcomes:

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

CO1	the scientific study of language.
CO2	some basic issues and questions related to language and its linking with brain, society and world.
CO3	brief outline of language studies in Indian and western tradition and many applications of linguistics in different fields.

Module I: Language and Linguistics (14 Hours)

What is language and where is language?: Language is a means of communication, a social product, Language is a cognitive ability, relation between language and brain. What is Linguistics and what is not Linguistics?: Linguistics is not prescriptive grammar learnt in the school, Linguistics is not learning of many languages , Linguistics provides tools to analyze language structure scientifically. Study of Language in Indian and western traditions.

Module II: Language Analysis (22 Hours)
Levels of Language Analysis: Form and content , Sound, Word, Sentence, meaning. Similarities and differences of languages

Module III: Applications (4 Hours)
Applications of Linguistics: Natural Language Processing, Clinical Linguistics, Psycholinguistics etc.

Course HSMC-18: Film Appreciation
Course Outcomes:
At the end of this course, the students will be introduced broadly to

CO1	The development of film as an art and entertainment form.
CO2	Understand the language of cinema as it evolved over a century.
CO3	How to read a film and appreciate the various nuances of a film as a text.

Module 1: The Component of Films (8 Hours)
The material and equipment, The story, screenplay and script, The actors, crew members, and the director, The process of film making: structure of a film, Studio System.

Module 2: Evolution of Film Language (20 Hours)
Silent Cinema: Primitive and Pioneers, Films from 1895 – 1910. [Reference Films: *Films by Lumiere Bros, A Trip To The Moon, The Great Train Robbery*]. Narrative Cinema and Institutional Mode of Representation: D. W. Griffith [Reference Films: *The Birth of a Nation (1915)*]. **Post WW I:** German Expressionism: Robert Weine & Fritz Lang [Reference film: *Cabinet of Dr Caligari (1919), Metropolis (1927)*. Soviet Montage: Lev Kuleshov, Vsevolod Pudovkin, Sergei Eisenstein [Reference film: *Battleship Potemkin (1925)*]. Surrealism: Luis Bunuel [Reference film: *Un Chien Andalou (1929)*]. Silent Comedy: Chaplin [Reference film: *Chaplin's Short Comedies*, *Modern Times (1936)*]. **Post WW II :** Italian Neo-Realism: Roberto Rossellini & Vittorio De Sica [Reference film: *Rome, Open City (1945) & Bicycle Theives (1948)*]. French New Wave: Francois Truffaut & Jean Luc Godard
[Reference film: *400 Blows (1959) & Breathless (1960)*]. Japanese Cinema: Ozu, Akira Kurosawa & Mizoguchi [Reference film: *Tokyo Story (1953), Rashomon (1950), Life of Oharu (1952)*].

Module 3: Indian Films (12 Hours)

Early cinema: Hiralal Sen, D. G. Phalke, Studio system: New Theatres, Bombay Talkies Post Studio System: a) Melodrama [Reference Films: *Mother India (1957), Anand (1971), Sholay (1975), Parinda (1989), Dilwale Dulhaniya Le Jayenge (1996)*]. b) Auteurs : Satyajit Ray [Reference films: *Apu Trilogy*], Ritwik Ghatak [Reference films: *Partition Trilogy*]. Indian New Wave [Reference films: *Bhuvan Shome (1969), Uski Roti (1969), Ankur (1972) Garam Hawa (1974), Rat Trap (1982), Ardh Satya (1983), Jaane Bhi Do Yaaron (1983)*]. Middle cinema [Reference films: *Choti Si Baat (1976), Gol Maal (1979), Khosla Ka Ghosla (2006)*]

Text/References:
1. Barsam, Richard and Dave Monahan, "Looking at Movies", New York: Norton, 2016. 5th edition.
2. Braudy, Leo and Marshall Cohen. Eds, "Film Theory and Criticism", Oxford: Oxford University Press, 1999.

3. Ranjani Mazumdar, “Bombay Cinema”, University of Minnesota, 2007.
4. Satyajit Ray, “Our Films, Their Films”, Orient BlackSwan, 2001.
5. Satyajit Ray, “Deep Focus: Reflections on Cinema”, Harper, 2013.
6. Renu Saran, “History of Indian Cinema”, Diamond Books, 2012.

Course HSMC-19: Law and Engineering

Course Outcomes:

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

CO1	A basic understanding of the legal concepts and issues relevant to those wishing to practice as Engineers.
CO2	Basic principles of contract and goods law.
CO3	About business organisations.

Module 1. The Legal System: Sources of Law and The Court Structure: (10 Hours)

Enacted law -Acts of Parliament are of primary legislation, Common Law or Case law- Principles taken from decisions of judges constitute binding legal rules. The Court System in India and Foreign Courtiers. (District Court, District Consumer Forum, Tribunals, High Courts, Supreme Court). Arbitration: As an alternative to resolving disputes in the normal courts, parties who are in dispute can agree that this will instead be referred to arbitration. Basic principles of contract law, sale of goods law

Module 2: Business Organisations (8 Hours)

Sole traders (Business has no separate identity from you, all business property belongs to you). Partnerships: three types of Partnerships: Limited Liability Partnership, General Partnership, Limited Partnerships. Companies: The nature of companies. Classification of companies. Formation of companies. Features of a public company. Carrying on business. Directors–Their Powers and Responsibilities/Liabilities.

Module 3: Intellectual Property law (10 Hours)

Laws relating to industrial pollution, accident, environmental protection, health and safety at work. Patent law. Information technology law and cyber crimes.

Module 4: Engineering and constitutional law (12 Hours)

Law and society: Interdisciplinary nature of law, legal ideologies/philosophy/ schools of jurisprudence. Constitutional law: the supreme law of the land. Case studies: important legal disputes and judicial litigations.

Reference: