

Engineering

Study Scheme & Syllabus of Bachelor of Technology Electrical Engineering

Batch 2023 onwards (3rd -8th Semester)

For

**University Main Campus,
Constituent Campuses and
Affiliated colleges**



Department of Academics

I.K. Gujral Punjab Technical University



Semester III [Second year]					Branch: Electrical Engineering					
Sr. No.	Course code	Course Title	L	T	P	Hours/Week	Internal Marks	External Marks	Total Marks	Credits
1	BTEE-301-18	Electrical Circuit Analysis	3	1	0	4	40	60	100	4
2	BTEE-302-18	Analog Electronics	3	0	0	3	40	60	100	3
3	BTEE-303-18	Electrical Machines – I	3	0	0	3	40	60	100	3
4	BTEE-304-18	Electromagnetic Fields	3	1	0	4	40	60	100	4
5	BTEE-305-18	Engineering Mechanics	3	1	0	4	40	60	100	4
6	BTEE-311-18	Analog Electronics Laboratory	0	0	2	2	30	20	50	1
7	BTEE-312-18	Electrical Machines – I Laboratory	0	0	2	2	30	20	50	1
8	BTMC-XXX-18	Mandatory Course (BTMC-101-18 or BTMC 102-18)	3	0	0	3	40	60	100	S/US
9	BMPD-301-18	Mentoring and Professional Development of Students	0	1	0	1	50	-	50	S/US
10	BTEE-321-18	Institutional Summer Vacation Training*	-	-	-	35*	-	-		S/US
Total			18	4	4	26	410	400	750	20

***BTEE-321-18: Institutional Summer Vacation Training: Four (04) weeks Institutional Summer Vacation Training after 2nd Semester for programme. B.Tech. (Electrical Engineering).**



Semester IV [Second year]					Branch: Electrical Engineering					
Sr. No.	Course code	Course Title	L	T	P	Hours/Week	Internal Marks	External Marks	Total Marks	Credits
1	BTEE-401-18	Digital Electronics	3	0	0	3	40	60	100	3
2	BTEE-402-18	Electrical Machines – II	3	0	0	3	40	60	100	3
3	BTEE-403-18	Power Electronics	3	0	0	3	40	60	100	3
4	BTEE-404-18	Signals and Systems	3	0	0	3	40	60	100	3
5	BTAM-302-23	Mathematics-III (Probability & Statistics)	4	1	0	4	40	60	100	3
6	BTEE-411-18	Measurements and Instrumentation Lab.	2	0	2	4	30	20	50	3
7	BTEE-412-18	Digital Electronics Laboratory	0	0	2	2	30	20	50	1
8	BTEE-413-18	Electrical Machines – II Laboratory	0	0	2	2	30	20	50	1
9	BTEE-414-18	Power Electronics Laboratory	0	0	2	2	30	20	50	1
10	BTMC-XXX-18	Mandatory Course (BTMC-101-18 or BTMC 102-18)	3	0	0	3	40	60	100	S/US
11	BMPD-401-18	Mentoring and Professional Development of Students	0	1	0	1	50	-	50	S/US
Total			21	2	8	30	410	440	850	21

Students to undertake Six weeks summer industry internship/ field training (during vacation).

Additional Lectures/Tutorials: Need based additional lectures/tutorials may be introduced of any Course, however, the Credits of the course will not change.

BTEE-321-18: Institutional Summer Vacation Training: Four (04) weeks Institutional Summer Vacation Training after 2nd semester for programme. B. Tech. (Electrical Engineering)

Objective: The training is compulsory and is for the orientation of the students of the Electrical Engineering so that they are aware of/can identify the industrial, departmental, environmental, societal and other issues that are a challenge in the society and develop the ability to find solutions. The training in the concerned discipline will be provided in College/Department Labs /Workshops

Content to be covered:

Module I, II & III: Hands on training/ practical knowledge on any three/four of the given contents

Module IV & V: Compulsory

Module	Content	Remarks
I	- Hands on training of wiring (Tube light, Incandescent bulb & LED light fitting, extension board, staircase). - Preparation of wiring diagram for domestic load/commercial load - Study of types of switches, protective devices (samples to be made available)	30 hours



Module	Content	Remarks
	- Types of electrical wires and Cables (samples to be made available) - Classification of Insulation (samples to be made available)	
II	- Single Line diagram of power generation, transmission distribution - Power scenario in India (Conventional & renewable sources of energy) (recent information from the website of Ministry of power to be included) - Introduction to the concept of Heating, Ventilation and Air conditioning. - The need of industrial safety. - Introduction to electrical machines and their maintenance.	30 hours
III	- Introduction to multimeter, function generator, CRO, - Identification and testing of resistors, capacitors, transistors and diodes, etc. - Observing the response of various circuits on CRO - Design and fabrication of +5V / +12V powers supply on bread board - Design and fabrication of half wave and/or full wave rectifier - Logics gates (using ICs)	30 hours
IV	- Study of main components of a sub-station and visit to local sub Station - Visit to industry/manufacturing unit related to discipline/branch (In case of small-scale industries/MSMEs, the faculty and students to identify small issues and propose requisite solutions/ remedies/ innovative solutions based on engineering) - Invited talk by Industry Expert - Expert talk on recent technologies	25 hours
V	- Visit to local NGO/village/city to identify socio-economic/ environmental issues and identify a problem and prepare a “Problem formulation report” - To have a group discussion on the issues identified with faculty and to propose requisite solutions/remedies/innovative solutions based on Engineering.	25 hours
Total Time		140 hours

Evaluation Criterion:

- Four (04) weeks Institutional Summer Vacation Training after 2nd semester is a compulsory non-Credit course.
- The students are required to maintain a daily dairy and submit it along with the “Problem formulation report”.
- Student falling short of 75% attendance criterion is required to repeat the training with next batch.
- Continuous evaluation to be done and proper record to be maintained.
- The result will be “Satisfactory/Unsatisfactory” which is to be recorded within 3 working days after the completion of the training.



BTEE-521-18	Summer Industry Internship/ Field Training	(Non-Credit)
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Six weeks in an Industry in the area of Electrical Engineering during summer vacations after 4th semester. The summer internship should give exposure to the practical aspects of the discipline. In addition, the student may also work on a specified task or project which may be assigned to him/her. The outcome of the internship should be presented in the form of a report. The student will make a presentation based upon the Industry Internship attended. Performance to be rated as Satisfactory/Un -Satisfactory (S/US). For unsatisfactory the internship to be repeated.

Evaluation scheme (Summer Industry Internship/ Field Training)

Internal (to be evaluated by Industry)	Marks	External* (to be evaluated by Department)	Marks
Attendance	15	Daily Dairy	5
Performance (Work done /simulation/hardware/project developed)	30	Report	10
Report	10	Presentation (Work done /simulation/hardware/project developed)	25
Daily Dairy	05		
Total	60	Total	40

*External examiner not to be called.

Range of credits for Honors Degree -Minimum credits as per scheme are required by a student to be eligible to get Under Graduate degree in Electrical Engineering. A student will be eligible to get Under Graduate degree with Honours, if he/she completes an additional 20 credits. These could be acquired through MOOCs and registering in the department.

Range of Credits and Courses for Major Degree in B. Tech. (Electrical Engineering) and Minor Degree in B.Tech. (Electrical and Computer Engineering)

- A student admitted in B. Tech (EE) may opt for Major Degree in B. Tech. (Electrical Engineering) and Minor Degree in B.Tech. (Electrical and Computer Engineering) with effect from 3rd semester onwards..
- The student must clear his/her previous two semesters (1st and 2nd Semester).
- The student/candidate will require to clear at least five theory subjects for Minor Degree in B.Tech.
- The minimum credits for Minor Degree in B. Tech. will be 20 in which the student will have to clear minimum two (2) Core Courses and three (3) Professional Elective (PE) Courses / Core Courses).
- A student is permitted to take maximum 8 credits (theory + lab) per semester pertaining to their Minor Degree in B.Tech.

Virtual Laboratories: Students may take at least one virtual laboratory any time before the commencement of the 8th Semester.

Open Elective: A student may take Courses from the list of Open Electives offered by other Departments or MOOCs Courses of SWAYAM/MOOCs courses approved by the Board of Studies.



MANDATORY COURSES (Non-Credit Courses)

Sr. No.	Semester	Course Code	Course Title	Hours/Week	Credits
1.	III/IV	BTMC-101-18	Indian Constitution	3L:0T:0P	Nil
2.	III/IV	BTMC-102-18	Essence of Indian Traditional Knowledge	3L:0T:0P	Nil
3.	V	EVS 101-18	Environmental Studies	2L:0T:0P	Nil



Students to undertake Six Weeks Summer Industry Internship (during vacation).										
Semester V [Third year]					Branch: Electrical Engineering					
Sr. No.	Course code	Course Title	L	T	P	Hours/Week	Internal Marks	External Marks	Total Marks	Credits
1	BTEE-501-18	Power Systems – I (Apparatus & Modelling)	3	1	0	4	40	60	100	4
2	BTEE-502-18	Control Systems	3	1	0	4	40	60	100	4
3	BTEE-503-18	Microprocessors	3	1	0	4	40	60	100	4
4	BTEE-601X-18	Programme Elective-1	3	0	0	3	40	60	100	3
5	EVS-101-18	Environmental Studies	2	0	0	2	50	-	50	S/US
6	BTEE-511-18	Power Systems-I Laboratory	0	0	2	2	30	20	50	1
7	BTEE-512-18	Control Systems Laboratory	0	0	2	2	30	20	50	1
8	BTEE-513-18	Microprocessors Laboratory	0	0	2	2	30	20	50	1
9	BTEE-521-18	Summer Industry Internship	-	-	-	-	40	60	100	S/US
10	BMPD-501-18	Mentoring and Professional Development of Students	0	1	0	1	50	-	50	S/US
Total			14	4	6	24	390	360	750	18
Semester VI [Third year]					Branch: Electrical Engineering					
Sr. No.	Course code	Course Title	L	T	P	Hours/Week	Internal Marks	External Marks	Total Marks	Credits
1	BTEE-601-18	Power System-II (Operation and Control)	3	1	0	4	40	60	100	4
2	BTEE-602-18	Power Generation and Economics	3	1	0	4	40	60	100	4
3	BTEE-603X-18	Programme Elective-2	3	0	0	3	40	60	100	3
4	BTEE-604-18	Programme Elective-3	3	0	0	3	40	60	100	3
5	OXX-XXX-18	Open Elective-1	3	0	0	3	40	60	100	3
6	HSMC-XXX-18	Humanities & Social Sciences including Mgt.	3	0	0	3	40	60	100	3
7	BTEE-611-18	Electronic Design Laboratory	1	0	2	3	30	20	50	2
8	BTEE-612-18	Power Systems-II Laboratory	0	0	2	2	30	20	50	1
9	BTEE-621-18	Project-1	0	0	6	6	60	40	100	3
10	BMPD-601-18	Mentoring and Professional Development of Students	0	1	0	1	50	-	50	S/US
Total			19	3	10	32	410	440	850	26



Semester VII/VIII [Fourth year]					Branch: Electrical Engineering					
Sr. No.	Course code	Course Title	L	T	P	Hours/Week	Internal Marks	External Marks	Total Marks	Credits
1	BTEE-701X-18	Programme Elective-4	3	0	0	3	40	60	100	3
2	BTEE-702X-18	Programme Elective-5	3	0	0	3	40	60	100	3
3	BTOE-703X-18	Programme Elective-6	3	0	0	3	40	60	100	3
4	OXX-XXX-18	Open Elective-2	3	0	0	3	40	60	100	3
5	OXX-XXX-18	Open Elective-3	3	0	0	3	40	60	100	3
6	HSMC-XXX-18	Humanities & Social Sciences including Mgt.	3	0	0	3	40	60	100	3
7	BTEE-721-18	Project-2	0	0	12	12	120	80	200	6
8	BMPD-701-18	Mentoring and Professional Development of Students	-	1	0	1	50	-	50	S/US
Total			18	1	12	31	410	440	850	24



Institute/Department/Student may decide for Industry oriented courses in lieu of One Semester Training in 7th or 8th Semester (Subject to approval from Competent Authority).

Semester VII/VIII [Fourth year]				Branch: Electrical Engineering			
BTEE-721-18 One Semester Training	Marks				Total Marks	Credits	
	Internal			External			
	Mid- semester		End-semester				
Evaluation by	Institute	Industry	Institute	Industry	External Examiner		
Software Training & Project	50	25	50	25	200	500	16
Industrial Training & Project	50	25	50	25			
Total	300				200	500	16

or

Semester VII/VIII [Fourth year]				Branch: Electrical Engineering						
Sr. No.	Course code	Course Title	L	T	P	Hours/ Week	Internal Marks	External Marks	Total Marks	Credits
1	BTEE-801-18	Smart Grids	3	0	0	3	40	60	100	3
2	BTEE-802-18	Artificial Intelligence Techniques	3	0	0	3	40	60	100	3
3	BTEE-803-18	Indian Electricity Standards and Practices	3	1	0	4	40	60	100	4
4	BTEE-811-18	Modelling and Simulation Lab	0	0	4	4	30	20	50	2
5	BTEE-812-18	Technical Report Writing and Presentation	0	0	8	8	60	40	100	4
6	BMPD-801-18	Mentoring and Professional Development of Students	-	1	0	1	50	-	50	S/US
Total			9	2	12	23	260	240	500	16

or

Students may obtain relevant credits through MOOCS/SWAYAM Courses



PROFESSIONAL CORE COURSES [ELECTRICAL ENGINEERING] (also Core Courses for Minor Degree of B. Tech. (Electrical Engineering))										
Sem.	Course code	Course Title	L	T	P	Hours/Week	Internal Marks	External Marks	Total Marks	Credits
Odd	BTEE-301-18	Electrical Circuit Analysis	3	1	0	4	40	60	100	4
Odd	BTEE-302-18	Analog Electronics	3	0	0	3	40	60	100	3
Odd	BTEE-311-18	Analog Electronics Laboratory	0	0	2	2	30	20	50	1
Odd	BTEE-303-18	Electrical Machines – I	3	0	0	3	40	60	100	3
Odd	BTEE-312-18	Electrical Machines – I Laboratory	0	0	2	2	30	20	50	1
Odd	BTEE-304-18	Electromagnetic Fields	3	1	0	4	40	60	100	4
Even	BTEE-401-18	Digital Electronics	3	0	0	3	40	60	100	3
Even	BTEE-412-18	Digital Electronics Laboratory	0	0	2	2	30	20	50	1
Even	BTEE-402-18	Electrical Machines – II	3	0	0	3	40	60	100	3
Even	BTEE-413-18	Electrical Machines – II Laboratory	0	0	2	2	30	20	50	1
Even	BTEE-403-18	Power Electronics	3	0	0	3	40	60	100	3
Even	BTEE-414-18	Power Electronics Laboratory	0	0	2	2	30	20	50	1
Even	BTEE-404-18	Signals and Systems	3	0	0	3	40	60	100	3
Even	BTEE-411-18	Measurements and Instrumentation Lab.	2	0	2	4	30	20	50	3
Odd	BTEE-501-18	Power Systems – I (Apparatus & Modelling)	3	1	0	4	40	60	100	4
Odd	BTEE-511-18	Power Systems-I Laboratory	0	0	2	2	30	20	50	1
Odd	BTEE-502-18	Control Systems	3	1	0	4	40	60	100	4
Odd	BTEE-512-18	Control Systems Laboratory	0	0	2	2	30	20	50	1
Odd	BTEE-503-18	Microprocessors	3	1	0	4	40	60	100	4
Odd	BTEE-513-18	Microprocessors Laboratory	0	0	2	2	30	20	50	1
Even	BTEE-601-18	Power System-II (Operation and Control)	3	1	0	4	40	60	100	4
Even	BTEE-602-18	Power Generation and Economics	3	1	0	4	40	60	100	4
Even	BTEE-611-18	Electronic Design Laboratory	1	0	2	3	30	20	50	2
Even	BTEE-612-18	Power Systems-II Laboratory	0	0	2	2	30	20	50	1



PROFESSIONAL ELECTIVE (PE) COURSES [ELECTRICAL ENGINEERING] (also Professional Elective Courses for Minor Degree of B. Tech. (Electrical Engineering))						
Sr. No.	Semester	Programme Elective	Course Code	Course Title	Hrs/week	Credits
1.	V (odd)	PE-1	BTEE-504A-18	Electrical Engineering Materials	3L:0T:0P	3
2.	V (odd)	PE-1	BTEE-504B-18	Switchgear and Protection	3L:0T:0P	3
3.	V (odd)	PE-1	BTEE-504C-18	Electrical Machine Design	3L:0T:0P	3
4.	V (odd)	PE-1	BTEE-504D-18	Renewable Energy Sources	3L:0T:0P	3
5.	VI (even)	PE-2	BTEE-603A-18	Electromagnetic Waves	3L:0T:0P	3
6.	VI (even)	PE-2	BTEE-603B-18	Power System Dynamics and Control	3L:0T:0P	3
7.	VI (even)	PE-2	BTEE-603C-18	Electrical Drives	3L:0T:0P	3
8.	VI (even)	PE-2	BTEE-603D-18	Wind and Solar Energy Systems	3L:0T:0P	3
9.	VI (even)	PE-3	BTEE-604A-18	High Voltage Engineering	3L:0T:0P	3
10.	VI (even)	PE-3	BTEE-604B-18	Power System Reliability	3L:0T:0P	3
11.	VI (even)	PE-3	BTEE-604C-18	Line-Commutated and Active PWM Rectifiers	3L:0T:0P	3
12.	VI (even)	PE-3	BTEE-604D-18	Energy Efficient Systems	3L:0T:0P	3
13.	VII/VIII (Odd/Even)	PE-4	BTEE-701A-18	Electrical Energy Conservation & Auditing	3L:0T:0P	3
14.	VII/VIII (Odd/Even)	PE-4	BTEE-701B-18	Computer Aided Power System Analysis	3L:0T:0P	3
15.	VII/VIII (Odd/Even)	PE-4	BTEE-701C-18	Power Quality and FACTS	3L:0T:0P	3
16.	VII/VIII (Odd/Even)	PE-4	BTEE-701D-18	Electrical and Hybrid Vehicles	3L:0T:0P	3
17.	VII/VIII (Odd/Even)	PE-5	BTEE-702A-18	Computational Electromagnetics	3L:0T:0P	3
18.	VII/VIII (Odd/Even)	PE-5	BTEE-702B-18	Microcontroller and PLC	3L:0T:0P	3
19.	VII/VIII (Odd/Even)	PE-5	BTEE-702C-18	Control Systems Design	3L:0T:0P	3
20.	VII/VIII (Odd/Even)	PE-6	BTEE-702D-18	Distributed Generation	3L:0T:0P	3



21.	VII/VIII (Odd/Even)	PE-6	BTEE-703A-18	Industrial Electrical Systems	3L:0T:0P	3
22.	VII/VIII (Odd/Even)	PE-6	BTEE-703B-18	Restructured Power Systems	3L:0T:0P	3
23.	VII/VIII (Odd/Even)	PE-6	BTEE-703C-18	Advanced Electric Drives	3L:0T:0P	3
24.	VII/VIII (Odd/Even)	PE-6	BTEE-703D-18	Energy Storage System	3L:0T:0P	3

		The institute may offer Professional Elective (PE) Courses [Electrical Engineering] as per the groups given below (PE in the list if AICTE curriculum)			
Sem		Group-A: Power Engineering	Group-B: Power Systems	Group-C: Power Electronics	Group-D: Renewable Energy
V (Odd)	PE-1	Electrical Engineering Materials	Switchgear and Protection	Electrical Machine Design	Renewable Energy Sources
VI (even)	PE-2	Electromagnetic Waves	Power System Dynamics and Control	Electrical Drives	Wind and Solar Energy Systems
	PE-3	High Voltage Engineering	Power System Reliability	Line-Commutated and Active PWM Rectifiers	Energy Efficient Systems
VII / VIII (Odd/Even)	PE-4	Electrical Energy Conservation & Auditing	Computer Aided Power System Analysis	Power Quality and FACTS	Electrical and Hybrid Vehicles
	PE-5	Computational Electromagnetics	Microcontroller and PLC	Control Systems Design	Distributed Generation
	PE-6	Industrial Electrical Systems	Restructured Power Systems	Advanced Electric Drives	Energy Storage System

**LIST OF OPEN ELECTIVE COURSES FOR STUDENTS OF OTHER PROGRAMMS
OFFERED BY ELECTRICAL ENGINEERING**

Prerequisite: To have passed Basic Electrical Engineering/Basic Electronics Engineering Course

Sr. No.	Course Code	Semester	Course Title	L	T	P	Hours/Week	Credits
1.	OEE-101-18	Odd	Control Systems	3	0	0	3	3
2.	OEE-102-18	Odd	Power Electronics	3	0	0	3	3
3.	OEE-103-18	Odd	Electrical Energy Conservation & Auditing	3	0	0	3	3
4.	OEE-104-18	Odd	Renewable Energy Sources	3	0	0	3	3
5.	OEE-201-18	Even	Electric Machines	3	0	0	3	3
6.	OEE-202-18	Even	Industrial Electrical Systems	3	0	0	3	3
7.	OEE-203-18	Even	Wind and Solar Energy Systems	3	0	0	3	3
8.	OEE-204-18	Even	Power Systems	3	0	0	3	3



HUMANITIES & SOCIAL SCIENCES INCLUDING MANAGEMENT

Sr. No.	Course Code	Course Title	Hrs. /Week L: T: P	Credits	Semester
1	BTHU-101-18	English	2:0:0	2	I/II
2	BTHU-102-18	English Laboratory	0:0:2	1	I/II
3	HSMC-XXX-18	To be selected by Individual Institutions from the given list of Humanities & Social Sciences including Management	3:0:0	3	VI
4	HSMC-XXX-18		3:0:0	3	VII
Total			-	9	-

List of Humanities & Social Sciences including Management

Sr. No.	Course Code	Course Title	Hours/ week	Credits
1.	HSMC103-18	Education, Technology and Society	2L:1T:0P	3
2.	HSMC104-18	History of Science and Technology in India	2L:1T:0P	3
3.	HSMC113-18	Values and Ethics	2L:1T:0P	3
4.	HSMC118-18	Introduction to Women's and Gender Studies	2L:1T:0P	3
5.	HSMC124-18	Sanskrit Bhasa	2L:1T:0P	3
6.	HSMC (MME-303)	Law and Engineering	2L:1T:0P	3

Details of Credits and Maximum Marks

Semester	Hrs per week	Credits	Maximum Marks
1&2	24+29	17.5+20.5=38	500+650=1150
3	26	20	750
4	30	21	850
5	24	18	750
6	32	26	850
7	31	24	850
8	23 (for those not opting for one semester training)	16	500
Total		163	5700



IKG Punjab Technical University

Syllabus

(3th - 8th Semester)

for

Undergraduate Degree Programme

Bachelor of Technology

in

ELECTRICAL ENGINEERING

2018 & onwards



SEMESTER: III

[Second Year]



BTEE-301-18	Electrical Circuit Analysis	3L:1T:0P	4 credits
Internal Marks: 40 External Marks: 60 Total Marks: 100			

Course Outcomes:

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

CO 1	Apply network theorems for the analysis of electrical circuits.
CO 2	Obtain the transient and steady-state response of electrical circuits.
CO 3	Analyze circuits in the sinusoidal steady-state (single-phase and three-phase). Analyze two port circuit behavior.
CO 4	Synthesize networks and filters.

Module 1: Basic Network Analysis (14 Hours)

Superposition theorem, Thevenin's theorem, Norton's theorem, Maximum power transfer theorem, Reciprocity theorem, Compensation theorem. Analysis with dependent current and voltage sources. Node and Mesh Analysis. Concept of duality and dual networks. Solution of first and second order differential equations for series and parallel R-L, R-C, R-L-C circuits, initial and final conditions in network elements, forced and free response, time constants, steady state and transient state response.

Module 2: Electrical circuit and steady state analysis (14 Hours)

Representation of sine function as rotating phasor, phasor diagrams, impedances and admittances, AC circuit analysis, effective or RMS values, average power and complex power. Three-phase circuits. Mutual coupled circuits, Dot convention in coupled circuits, Ideal Transformer. Analysis of electrical circuits using Laplace Transform for standard inputs, transformed network with initial conditions. Frequency response (magnitude and phase plots), series and parallel resonances.

Module 3: Network functions and two port network (10 Hours)

Driving point impedance and admittance, natural response of a network, transfer impedance and admittance, concept of pole and zeros in a network function, Routh Hurwitz criterion of stability.

Two Port Networks: terminal pairs, relationship of two port variables, impedance parameters, admittance parameters, transmission parameters and hybrid parameters, interconnections of two port networks.

Module 4: Network Synthesis and Filters (10 Hours)

Network synthesis techniques for 2-terminal network, Foster and Cauer forms.

Filters: Classification of filters, characteristics impedance and propagation constant of pure reactive network, ladder network, T-section, π -section, terminating half section, pass bands and stop bands, Design of constant-K, m-derived filters.

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.



BTEE- 302-18	Analog Electronics	3L:0T:0P	3 credits
Internal Marks: 40	External Marks: 60	Total Marks: 100	

Course Outcomes:

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

CO 1	Understand the characteristics of transistors.
CO 2	Design and analyse various rectifier and amplifier circuits.
CO 3	Design sinusoidal and non-sinusoidal oscillators.
CO 4	Understand the functioning of OP-AMP and design OP-AMP based circuits.

Module 1: Diode and BJT circuits (12 Hours)

P-N junction diode, V - I characteristics of a diode; review of half-wave and full-wave rectifiers, Zener diodes, clamping and clipping circuits.

BJT circuits: Structure and V - I characteristics of a BJT; BJT as a switch. BJT as an amplifier: small-signal model, biasing circuits, current mirror; common-emitter, common-base and common-collector amplifiers.

Module 2: MOSFET circuits (10 Hours)

MOSFET structure and V - I 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 bandwidth product)

Module 4: Linear applications of op-amp (10 Hours)

Idealized analysis of op-amp circuits. Specifications. Inverting and non-inverting amplifier, differential amplifier, instrumentation amplifier, integrator, active filter, voltage regulator, Oscillators: Principle of operation, Wein's bridge and phase shift oscillator.

Text/References:

1. A. S. Sedra & 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.



BTEE-303-18	Electrical Machines-I	3L:0T:0P	3 credits
Internal Marks: 40	External Marks: 60	Total Marks: 100	

Course Outcomes:

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

CO 1	Understand the concepts of magnetic circuits.
CO 2	Understand the operation of DC machines.
CO 3	Analyse the differences in operation of different DC machine configurations.
CO 4	Analyse single phase and three phase transformers circuits.

Module 1: Magnetic fields and magnetic circuits (6 Hours)

Review of magnetic circuits - MMF, flux, reluctance, inductance; Visualization of magnetic fields produced by a bar magnet and a current carrying coil - through air and through a combination of iron and air; influence of highly permeable materials on the magnetic flux lines.

Module 2: DC machines (12 Hours)

Basic construction of a DC machine, magnetic structure - stator yoke, stator poles, pole-faces or shoes, air gap and armature core, visualization of magnetic field produced by the field winding excitation with armature winding open, air gap flux density distribution, flux per pole, induced EMF in an armature coil. Armature winding and commutation - Elementary armature coil and commutator, lap and wave windings, construction of commutator, linear commutation Derivation of back EMF equation, armature MMF wave, derivation of torque equation, armature reaction, air gap flux density distribution with armature reaction.

Module 3: DC machine - motoring and generation (12 Hours)

Armature circuit equation for motoring and generation, Types of field excitations - separately excited, shunt and series. Open circuit characteristic of separately excited DC generator, back EMF with armature reaction, voltage build-up in a shunt generator, critical field resistance and critical speed. V-I characteristics and torque-speed characteristics of separately excited, shunt and series motors. Speed control through armature voltage. Losses, load testing and back-to-back testing of DC machines

Module 4: Transformers (12 Hours)

Principle, construction and operation of single-phase transformers, equivalent circuit, phasor diagram, voltage regulation, losses and efficiency, Testing - open circuit and short circuit tests, polarity test, back-to-back test, separation of hysteresis and eddy current losses, Three-phase transformer - construction, types of connection and their comparative features, Parallel operation of single-phase and three-phase transformers, Autotransformers - construction, principle, applications and comparison with two winding transformer, Magnetizing current, effect of nonlinear B-H curve of magnetic core material, harmonics in magnetization current, Phase conversion - Scott connection, three-phase to six-phase conversion, Tap-changing transformers - No-load and on-load tap-changing of transformers, Three-winding transformers. Cooling of transformers.

Text / References:

1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery", New York, McGraw Hill Education, 2013.



2. A. E. Clayton and N. N. Hancock, “Performance and design of DC machines”, CBS Publishers, 2004.
3. M. G. Say, “Performance and design of AC machines”, CBS Publishers, 2002.
4. P. S. Bimbhra, “Electrical Machinery”, Khanna Publishers, 2011.
5. I. J. Nagrath and D. P. Kothari, “Electric Machines”, McGraw Hill Education, 2010.



BTEE-304-18	Electromagnetic Fields	3L:1T:0P	4 credits
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Internal Marks: 40 External Marks: 60 Total Marks: 100

Course Outcomes:

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

CO 1	To understand the basic laws of electromagnetism.
CO 2	To obtain the electric and magnetic fields for simple configurations under static conditions.
CO 3	To analyse time varying electric and magnetic fields.
CO 4	To understand Maxwell's equation in different forms and different media.
CO 5	To understand the propagation of EM waves.

This course shall have Lectures and Tutorials. Most of the students find difficult to visualize electric and magnetic fields. Instructors may demonstrate various simulation tools to visualize electric and magnetic fields in practical devices like transformers, transmission lines and machines.

Module 1: Review of Vector Calculus (8 hours)

Vector algebra-addition, subtraction, components of vectors, scalar and vector multiplications, triple products, three orthogonal coordinate systems (rectangular, cylindrical and spherical). 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 (15 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.

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 3: Magnetic Forces, and Inductance (10 Hours)

Biot-Savart's law, Ampere's law of force, Ampere's circuital law, Faraday's law, Force on a moving charge, Force on a differential current element, Force between differential current elements, Magnetic boundary conditions, Magnetic circuits, calculations of inductances and mutual inductances for a solenoid and toroid.

Module 4: Maxwell's Equations in Time Varying Fields and Wave theory (15 Hours)

Concept of displacement current and conduction current, Maxwell's equation-differential and integral form, Poynting's theorem, its significance and Poynting's vector, Boundary Conditions.

Wave theory: 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. Attenuation, phase and propagation constant, intrinsic impedance, Relation between E & H, wave equation for a conducting medium, Plane waves in lossy dielectrics, Propagation in good conductors, Skin effect.



Text / References:

1. M. N. O. Sadiku, “Elements of Electromagnetics”, Oxford University Publication, 2014.
2. A. Pramanik, “Electromagnetism - Theory and applications”, PHI Learning Pvt. Ltd, New Delhi, 2009.
3. A. Pramanik, “Electromagnetism-Problems with solution”, Prentice Hall India, 2012.
4. G. W. Carter, “The electromagnetic field in its engineering aspects”, Longmans, 1954.
5. W. J. Duffin, “Electricity and Magnetism”, McGraw Hill Publication, 1980.
6. W. J. Duffin, “Advanced Electricity and Magnetism”, McGraw Hill, 1968.
7. E. G. Cullwick, “The Fundamentals of Electromagnetism”, Cambridge University Press, 1966.
8. B. D. Popovic, “Introductory Engineering Electromagnetics”, Addison-Wesley Educational Publishers, International Edition, 1971.
9. W. Hayt, “Engineering Electromagnetics”, McGraw Hill Education, 2012.



BTEE-305-18	Engineering Mechanics	3L:1T:0P	4 credits
Internal Marks: 40 External Marks: 60 Total Marks: 100			

Course Outcomes:

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

CO 1	Understand the concepts of co-ordinate systems.
CO 2	Analyse the three-dimensional motion.
CO 3	Understand the concepts of rigid bodies.
CO 4	Analyse the free-body diagrams of different arrangements.
CO 5	Analyse torsional motion and bending moment.

Module 1: Introduction to vectors and tensors and co-ordinate systems (5 hours)

Introduction to vectors and tensors and coordinate systems; Vector and tensor algebra; Indicical notation; Symmetric and anti-symmetric tensors; Eigenvalues and Principal axes.

Module 2: Three-dimensional Rotation (4 hours)

Three-dimensional rotation: Euler's theorem, Axis-angle formulation and Euler angles; Coordinate transformation of vectors and tensors.

Module 3: Kinematics of Rigid Body (6 hours)

Kinematics of rigid bodies: Definition and motion of a rigid body; Rigid bodies as coordinate systems; Angular velocity of a rigid body, and its rate of change; Distinction between two and three-dimensional rotational motion; Integration of angular velocity to find orientation; Motion relative to a rotating rigid body: Five term acceleration formula.

Module 4: Kinetics of Rigid Bodies (5 hours)

Kinetics of rigid bodies: Angular momentum about a point; Inertia tensor: Definition and computation, Principal moments and axes of inertia, Parallel and perpendicular axes theorems; Mass moment of inertia of symmetrical bodies, cylinder, sphere, cone etc., Area moment of inertia and Polar moment of inertia, Forces and moments; Newton-Euler's laws of rigid body motion.

Module 5: Free Body Diagram (1 hour)

Free body diagrams; Examples on modelling of typical supports and joints and discussion on the kinematic and kinetic constraints that they impose.

Module 6: General Motion (9 hours)

Examples and problems. General planar motions. General 3-D motions. Free precession, Gyroscopes, Rolling coin.

Module 7: Bending Moment (5 hours)

Transverse loading on beams, shear force and bending moment in beams, analysis of cantilevers, simply supported beams and overhanging beams, relationships between loading, shear force and bending moment, shear force and bending moment diagrams.

Module 8: Torsional Motion (2 hours)

Torsion of circular shafts, derivation of torsion equation, stress and deformation in circular and hollow shafts.



Module 9: Friction (3 hours)

Concept of Friction; Laws of Coulomb friction; Angle of Repose; Coefficient of friction.

Text / References:

1. J. L. Meriam and L. G. Kraige, “Engineering Mechanics: Dynamics”, Wiley, 2011.
2. M. F. Beatty, “Principles of Engineering Mechanics”, Springer Science & Business Media, 1986.



BTEE-311-18	Analog Electronics Laboratory	0L:0T:2P	1 Credit
Internal Marks: 30 External Marks: 20 Total Marks: 50			

Course Outcomes:

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

CO 1	Understand the use and importance of various types of equipments used in the laboratory.
CO 2	Ability to make circuits on bread-board.
CO 3	Analyze, take measurements to understand circuit behavior and performance under different conditions.
CO 4	Troubleshoot, design and create electronic circuits meant for different applications.
CO 5	Evaluate the performance electronic circuits and working small projects employing semiconductor devices.

Hands-on experiments related to the course contents of BTEE302-18

Note: A student to perform any 8-10 experiments and make one minor working model project.

Suggested List of Experiments:

1. To draw V-I characteristics of a PN junction diode (Ge, Si, switching and signal).
2. To design half wave rectifier.
3. To design full wave and bridge rectifiers.
4. To study the transistor characteristics in common base, common collector, and common emitter configurations.
5. To study the V-I characteristics of a MOSFET.
6. To design a voltage regulator IC using zener diode and also see the effect of line and load regulation
7. To design various clippers and clampers using diodes.
8. To obtain the frequency response of an amplifier and calculate the gain bandwidth of the amplifier.
9. To investigate the emitter follower (Buffer) amplifier and determine A_V , R_i , and R_o
10. To design and study various type of oscillators, and determine frequency of oscillations.
11. To design a transistor series voltage regulator with current limits and observe its current feedback characteristics.
12. To study the characteristics of a complementary symmetry amplifier.
13. To study the application of an Op-Amp (741) as inverting and non-inverting amplifier.
14. To use the OP-AMP as summing, scaling and averaging amplifier.
15. Design differentiator and integrator using OP-AMP and also determine the time constant and cut-off frequency.



BTEE-312-18	Electrical Machines – I Laboratory	0L:0T:2P	1 Credit
Internal Marks: 30 External Marks: 20 Total Marks: 50			

Course Outcomes:

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

CO 1	Analyze three-phase transformer/system connections.
CO 2	Evaluation of equivalent circuit parameters, efficiency and voltage regulation by performing various tests on transformer.
CO 3	Analyze parallel operation of transformers.
CO 4	Analyze performance characteristics of DC generators.

Hands-on experiments related to the course contents of BTEE303-18

Note: A student to perform any 8-10 Experiments and make one minor working model project.

Suggested List of Experiments:

1. To perform the load test on a single phase transformer.
2. To perform open circuit and short circuit tests on a single phase transformer and hence draw the equivalent circuit, calculate the voltage regulation and efficiency.
3. To find the efficiency and voltage regulation of single phase transformer under different loading conditions.
4. To perform parallel operation of two single phase transformers.
5. To study the various connections of a three phase transformer.
6. To perform Scott connections on three phase transformer to get two phase supply.
7. To study the constructional details of DC machine and to draw sketches of different components.
8. To measure armature and field resistance of DC shunt generator and to obtain its open circuit characteristics.
9. To obtain load characteristics of DC shunt/series/compound generator.
10. To draw speed-torque and torque-speed characteristics of DC shunt/series /compound generator.
11. To study the three point and four point DC motor starters.
12. To perform Swinburne's test (no load test) to determine various losses of DC shunt motor.
13. To visualize the magnetic fields produced by a bar magnet and a current carrying coil using FEMM/ ANSYS Maxwell.
14. To visualize the magnetic field produced in an electrical machine using FEMM/ ANSYS Maxwell.



SEMESTER: IV

[Second Year]



BTEE-401-18	Digital Electronics	3L:0T:0P	3 credits
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Internal Marks: 40 External Marks: 60 Total Marks: 100

Course Outcomes:

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

CO 1	Understand working of logic families and logic gates.
CO 2	Design and implement Combinational and Sequential logic circuits.
CO 3	Understand the process of Analog to Digital conversion and Digital to Analog conversion.
CO 4	Be able to understand memories.

Module 1: Fundamentals of Digital Systems and logic families (10 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 ICs, digital logic families, TTL, Schottky TTL and CMOS logic, interfacing CMOS and TTL, Tri-state logic.

Module 2: Combinational Digital Circuits (10 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, De-Multiplexer/Decoders, Adders, Subtractors, BCD arithmetic, carry look ahead adder, serial adder, ALU, elementary ALU design, popular MSI chips, digital comparator, parity checker/generator, code converters, priority encoders, decoders/drivers for display devices, Q-M method of function realization.

Module 3: Sequential circuits and systems (12 Hours)

A 1-bit memory, the circuit properties of Bi-stable latch, the clocked SR flip flop, J- K-T and D- types flipflops, applications of flipflops, 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, special counter IC's, asynchronous sequential counters, applications of counters.

Module 4: A/D and D/A Converters (10 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, A/D converter using Voltage to frequency and voltage to time conversion, specifications of A/D converters, example of A/D converter ICs, concept of memories.

Text/References:

1. R. P. Jain, "Modern Digital Electronics", McGraw Hill Education, 2009.
2. M. M. Mano, "Digital logic and Computer design", Pearson Education India, 2016.
3. A. Kumar, "Fundamentals of Digital Circuits", Prentice Hall India, 2016.



BTEE-402-18	Electrical Machines – II	3L:0T:0P	3 credits
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Internal Marks: 40 External Marks: 60 Total Marks: 100

Course Outcomes:

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

CO 1	Understand the concepts of rotating magnetic fields.
CO 2	Understand the operation of AC machines.
CO 3	Analyse performance characteristics of AC machines.
CO4	To understand the difference between the synchronous machines and asynchronous machines

Module 1: Fundamentals of AC machine windings (8 Hours)

Physical arrangement of windings in stator and cylindrical rotor; slots for windings; single-turn coil - active portion and overhang; full-pitch coils, concentrated winding, distributed winding, winding axis, 3D visualization of the above winding types, Air-gap MMF distribution with fixed current through winding - concentrated and distributed, Sinusoidally distributed winding, winding distribution factor

Module 2: Pulsating and revolving magnetic fields (12 Hours)

Constant magnetic field, pulsating magnetic field - alternating current in windings with spatial displacement, Magnetic field produced by a single winding - fixed current and alternating current Pulsating fields produced by spatially displaced windings, Windings spatially shifted by 90 degrees, Addition of pulsating magnetic fields, Three windings spatially shifted by 120 degrees (carrying three-phase balanced currents), revolving magnetic field.

Module 3: Induction Machines (12 Hours)

Concept of rotating magnetic field, Construction, Types (squirrel cage and slip-ring), Torque Slip Characteristics, Starting and maximum torque, power flow diagram, Equivalent circuit. Phasor diagram, Losses and efficiency. Effect of parameter variation on torque speed characteristics (variation of rotor and stator resistances, stator voltage, frequency). Methods of starting, braking and speed control for induction motors. Generator operation. Self-excitation. Doubly-fed induction machines.

Single phase induction motors: Constructional features, double revolving field theory, equivalent circuit, determination of parameters. Split-phase starting methods and applications

Module 4: Synchronous machines (10 Hours)

Constructional features, cylindrical rotor and salient pole synchronous machine - generated EMF, coil span and distribution factor, equivalent circuit and phasor diagram, armature reaction at different power factor loads, voltage regulation by synchronous impedance and zero power factor method, concept of short circuit ratio, Operating characteristics of synchronous machines, V-curves and inverter-V curves. Hunting. Salient pole machine - two reaction theory, analysis of phasor diagram, power angle characteristics. Parallel operation of alternators - synchronization and load division.

Text/References:

1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery", McGraw Hill Education, 2013.
2. M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.
3. P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
4. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.
5. A. S. Langsdorf, "Alternating current machines", McGraw Hill Education, 1984.
6. P. C. Sen, "Principles of Electric Machines and Power Electronics", John Wiley & Sons, 2007.



BTEE-403-18	Power Electronics	3L:0T:0P	3 credits
Internal Marks: 40 External Marks: 60 Total Marks: 100			

Course Outcomes:

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

CO 1	Understand the differences between signal level and power level devices.
CO 2	Analyse controlled rectifier circuits.
CO 3	Analyse the operation of DC-DC choppers.
CO 4	Analyse the operation of voltage source inverters.

Module 1: Power switching devices (8 Hours)

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

Module 2: Thyristor rectifiers (10 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 converter (12 Hours)

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

Module 4: Single-phase voltage source inverter (12 Hours)

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 voltage source inverter: 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

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. P. S. Bimbhra, "Power Electronics", Khanna Publishers



BTEE-404-18	Signals and Systems	3L:0T:0P	3 credits
Internal Marks: 40 External Marks: 60 Total Marks: 100			

Course Outcomes:

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

CO 1	Understand the concepts of continuous time and discrete time systems.
CO 2	Analyse systems in complex frequency domain.
CO 3	Understand sampling theorem and its implications.
CO 4	Understand mathematical tools to be able to apply in state variable modeling

Module 1: Introduction to Signals and Systems (12 hours):

Signals and systems as seen in everyday life, and in various branches of engineering and science. 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 (10 hours)

Fourier series representation of periodic signals, Waveform 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 (8 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 & S.H. Nawab, "Signals and systems", Prentice Hall, 1997.
2. G. Proakis and D. G. Manolakis, "Digital Signal Processing: Principles, Algorithms, and Applications", Pearson, 2006.
3. 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. A. V. Oppenheim and R. W. Schaffer, "Discrete-Time Signal Processing", Prentice Hall, 2009.
6. M. J. Robert "Fundamentals of Signals and Systems", McGraw Hill Education, 2007.
7. P. Lathi, "Linear Systems and Signals", Oxford University Press, 2009.



BTAM 302-23	Mathematics-III (Probability and Statistics)	L-4,P-1,T-0	4 Credits
Internal Marks: 40 External Marks: 60 Total Marks: 100			
Pre-requisite: Intermediate Calculus and Basic algebra			
Course Objectives: The objective of this course is to familiarize the students with fundamental concepts of theory of probability and statistics. The major focus of the course will be on a systematic mathematical treatment of these concepts and their applications.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Analyze given data using measures of central tendency, skewness and kurtosis.		
CO2	Understand and deal with randomness occurring in real world phenomena.		
CO3	Apply theoretical discrete and continuous probability distributions to deal with real world problems.		
CO4	Analyze given data using the concepts of correlation and regression and fitting of curves.		
CO5	Analyze hypothesis based on small and large samples using different tests of significance.		

Detailed Content:

Unit I

Measures of Central tendency: Moments, skewness and Kurtosis, Random experiment, Probability axioms, Definition of Probability, conditional probability, Discrete and Continuous random variables, Expectation of Discrete and Continuous random variables.

Unit II

Probability distributions: Binomial, Poisson and Normal, Poisson approximation to the binomial distribution, Evaluation of statistical parameters for these three distributions, Bivariate distributions and their properties.

Unit III

Correlation and regression for bivariate data, Rank correlation. Curve fitting by the method of least squares, fitting of straight lines, second degree parabolas and more general curves.

Unit IV

Test of significances: Sampling and standard error, Tests of significance for large samples and small samples (t-distribution, F-distribution), Chi-square test for goodness of fit and independence of attributes.

Recommended Books:

1. S.P. Gupta, Statistical Methods, Sultan Chand & Sons, 33rd Edition, 2005.
2. S.C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons, 2014.
3. S. Ross, A First Course in Probability, 6th Edition, Pearson Education India, 2002.
4. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
5. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, 7th Edition, Pearson, 2012.



BTEE-411-18	Measurements and Instrumentation Laboratory	2L:0T:2P	3 credits
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Internal Marks: 30 External Marks: 20 Total Marks: 50

Course Outcomes:

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

CO 1	Design and validate DC and AC bridges.
CO 2	Analyze the dynamic response and the calibration of few instruments.
CO 3	Learn about various measurement devices, their characteristics, their operation and their limitations.
CO 4	Understand statistical data analysis.
CO 5	Understand computerized data acquisition.

Lectures/Demonstrations:

1. Concepts relating to Measurements: True value, Accuracy, Precision, Resolution, Drift, Hysteresis, Dead-band, Sensitivity.
2. Errors in Measurements. Basic statistical analysis applied to measurements: Mean, Standard Deviation, Six-sigma estimation, C_p , C_{pk} .
3. Sensors and Transducers for physical parameters: temperature, pressure, torque, flow. Speed and Position Sensors.
4. Current and Voltage Measurements. Shunts, Potential Dividers. Instrument Transformers, Hall Sensors.
5. Measurements of R, L and C.
6. Digital Multi-meter, True RMS meters, Clamp-on meters, Meggers.
7. Digital Storage Oscilloscope.

Experiments

1. Measurement of a batch of resistors and estimating statistical parameters.
2. Measurement of L using a bridge technique as well as LCR meter.
3. Measurement of C using a bridge technique as well as LCR meter.
4. Measurement of Low Resistance using Kelvin's double bridge.
5. Measurement of High resistance and Insulation resistance using Megger.
6. Usage of DSO for steady state periodic waveforms produced by a function generator. Selection of trigger source and trigger level, selection of time-scale and voltage scale. Bandwidth of measurement and sampling rate.
7. Download of one-cycle data of a periodic waveform from a DSO and use values to compute the RMS values using a C program.
8. Usage of DSO to capture transients like a step change in R-L-C circuit.
9. Current Measurement using Shunt, CT, and Hall Sensor.
10. Measurement of frequency using Wein's Bridge.
11. To find 'Q' of an inductance coil and verify its value using Q- meter.
12. Plotting of Hysteresis loop for a magnetic material using flux meter.

Note: A student to perform any 8-10 Experiments and make one minor working model project.



BTEE-412-18	Digital Electronics Laboratory	0L:0T:2P	1 Credit
Internal Marks: 30 External Marks: 20 Total Marks: 50			

Course Outcomes:

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

CO 1	To understand of basic electronic components and circuits
CO 2	Understanding verify truth tables of TTL gates
CO 3	Design and fabrication and realization of all gates and basic circuits
CO 4	Design the truth tables and basic circuits
CO 5	Testing of basic electronics circuits

Hands-on experiments related to the course contents of BTEE401-18

Note: A student to perform any 8-10 Experiments and make one working minor project.

Suggested List of Experiments:

1. Design a delay circuit using 555 timer and study the monostable, bistable and astable operations using 555.
2. a) Verification of the truth tables of TTL gates viz;
7400, 7402, 7404, 7408, 7432, 7486.
b) Design and fabrication and realization of all gates using NAND/NOR gates.
3. Verification of truth table of Multiplexer(74150)/Demultiplexer(74154)
4. Design and verification of truth tables of half-adder, full-adder and subtractor circuits using gates 7483 and 7486(controlled inverter).
5. To study the operation of Arithmetic Logic Unit IC 74181.
6. Design fabrication and testing of
 - a) Monostable multivibrator of $t = 0.1\text{ms}$ approx. using 74121/123. testing for both positive and negative edge triggering, variation in pulse width and retriggering.
 - b) Free running multivibrator at 1KHz and 1Hz using 555 with 50% duty cycle. Verify the timing from theoretical calculations.
7. Design and test S-R flip-flop using NOR/NAND gates.
8. Design, fabricate and test a switch debouncer using 7400.
9. Verify the truth table of a JK flip flop using IC 7476,
10. Verify the truth table of a D flip flop using IC 7474 and study its operation in the toggle and asynchronous mode.
11. Operate the counters 7490, 7493 and 74193(Up/Down counting mode). Verify the frequency division at each stage. Using a frequency clock (say 1 Hz) display the count of LED's.
12. Verify the truth table of decoder driver 7447/7448. Hence operate a 7 segment LED display through a counter using a low frequency clock. Repeat the above with the BCD to Decimal decoder 7442.



BTEE-413-18	Electrical Machines-II Laboratory	0L:0T:2P	1 Credit
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Internal Marks: 30 External Marks: 20 Total Marks: 50

Course Outcomes:

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

CO 1	Construct equivalent circuits induction motors by routine tests.
CO 2	Comprehend the requirement of starting and speed control methods of induction motors in the various applications of industry.
CO 3	Construct equivalent circuits of synchronous generator and motor.
CO 4	Apply knowledge to show utility of alternator, synchronous motors and synchronous condenser for various applications in power system.
CO 5	Construct characteristic curves for induction and synchronous machines
CO 6	Understand the concept of parallel operation of three phase alternators.

Hands-on experiments related to the course contents of BTEE402-18

Note: A student to perform any 8-10 Experiments and make one hardware/software based minor project.

Suggested List of Experiments:

- To perform load-test on three-phase Induction motor and to plot torque versus speed characteristics.
 - To perform no-load and blocked-rotor tests on three-phase Induction motor to obtain equivalent circuit.
 - To develop an algorithm (Matlab/C/C++) for speed torque characteristics using calculated equivalent circuit parameters.
- To study the speed control of three-phase Induction motor by Kramer's Concept.
- To study the speed control of three-phase Induction motor by cascading of two induction motors, i.e. by feeding the slip power of one motor into the other motor.
- To study star- delta starters physically and
 - to draw electrical connection diagram
 - to start the three-phase Induction motor using it.
 - to reverse the direction of three-phase Induction motor
- To start a three-phase slip –ring induction motor by inserting different levels of resistance in the rotor circuit and plot torque –speed characteristics.
- To perform no-load and blocked-rotor test on single-phase Induction motor and to determine the parameters of equivalent circuit drawn on the basis of double revolving field theory.
- To perform no load and short circuit. Test on three-phase alternator and draw open and short circuit characteristics.
- To find voltage regulation of an alternator by zero power factor (ZPF.) method.
- To study effect of variation of field current upon the stator current and power factor with synchronous motor running at no load and draw Voltage and inverted Voltage curves of motor.
- Parallel operation of three phase alternators using
 - Dark lamp method
 - Two-Bright and one dark lamp method
- To study synchroscope physically and parallel operation of three-phase alternators using synchroscope.
- Starting of synchronous motors using:
 - Auxiliary motor
 - Using Damper windings



BTEE-414-18	Power Electronics Laboratory	0L:0T:2P	1 Credit
Internal Marks: 30 External Marks: 20 Total Marks: 50			

Course Outcomes:

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

CO 1	Understand the properties and characteristics of thyristors.
CO 2	Understand the different types of waveforms of inverter and chopper circuits.
CO 3	Analyze speed and direction control of single phase and three phase electric motors using ac and dc drive.
CO 4	Understand the effect of free-wheeling diode on pf with RL load.
CO 5	Check the performance of a choppers, and inverter.

Hands-on experiments related to the course contents of BTEE403-18

Note: A student to perform any 8-10 Experiments and make one hardware/software based minor project.

Suggested List of Experiments:

1. To plot V-I characteristics and study the effect of gate triggering on turning on of SCR.
2. To study the effect of free-wheeling diode on power factor for single phase half-wave rectifier with R-L load.
3. To plot waveforms for output voltage and current, for single phase full-wave, fully controlled bridge rectifier, for resistive and resistive cum inductive loads.
4. Study of the microprocessor-based firing control of a bridge converter.
5. To study three phase fully controlled bridge converter and plot waveforms of output voltage, for different firing angles.
6. To study Jones chopper or any chopper circuit to check the performance.
7. Thyristorised speed control of a D.C. Motor.
8. Speed Control of induction motor using thyristors.
9. Study of series inverter circuit and to check its performance.
10. Study of a single-phase cycloconverter.
11. To check the performance of a McMurray half-bridge inverter.



BTEE-521-18	Summer Industry Internship/ Field Training	(Non-Credit)
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Six weeks in an Industry in the area of Electrical Engineering. The summer internship should give exposure to the practical aspects of the discipline. In addition, the student may also work on a specified task or project which may be assigned to him/her. The outcome of the internship should be presented in the form of a report. The student will make a presentation based upon the Industry Internship attended. Performance to be rated as Satisfactory/Un -Satisfactory (S/US). For unsatisfactory the internship to be repeated.

Evaluation scheme (Summer Industry Internship/ Field Training)

Internal (to be evaluated by Industry)	Marks	External* (to be evaluated by Department)	Marks
Attendance	15	Daily Dairy	5
Performance (Work done /simulation/hardware/project developed)	30	Report	10
Report	10	Presentation (Work done /simulation/hardware/project developed)	25
Daily Dairy	05		
Total	60	Total	40

*External examiner not to be called.



Mandatory Courses (non-credit)



BTMC-101-18	Indian Constitution	3L:0T:0P	0 credits
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Internal Marks: 40 External Marks: 60 Total Marks: 100

The Constitution of India is the supreme law of India. Parliament of India cannot make any law which violates the Fundamental Rights enumerated under the Part III of the Constitution. The Parliament of India has been empowered to amend the Constitution under Article 368, however, it cannot use this power to change the “basic structure” of the constitution, which has been ruled and explained by the Supreme Court of India in its historical judgments. The Constitution of India reflects the idea of “Constitutionalism” – a modern and progressive concept historically developed by the thinkers of “liberalism” – an ideology which has been recognized as one of the most popular political ideology and result of historical struggles against arbitrary use of sovereign power by state. The historic revolutions in France, England, America and particularly European Renaissance and Reformation movement have resulted into progressive legal reforms in the form of “constitutionalism” in many countries. The Constitution of India was made by borrowing models and principles from many countries including United Kingdom and America.

The Constitution of India is not only a legal document but it also reflects social, political and economic perspectives of the Indian Society. It reflects India’s legacy of “diversity”. It has been said that Indian constitution reflects ideals of its freedom movement, however, few critics have argued that it does not truly incorporate our own

ancient legal heritage and cultural values. No law can be “static” and therefore the Constitution of India has also been amended more than one hundred times. These amendments reflect political, social and economic developments since the year 1950. The Indian judiciary and particularly the Supreme Court of India has played an historic role as the guardian of people. It has been protecting not only basic ideals of the Constitution but also strengthened the same through progressive interpretations of the text of the Constitution. The judicial activism of the Supreme Court of India and its historic contributions has been recognized throughout the world and it gradually made it “as one of the strongest court in the world”.

Course content

- 1 Meaning of the constitution law and constitutionalism
- 2 Historical perspective of the Constitution of India
- 3 Salient features and characteristics of the Constitution of India
- 4 Scheme of the fundamental rights
- 5 The scheme of the Fundamental Duties and its legal status
- 6 The Directive Principles of State Policy – Its importance and implementation
- 7 Federal structure and distribution of legislative and financial powers between the Union and the States
- 8 Parliamentary Form of Government in India – The constitution powers and status of the President of India
- 9 Amendment of the Constitutional Powers and Procedure
- 10 The historical perspectives of the constitutional amendments in India
- 11 Emergency Provisions: National Emergency, President Rule, Financial Emergency



- 12 Local Self Government – Constitutional Scheme in India
- 13 Scheme of the Fundamental Right to Equality
- 14 Scheme of the Fundamental Right to certain Freedom under Article 19
- 15 Scope of the Right to Life and Personal Liberty under Article 21

Objectives: The objective of the course is to provide the basic knowledge about the Political System of the Country. The basic idea is to make the students aware of their duties and rights. Apart from it the course will aim to educate the pupils about the working of different organs of the government, various constitutional bodies and the agencies of the government. In addition to it, students will be given brief knowledge regarding the different challenges of Indian Political System, forms of Government in India and nature & dimensions of Indian Federal System.

Course Pedagogy: Since the course is of Practical Importance, it is recommended that during the course students will be taken out for one visit to any place with the potential of imparting practical knowledge to the students about the Indian Political System. Such places can be Indian Parliament, State Legislative Assembly, Youth Parliament Pune. It is expected that students should be given case studies about the Indian Political System and Debates on Constitutional Issues should be organised in the campus.

Course Outcome: After the successful completion of the course students will be to understand the different dimensions of Indian Political System. They will be aware about their duties towards the fellow citizens. Students will be able to challenges of the democratic institutions and theoretical aspects of the state and its organs.

Suggested Reading:

1. Indian Political System by J C Johri
2. Indian Political System by Mahendra Prasad Singh
3. Fundamentals of Indian Political System by Rajesh K Jha
4. Our Constitution by Subhash C Kashyap
5. Our Political System by Subhash C Kashyap
6. Indian Federalism – An Introduction by Mahendra Prasad Singh
7. Indian Federalism and Autonomy by S Chandrasekhar



BTMC-102-18	Essence of Indian Traditional Knowledge	3L:0T:0P	0 credits
<i>Internal Marks: 40 External Marks: 60 Total Marks: 100</i>			

Part-1

Course objective

The course aims at imparting basis principals of thought process. Reasoning and inferencing Sustainability is at the core of Indian Traditional Knowledge Systems connecting society and nature. Holistic life style of yogic science and wisdom capsules in Sanskrit Literature are also important in modern society with rapid technological advancements and societal disruptions Part-1 focuses on introduction to Indian Knowledge System. Indian perspective of modern scientific world -view and basis principal of Yoga and holistic health care system.

Course contents

- Basic Structure of Indian Knowledge system
- Modern Science and Indian Knowledge system
- Yoga and Holistic Health Care
- Case studies

References

- Fritzo of Capra Too of Physics
- Fritzo of Capra The Wave of life
- Yoga Sutra of Patanjali. Ramakrishna Mission. Kolkata.
- RN Jha Science of Consciousness Psychotherapy and Yoga Practices. Vidyanidhi Prakashan. Delhi 2016
- PB Sharma (English translation) ShodashangHridayam

Pedagogy: Problem based learning, group discussion, collaborative mini projects

Outcome: Ability to understand connect up and explain basics of Indian traditional Knowledge in Modern scientific perspective.

Part-2

Course objective

The course aims at imparting basis principals of thought process. Reasoning and inferencing Sustainability is at the core of Indian Traditional Knowledge Systems connecting society and nature. Holistic life style of yogic science and wisdom capsules in Sanskrit Literature are also important in modern society with rapid technological advancements and societal disruptions Part-2 focuses on Indian philosophical traditions. Indian linguistic Tradition, and Indian artistic tradition.

Course contents

- Philosophical Tradition
- Indian Linguistic Tradition (Phonology, morphology, syntax and semantics)
- Indian Artistic Tradition
- Case studies

References

- V.Sivaramakrishnan (Ed.), Cultural Heritage of India-Course material, Bhartiya Vaidya Bhawan Mumbai 5th Edition 2014
- S.C Chaterjee & D.M .Datta , An introduction to Indian Philosophy ,University of Calcutta 1984



- KS Subrahmanialyer ,Vakyapadiya of Bhattaraihari (Brahma Kanda), Deccan College Pune 1965
- VN Jha, Language Thought and Reality
- Pramod Chandra. India Arts Howard Univ. Press 1983
- Krishna Chaitanya Arts of India. Abhinav Publications. 1987
- R Nagaswamy , Foundations of Indian Art Tamil Arts Academy.2002

Pedagogy: Problem based learning, group discussion, collaborative mini projects

Outcome: Ability to understand connects up and explain basics of Indian traditional Knowledge in Modern scientific perspective.



SEMESTER: V

[Third Year]



BTEE-501-18	Power Systems-I (Apparatus and Modelling)	3L:1T:0P	Credits:4
<i>Internal Marks: 40</i>	<i>External Marks: 60</i>	<i>Total Marks: 100</i>	

Course Outcomes:

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

CO 1 Understand the concepts of power systems.

CO 2 Understand the various power system components.

CO 3 Evaluate fault currents for different types of faults.

CO 4 Understand the generation of over-voltages and insulation coordination.

CO 5 Understand basic protection schemes.

CO 6 Understand concepts of HVDC power transmission and renewable energy generation.

Module 1: Basic Concepts (4 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. Power Transfer in AC circuits and Reactive Power.

Module 2: Power System Components (15 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. Power Transfer, Voltage profile and Reactive Power. Characteristics of transmission lines. 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: 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.

Module 4: Fault Analysis and Protection Systems (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. Types of Circuit Breakers. Attributes of Protection schemes, Back-up Protection. Protection schemes (Over-current, directional, distance protection, differential protection) and their application.

Module 5: Introduction to DC Transmission & Renewable Energy Systems (9 hours)



DC Transmission Systems: Line-Commutated Converters (LCC) and Voltage Source Converters (VSC) based dc link, Real Power Flow control in a dc link. Comparison of ac and dc transmission. Solar PV systems: I-V and P-V characteristics of PV panels, power electronic interface of PV to the grid. Wind Energy Systems: Power curve of wind turbine. Fixed and variable speed turbines.

Text/References:

1. J.S. Dhillon I.J. Nagrath and D.P. Kothari, Power System Engineering, 3rd Edition, McGraw Hill Education (India) Private Ltd., 2019
2. D.P. Kothari and J. S. Dhillon, Power System Optimization, 2nd edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2011, ISBN -978-81-203-4085-5.
3. J. Grainger and W. D. Stevenson, "Power System Analysis", McGraw Hill Education, 1994.
4. O. I. Elgerd, "Electric Energy Systems Theory", McGraw Hill Education, 1995.
5. A. R. Bergen and V. Vittal, "Power System Analysis", Pearson Education Inc., 1999.
6. D. P. Kothari and I. J. Nagrath, "Modern Power System Analysis", McGraw Hill Education, 2003.
7. B. M. Weedy, B. J. Cory, N. Jenkins, J. Ekanayake and G. Strbac, "Electric Power Systems", Wiley, 2012.



BTEE-502-18	Control Systems	3L:1T:0P	4 credits
<i>Internal Marks: 40 External Marks: 60 Total Marks: 100</i>			

Course Outcomes:

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

CO 1 Understand the modelling of linear-time-invariant systems using transfer function and state-space representations.

CO 2 Understand the concept of stability and its assessment for linear-time invariant systems. Design simple feedback controllers.

Module 1: Introduction to control problem (4 hours)

Industrial Control examples. 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.

Module 2: 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 (10 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.

Module 5: State variable Analysis (6 hours)

Concepts of state variables. State space model. Diagonalization of State Matrix. Solution of state equations. Eigenvalues 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 (5 hours) Performance Indices. Regulator problem, Tracking Problem. Nonlinear system–Basic concepts.-

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.



BTEE-503-18	Microprocessors	3L:1T:0P	4 credits
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Internal Marks: 40 External Marks: 60 Total Marks: 100

Course Outcomes:

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

CO 1 Study of 8085 and 8086 Microprocessors.

CO 2 Do assembly language programming.

CO 3 Do interfacing design of peripherals like 8255, 8253, 8279, 8251 etc.

CO 4 Develop systems using different microprocessors.

Module 1: Fundamentals of Microprocessors: (3 Hours)

Digital Computers: General architecture and brief description of elements, programming system, Buses and CPU Timings. Microprocessor and Microprocessor Development Systems: Evolution of Microprocessor, memory, data transfer schemes, architecture advancements of microprocessors, typical microprocessor development system, higher level languages.

Module 2: The 8085 Architecture (10 Hours)

Microprocessor architecture and its operations, Pin configuration, internal architecture. Timing & Signals: control and status, interrupt: ALU, machine cycles, Instruction format, op-codes, mnemonics, number. of bytes, Instruction Set of 8085: Addressing Modes: Register addressing, direct addressing; register indirect addressing, immediate addressing, and implicit addressing. RTL, variants, number. of machine cycles and T states, addressing modes. Instruction Classification: Data transfer, arithmetic operations, logical operations, branching operation, machine control; Writing assembly Language programs, Assembler directives.

Module 3: The 8086 Architecture (9 Hours)

8086 Microprocessors: Architecture: Architecture of INTEL 8086 (Bus Interface Unit, Execution unit), register organization, memory addressing, memory segmentation, Operating Modes Instruction Set of 8086 Addressing Modes: Instruction format: Discussion on instruction Set: Groups: data transfer, arithmetic, logic string, branch control transfer, processor control. Interrupts: Hardware and software interrupts, responses and types.

Module 4: Fundamental of Programming (9 Hours)

Development of algorithms, flowcharts in terms of structures ,(series, parallel, if-then-else etc.) Assembler Level Programming: memory space allocation (mother board and user program) Assembler level programs (ASMs) .

Module 5: Peripheral memory and I/O Interfacing (8 Hours)

Interfacing devices, Interfacing of Memory, Programmed I/O, Interrupt Driven I/O, memory I/O, 8255- Programmable peripheral interface, 8253/8254 Programmable timer/counter. 8259 programmable Interrupt Controller, 8251- USART

Text / References:

1. Gaonkar, Ramesh S, “Microprocessor Architecture, programming and applications with the 8085” Pen ram International Publishing 5th Ed.
2. Uffenbeck, John, “Microcomputers and Microprocessors” PHI/ 3rd Edition.
3. Ray, A.K. & Burchandi, K.M., “Advanced Microprocessors and Peripherals: Architecture, Programming and Interfacing” Tata Mc. Graw Hill.



4. Krishna Kant, “Microprocessors and Microcontrollers” PHI Learning.
5. Brey, Barry B. “INTEL Microprocessors” Prentice Hall (India)
6. ADitya P Mathur, “Introduction to Microprocessor” Tata Mc Graw Hill
7. M. Rafiquzzaman, “Microprocessors- Theory and applications” PHI
8. B. Ram, “Advanced Microprocessor & Interfacing” Tata McGraw Hill
9. Renu Singh & B.P.Singh, “Microprocessor and Interfacing and applications” New Age International
10. N. Senthil Kumar, “Microprocessors and Microcontroller”, Oxford University Press.
10. Liu and Gibson G.A., “Microcomputer Systems: The 8086/8088 Family” Prentice Hall (India)



Semester	Programme Elective	Course Code	Course Title	Hrs/week	Credits
V (odd)	PE-1	BTEE-504A-18	Electrical Engineering Materials	3L:0T:0P	3
V (odd)	PE-1	BTEE-504B-18	Switchgear and Protection	3L:0T:0P	3
V (odd)	PE-1	BTEE-504C-18	Electrical Machine Design	3L:0T:0P	3
V (odd)	PE-1	BTEE-504D-18	Renewable Energy Sources	3L:0T:0P	3



BTEE-504A-18	Electrical Engineering Materials	3L:0T:0P	3 credits
<i>Internal Marks: 40</i>	<i>External Marks: 60</i>	<i>Total Marks: 100</i>	

Course Outcomes:

- CO 1** To Understand the basic concepts of materials.
- CO 2** To use simplified materials selection concepts for design purposes.
- CO 3** To Understand the properties of Materials.

Module I: Elementary Materials Science Concepts (8 hours)

Bonding and types of solids, Crystalline state and their defects, Classical theory of electrical and thermal conduction in solids, temperature dependence of resistivity, skin effect, Hall effect.

Module II: Conductivity of Metal (8 hours)

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

Module III: Magnetic properties of Materials (8 hours)

Introduction, Classification of magnetic materials, diamagnetism, paramagnetism, ferromagnetism, magnetization curve, the hysteresis loop, factors affecting permeability and hysteresis loss, common magnetic materials, magnetic resonance.

Module IV: Dielectric Properties (8 hours)

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

Module V: Semiconductors (8 hours)

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

Text Books:

1. Adrianus J Dekker, Electrical Engineering Materials PHI Learning Publishers.
2. L. Solymar, Electrical Properties of Materials, 8th Edition by Oxford University Press New Delhi.
3. C Indulkar, Introduction to Electrical Engineering Materials 4th Edn. 2004 Edition by, S. Chand & Company Ltd-New Delhi.
4. SK Bhattacharya, Electrical and Electronic Engineering Materials, Khanna Publishers, New Delhi.



BTEE-504B-18	Switchgear and Protection	3L:0T:0P	3 credits
<i>Internal Marks: 40</i>		<i>External Marks: 60</i>	<i>Total Marks: 100</i>

Course Outcomes:

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

- CO 1** Understand power system protection.
- CO 2** Understand the main components used in power system protection for electric machines, transformers.
- CO 3** Understand the bus bars, overhead and underground feeders.
- CO 4** Understand the earthing protection.

Module 1: Electrical Switchgear

Fundamentals and Types of Circuit Breakers, Gaseous Discharges and Ionization Process in a Gaseous Insulating Medium, decay Process, Quenching of AC Arc, Arc Interruption Theories, Fuse-types, Rating, Selection, theory and characteristics, application, Factors Affecting RRRV, Re-Striking Voltage and Recovery Voltage, Resistance Switching, Quenching of DC Arc, High-Voltage AC Circuit Breakers, High-Voltage DC (HVDC) Circuit Breakers, Isolators.

Module 2: Protective Relaying System

Basics terminology and operating principle of Relays, Functions of Protective Relay Schemes, Basic Tripping Circuit with System Transducers, Zones of Protection, Requirements of a Protective System, Relay Operating Criteria, Main and Back-Up Protection.

Relays: Introduction, classification, constructional features; and Characteristics of Electromagnetic, Induction, Thermal, Overcurrent relays, Directional relays, Distance relays, Differential, Negative sequence relay, introduction to static and up-based relays.

Static Relays: Introduction, Basic Elements & Classification of Static Relays, Advantages and limitations of Static Relays.

Module 3: Power Apparatus Protection

Generator Protection: Generators faults, Differential Protection, Inter-Turn Fault Protection, Stator Earth-Fault Protection, Rotor Earth-Fault Protection, Negative Phase Sequence Protection (Protection Against Unbalanced Loading), Field Failure Protection (Protection Against Loss of Excitation), Overload Protection, Overvoltage Protection, Reverse Power Protection, Under-Frequency Protection.

Transformer Protection: Faults in Transformers, Gas-Operated Relays, Overcurrent Protection, Restricted Earth-Fault Protection, Differential Protection, Protection Against Over fluxing, Protection of Grounding Transformers, Protection Against Overheating

Module 4: Protection of Feeders and Transmission line:

Protection of Feeders: Basic Radial Feeder, Methods of Discrimination, Time and current protection, different pilot wire protection of feeders, current balance differential protection, Differential and Distance protection of feeders, choice between Impedance, Reactance and Mho relays.

Protection of Transmission Lines: Overcurrent Relays, Rules for Setting the IDMT Relays, Distance Relays: Stepped Distance Characteristics of a Distance Relay, Elementary idea about carrier current protection of lines, Quantities to be Fed to Distance Relays



Module 5: Bus Zone, Over voltage and Earthing Protection:

Bus-zone protection: Introduction, Bus-bar arrangements, Bus-zones faults, Protection Requirements, Fault-bus and backup protection of bus-bars, Non-Unit Protection by Back-up Relays, Unit Protection Schemes.

Protection against over voltage and earthing: Ground wires, Rod gap, Impulse gap, Valve type and Metal Oxide Arresters, Line Arrester/Surge Absorber. Ungrounded neutral system, Grounded neutral system and Selection of Neutral Grounding.

Text Books

1. B. A. Oza, Nirmal Kumar, C. Nair, R. P. Mehta, V. H. Makwana, Power System Protection & Switchgear, 1st Edition, Mc Graw Hill
2. Badri Ram, D. N. Vishwakarma, Power System Protection and Switchgear, Mc Graw Hill
3. Power System Protection and Switchgear by Wiley, John Wiley & Sons Canada, Limited,
4. Sunil S. Rao, Switchgear and Protection, 8th Edition, Khanna Book Publications
5. Handbook on switchgears, Bharat Heavy Electrical Limited



BTEE-504C-18	Electrical Machine Design	3L:0T:0P	3 credits
<i>Internal Marks: 40</i>	<i>External Marks: 60</i>	<i>Total Marks: 100</i>	

Course Outcomes:

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

- CO 1** Understand the construction and performance characteristics of electrical machines.
- CO 2** Understand the various factors which influence the design: electrical, magnetic and thermal loading of electrical machines
- CO 3** Understand the principles of electrical machine design and carry out a basic design of an ac machine.
- CO 4** Use software tools to do design calculations.

Module 1: Introduction

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.

Module 2: Transformers

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 3: Induction Motors

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 polyphase machines, magnetizing current, short circuit current, circle diagram, operating characteristics.

Module 4: Synchronous Machines

Sizing of a synchronous machine, main dimensions, design of salient pole machines, short circuit ratio, shape of pole face, armature design, armature parameters, estimation of air gap length, design of rotor, design of damper winding, determination of full load field mmf, design of field winding, design of turbo alternators, rotor design.

Module 5: Computer aided Design (CAD):

Limitations (assumptions) of traditional designs, need for CAD analysis, synthesis and hybrid methods, design optimization methods, variables, constraints and objective function, problem formulation. Introduction to FEM based machine design. Introduction to complex structures of modern machines-PMSMs, BLDCs, SRM and claw-pole machines.

Text / References:

1. A. K. Sawhney, "A Course in Electrical Machine Design", Dhanpat Rai and 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", SatyaPrakashan, 1969.



5. A. Shanmugasundaram, G. Gangadharan and R. Palani, “Electrical Machine Design Data Book”, New Age International, 1979.
6. K. M. V. Murthy, “Computer Aided Design of Electrical Machines”, B.S. Publications, 2008.
7. Electrical machines and equipment design exercise examples using Ansoft’s Maxwell 2D machine design package.



BTEE-504D-18	Renewable Energy Sources	3L:0T:0P	3 credits
<i>Internal Marks: 40</i>		<i>External Marks: 60</i>	<i>Total Marks: 100</i>

Course Outcomes:

- CO 1** To Understand the Need, importance and scope of non-conventional and alternate energy resources.
- CO 2** To understand role significance of solar energy and wind energy
- CO 3** To understand the role of ocean energy in the Energy Generation.
- CO 4** To get the utilization of Biogas plants and geothermal energy
- CO 5** To understand the concept of energy Conservation

Module I: Introduction (6 hours)

Causes of Energy Scarcity, Solution to Energy Scarcity, Factors Affecting Energy Resource Development, Energy Resources and Classification, Renewable Energy – Worldwide Renewable Energy Availability, Renewable Energy in India.

Energy from Sun: Sun- earth Geometric Relationship, Layer of the Sun, Earth – Sun Angles and their Relationships, Solar Energy Reaching the Earth's Surface, Solar Thermal Energy Applications

Module II: Solar Thermal Energy Collectors (8 hours)

Types of Solar Collectors, Configurations of Certain Practical Solar Thermal Collectors, Material Aspects of Solar Collectors, Concentrating Collectors, Parabolic Dish – Stirling Engine System, Working of Stirling or Brayton Heat Engine, Solar Collector Systems into Building Services, Solar Water Heating Systems, Passive Solar Water Heating Systems, Applications of Solar Water Heating Systems, Active Solar Space Cooling, Solar Air Heating, Solar Dryers, Crop Drying, Space Cooling, Solar Cookers, Solar pond.

Solar Cells: Components of Solar Cell System, Elements of Silicon Solar Cell, Solar Cell materials, Practical Solar Cells, I – V Characteristics of Solar Cells, Efficiency of Solar Cells, Photovoltaic Panels, Applications of Solar Cell Systems

Module III Hydrogen and Wind Energy (10 hours)

Hydrogen Energy: Benefits of Hydrogen Energy, Hydrogen Production Technologies, Hydrogen Energy Storage, Use of Hydrogen Energy, Advantages and Disadvantages of Hydrogen Energy, Problems Associated with Hydrogen Energy.

Wind Energy: Windmills, Wind Turbines, Wind Resources, Wind Turbine Site Selection.

Geothermal Energy: Geothermal Systems, Classifications, Geothermal Resource Utilization, Resource Exploration, Geothermal Based Electric Power Generation, Associated Problems, environmental Effects

Solid waste and Agricultural Refuse: Waste is Wealth, Key Issues, Waste Recovery Management Scheme, Advantages and Disadvantages of Waste Recycling, Sources and Types of Waste, Recycling of Plastics

Module IV: Biomass and Biogas Energy (12 hours)

Biomass Energy: Biomass Production, Energy Plantation, Biomass Gasification, Theory of Gasification, Gasifier and Their Classifications, Chemistry of Reaction Process in Gasification, Updraft, Downdraft and Cross-draft Gasifiers, Fluidized Bed Gasification, Use of Biomass Gasifier, Gasifier Biomass Feed Characteristics, Applications of Biomass Gasifier, Cooling and Cleaning of Gasifiers.



Biogas Energy: Introduction, Biogas and its Composition, Anaerobic Digestion, Biogas Production, Benefits of Biogas, Factors Affecting the Selection of a Particular Model of a Biogas Plant, Biogas Plant Feeds and their Characteristics.

Tidal Energy: Introduction, Tidal Energy Resource, Tidal Energy Availability, Tidal Power Generation in India, Leading Country in Tidal Power Plant Installation, Energy Availability in Tides, Tidal Power Basin, Turbines for Tidal Power, Advantages and Disadvantages of Tidal Power, Problems Faced in Exploiting Tidal Energy.

Module V: Sea Wave and Ocean Thermal Energy (8 hours)

Introduction, Motion in the sea Waves, Power Associated with Sea Waves, Wave Energy Availability, Devices for Harnessing Wave Energy, Advantages and Disadvantages of Wave Power.

Ocean Thermal Energy: Introduction, Principles of Ocean Thermal Energy Conversion (OTEC), Ocean Thermal Energy Conversion plants, Basic Rankine Cycle and its Working, Closed Cycle, Open Cycle and Hybrid Cycle, Carnot Cycle, Application of OTEC in Addition to Produce Electricity, Advantages, Disadvantages and Benefits of OTEC.

Text Books:

1. Renewable energy resources: Tiwari and ghosal, Narosa publication.
2. Non conventional Energy Sources, Khanna Publication
3. Renewable Energy Sources: Twidell & Weir, CRC Press.
4. Solar Energy/ S.P. Sukhatme, Tata McGraw-Hill.
5. Non Conventional Energy Systems: K M. Mittal, A H Wheeler Publishing Co Ltd.
6. Renewable Energy Technologies: Ramesh & Kumar, Narosa publication.
7. Biomass Energy, Oxford & IBH Publication Co.



EVS-101-18	Environmental Studies	2L:0T:0P (Contact hours 21)	0 credits
<i>Internal Marks: 40</i>	<i>External Marks: 60</i>	<i>Total Marks: 100</i>	

*** 40 Hours are kept for various activities under the head of activities. There will be a final theory examination for the students of 50 marks but these marks will not be added to their final result as assessment will be satisfactory or non-satisfactory.**

Course Outcomes:

- CO 1** Students will enable to understand environmental problems at local and national level through literature and general awareness.
- CO 2** The students will gain practical knowledge by visiting wildlife areas, environmental institutes and various personalities who have done practical work on various environmental Issues.
- CO 3** The students will apply interdisciplinary approach to understand key environmental issues and critically analyze them to explore the possibilities to mitigate these problems.
- CO 4** Reflect critically about their roles and identities as citizens, consumers and environmental actors in a complex, interconnected world

Environment Science (Mandatory non-credit course)

We as human being are not an entity separate from the environment around us rather we are a constituent seamlessly integrated and co-exist with the environment around us. We are not an entity so separate from the environment that we can think of mastering and controlling it rather we must understand that each and every action of ours reflects on the environment and vice versa. Ancient wisdom drawn from Vedas about environment and its sustenance reflects these ethos. There is a direct application of this wisdom even in modern times. Idea of an activity based course on environment protection is to sensitize the students.

Detailed Contents

Module 1: Natural Resources : Renewable and non-renewable resources

Natural resources and associated problems.

- Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.
- Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.
- Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies.
- Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies.
- Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Case studies.
- Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification.
 - Role of an individual in conservation of natural resources.
 - Equitable use of resources for sustainable lifestyles.

Module 2: Ecosystems

Concept of an ecosystem. Structure and function of an ecosystem.



Food chains, food webs and ecological pyramids. Introduction, types, characteristic features, structure and function of following ecosystems:

- Forest ecosystem
- Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Module 3 : Biodiversity and its conservation

- Introduction – Definition: genetic, species and ecosystem diversity.
- Biodiversity at global, National and local levels.
- India as a mega-diversity nation
- Hot-spots of biodiversity.
- Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts.
- Endangered and endemic species of India

Module 4 : Social Issues and the Environment

- From Unsustainable to Sustainable development
- Resettlement and rehabilitation of people; its problems and concerns.
- Environmental ethics: Issues and possible solutions.
- Climate change, global warming, acid rain, ozone layer depletion,
- Nuclear accidents and holocaust. Case Studies.
- Public awareness.

***ACTIVITIES**

Nature club (bird watching, recognizing plants at institute/at home, recognizing local animals, appreciating biodiversity)

Impart knowledge and inculcate the habit of taking interest and understanding biodiversity in and around the college campus. The students should be encouraged to take interest in bird watching, recognizing local plants, herbs and local animals. The students should be encouraged to appreciate the difference in the local biodiversity in their hometown, in the place of their study and other places they visit for vacation/breaks etc.

Following activities must be included.

Identify a tree fruit flower peculiar to a place or having origin from the place.

Making high resolution big photographs of small creatures (bees, spiders, ants. Mosquitos etc.) especially part of body so that people can recognize (games on recognizing animals/plants).

Videography/ photography/ information collections on specialties/unique features of different types of common creatures.

Search and explore patents and rights related to animals, trees etc. Studying miracles of mechanisms of different body systems.

(A) Awareness Activities:

- Small group meetings about water management, promotion of recycle use, generation of less waste, avoiding electricity waste
- Slogan making event
- Poster making event
- Cycle rally
- Lectures from experts
- Plantation
- Gifting a tree to see its full growth
- Cleanliness drive



- i) To live with some eminent environmentalist for a week or so to understand his work.
- j) To work in kitchen garden for mess
- k) To know about the different varieties of plants
- l) Shutting down the fans and ACs of the campus for an hour or so
- m) Visit to a local area to document environmental assets
river/forest/grassland/hill/mountain/lake/Estuary/Wetlands
- n) Visit to a local polluted site-Urban/Rural/Industrial/Agricultural
- o) Visit to a Wildlife sanctuary, National Park or Biosphere Reserve

Suggested Readings

1. Agarwal, K.C. 2001 Environmental Biology, Nidi Publ. Ltd. Bikaner.
2. Bharucha Erach, The Biodiversity of India, Mapin Publishing Pvt. Ltd., Ahmedabad – 380 013, India, Email:mapin@icenet.net (R)
3. Brunner R.C., 1989, Hazardous Waste Incineration, McGraw Hill Inc. 480p
4. Clark R.S., Marine Pollution, Clanderson Press Oxford (TB)
5. Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. 2001, Environmental Encyclopedia, Jaico Publ. House, Mumbai, 1196p
6. Hawkins R.E., Encyclopedia of Indian Natural History, Bombay Natural History Society, Bombay (R)
7. Heywood, V.H & Weston, R.T. 1995. Global Biodiversity Assessment. Cambridge Univ. Press 1140p.
8. Mhaskar A.K., Matter Hazardous, Techno-Science Publication (TB)
9. Miller T.G. Jr. Environmental Science, Wadsworth Publishing Co. (TB)
10. Odum, E.P. 1971. Fundamentals of Ecology. W.B. Saunders Co. USA, 574p
11. Townsend C., Harper J, and Michael Begon, Essentials of Ecology, Blackwell Science (TB)
12. Trivedi R.K., Handbook of Environmental Laws, Rules Guidelines, Compliances and Standards, Vol I and II, Enviro Media (R)
13. Trivedi R. K. and P.K. Goel, Introduction to air pollution, Techno-Science Publication (TB)
14. Wanger K.D., 1998 Environmental Management. W.B. Saunders Co. Philadelphia, USA 499p



BTEE-511-18	Power Systems – I Laboratory	0L:0T:2P	1 credit
<i>Internal Marks: 30 External Marks: 20 Total Marks: 50</i>			

Hands-on experiments related to the course contents of BTEE501-18. Visits to power system installations (generation stations, EHV substations etc.) are Exposure to fault analysis and Electro-magnetic transient program (EMTP) and Numerical Relays are suggested.

Note: A student to perform any 8-10 Experiments.

Suggested List of Experiments:

(A) Hardware Based:

1. To measure negative sequence and zero sequence reactance of Synchronous Machines.
2. Fault analysis for line-to-line (L-L), Line-to-Ground (L-G) and double line to ground fault.
3. To study the performance of a transmission line and compute its ABCD parameters.
4. To study the earth resistance using three spikes.
5. To study the IDMT over current relay and determine the time current characteristics
6. To study percentage differential relay
7. To study Impedance, MHO and Reactance type distance relays.
8. To study operation of oil testing set.

(B) Simulation Based Experiments (using MATLAB or any other software)

9. To obtain steady state, transient and sub-transient short circuit currents in an alternator
10. To perform symmetrical fault analysis in a power system
11. To perform unsymmetrical fault analysis in a power system



BTEE-512-18	<i>Control Systems Laboratory</i>	0L:0T:2P	1 credit
<i>Internal Marks: 30 External Marks: 20 Total Marks: 50</i>			

Hands-on experiments related to the course contents of BTEE502-18

Note: A student to perform any 8-10 Experiments.

Suggested List of Experiments:

1. To study the characteristics of potentiometers and to use 2- potentiometers as an error detector in a control system.
2. To study the synchro Transmitter-Receiver set and to use it as an error detector
3. To study the Speed – Torque characteristics of an AC Servo Motor and to explore its applications.
4. To study the Speed – Torque characteristics of an DC Servo Motor and explore its applications.
5. To study the variations of time lag by changing the time constant using control engineering trainer
6. To simulate a third order differential equations using an analog computer and calculate time response specifications
7. To obtain the transfer function of a D.C. motor – D.C. Generator set using Transfer Function Trainer
8. To study the speed control of an A.C. Servo Motor using a closed loop and an open loop systems
 - a) To study the operation of a position sensor and study the conversion of position in to corresponding voltage
 - b) To study an PI control action and show its usefulness for minimizing steady state error of time response.
9. To measure Force / Displacement using Strain Gauge in a wheat stone bridge
10. To design a Lag compensator and test its performance characteristics.
11. To design a Lead-compensator and test its performance characteristics.
12. To design a Lead-Lag compensator and test its performance characteristics.



BTEE-513-18	Microprocessors Laboratory	0L:0T:2P	1 credit
<i>Internal Marks: 30 External Marks: 20 Total Marks: 50</i>			

Hands-on experiments related to the course contents of BTEE503-18

Note: A student to perform any 8-10 Experiments.

Suggested List of Experiments:

Suggested List of Experiments:

1. To study 8085 based microprocessor system
2. To study 8086 and 8086A based microprocessor system
3. To study Pentium Processor
4. To develop and run a program for finding out the largest/smallest number from a given set of numbers.
5. To develop and run a program for arranging in ascending/descending order of a set of numbers
6. To perform multiplication/division of given numbers
7. To perform conversion of temperature from 0 F to 0 C and vice-versa
8. To perform computation of square root of a given number
9. To perform floating point mathematical operations (addition, subtraction, multiplication and division)
10. To obtain interfacing of RAM chip to 8085/8086 based system
10. To obtain interfacing of keyboard controller, 8279
11. To obtain interfacing of PPI, 8255
12. To obtain interfacing of USART, 8251
13. To perform microprocessor-based stepper motor operation through 8085 kit
14. To perform microprocessor-based traffic light control
15. To perform microprocessor-based temperature control of hot water.



BTEE-521-18	Summer Industry Internship	(Non-Credit)
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Six weeks in an Industry in the area of Electrical Engineering. The summer internship should give exposure to the practical aspects of the discipline. In addition, the student may also work on a specified task or project which may be assigned to him/her. The outcome of the internship should be presented in the form of a report. Performance to be rated as Satisfactory/Un - Satisfactory (S/US). For unsatisfactory the internship to be repeated.

BMPD-501-18	Mentoring and Professional Development of Students	0L:1T:0P	(Non-Credit)
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Internal Marks: 50

External Marks: 00

The assigned mentor to engage the students to in activities such as:

- Identification of any one of the local environmental concern and propose workable solution for it.
- Arrange an Industrial visit of 2-3 days
- Expert/Invited talk pertaining to recent industrial development.
- Preparation of database for placement activities.
- Resume preparation.

The mentor to keep record of all activities (including those mentioned above) and assign internal marks accordingly.

Semester: VI

[Third Year]

BTEE-601-18	Power Systems – II (Operation & Control)	3L:1T:0P	4 credits
<i>Internal Marks: 40 External Marks: 60 Total Marks: 100</i>			

Course Outcomes:

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

- (i) Use numerical methods to analyze a power system in steady state.
- (ii) Understand stability constraints in a synchronous grid.
- (iii) Understand methods to control the voltage, frequency and power flow.
- (iv) Understand the monitoring and control of a power system.
- (v) Understand the basics of power system economics.

Module 1: Power Flow Analysis (8 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 a node. 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.

Module 3: Control of Frequency and Voltage (8 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. Power flow control using embedded dc links, phase shifters.

Module 4: Monitoring and Control (8 hours)

Overview of Energy Control Centre Functions: SCADA systems. Phasor Measurement Units and Wide-Area Measurement Systems. State-estimation. System Security Assessment. Normal, Alert, Emergency, Extremis states of a Power System. Contingency Analysis. Preventive Control and Emergency Control.

Module 5: Modern Power System Management (8 hours)

Basic Pricing Principles: Generator Cost Curves, Utility Functions, Power Exchanges, Spot Pricing. Electricity Market Models (Vertically Integrated, Purchasing Agency, Whole-sale competition, Retail Competition), Demand Side-management, Transmission and Distributions charges, Ancillary Services. Regulatory framework.

Text/Reference Books:

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

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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.

BTEE-602-18	Power Generation and Economics	3L:1T:0P	4 credits
<i>Internal Marks: 40 External Marks: 60 Total Marks: 100</i>			

Course Outcomes:

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

- (i) Understand the load curves, load-duration Curve.
- (ii) Understand the power plant economics and tariff
- (iii) Explore the significance of economic operation of steam plants
- (iv) Understand the hydro-thermal coordination.

Module 1: Loads and Load curves (8 hours)

Electrical energy sources, organization of power sector in India, single line diagram of thermal, hydro and nuclear power stations. Classification of power plants in base load and peak load plants.

Types of load (fixed voltage loads, resistive loads, Inductive motor loads, Mechanical load), effect of load on supply voltage, Maximum demand, Group diversity factor, Peak diversity factor, Types of load, chronological load curves, load-duration Curve, mass curves, load factor, capacity factor, utilization factor, base load and peak load plants, load forecasting.

Module 2: Power Plant Economics and Tariff (10 hours)

Capital cost of plants, annual fixed cost, operating costs and effect of load factor on cost of energy, depreciation. Objectives of tariff making, different types of tariff (domestic, commercial, agricultural and industrial loads). Need for power factor improvement, power factor improvement using capacitors, determination of economic power factor.

Module 3: Selection of plant, Cogeneration (8 hours)

Plant location, plant size, number and size of units in plants, economic comparison of alternatives based on annual cost, rate of return, present worth and capitalized cost methods. Definition and scope of cogeneration, Topping and Bottoming Cycles, Benefits, cogeneration technologies.

Module 4: Economics of Steam plants (8 hours)

Methods of loading turbo-generators, input- output curve, heat rate, incremental cost, method of Lagrangian multiplier, effect of transmission losses, co- ordination equations, and iterative procedure to solve co-ordination equations.

Module 5: Hydro-thermal co-ordination (8 hours)

Advantages of combined working of Run-off River plant and steam plant, reservoir hydro plants and thermal plants, long-term operational aspects, scheduling methods.

Text/Reference Books

1. M.V. Deshpande, Power Plant Engineering, Tata McGraw Hill (2004).
2. M.M. El-Wakit, Power Plant Engineering, McGraw Hill, USA 8. Rajput R.K., Power Plant Engineering, Luxmi Publications
3. P.C. Sharma, Power Plant Engineering, Kataria and Sons
4. B.G.A. Skrotzki and W.A. Vapot, Power Station Engineering and Economy, Tata McGraw-Hill
5. S.C. Arora and S. Dom Kundwar, A course in Power Plant Engineering, Dhanpat Rai.
6. P.K. Nag, Power Plant Engineering, Tata McGraw Hill
7. B.R. Gupta, Generation of Electrical Energy, S. Chand (1998).
8. I.J. Nagrath and D.P. Kothari, Power System Analysis Tata McGraw-Hill Publication
9. A. Chakrabarti, M.L. Soni, P.V. Gupta and U.S. Bhatnagar, A Textbook on Power System Engineering, Dhanpat Rai and Co

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BTEE-611-18	Electronics Design Laboratory	1L:0T:2P	2 credits
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Internal Marks: 30 External Marks: 20 Total Marks: 50

Course Outcomes:

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

- (i) Understand the practical issues related to practical implementation of applications using electronic circuits.
- (ii) Choose appropriate components, software and hardware platforms.
- (iii) Design a Printed Circuit Board, get it made and populate/solder it with components.
- (iv) Work as a team with other students to implement an application.

Basic concepts on measurements; Noise in electronic systems; Sensors and signal conditioning circuits; Introduction to electronic instrumentation and PC based data acquisition; Electronic system design, Analog system design, Interfacing of analog and digital systems, Embedded systems, Electronic system design employing microcontrollers, Complex Programmable Logic Devices (CPLDs), and field-programmable gate arrays (FPGAs), and printed circuit boards (PCB) design and layout; System assembly considerations. Group projects involving electronic hardware (Analog, Digital, mixed signal) leading to implementation of an application.

Text/Reference Books

1. S. Sedra and K. C. Smith, "Microelectronic circuits", Oxford University Press, 2007.
2. P. Horowitz and W. Hill, "The Art of Electronics", Cambridge University Press, 1997.
3. H.W.Ott, "Noise Reduction Techniques in Electronic Systems", Wiley, 1989.
4. W.C. Bosshart, "Printed Circuit Boards: Design and Technology", Tata McGraw Hill, 1983.
5. G.L. Ginsberg, "Printed Circuit Design", McGraw Hill, 1991.

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BTEE-612-18	<i>Power Systems-II Laboratory</i>	0L:0T:2P	1 credit
<i>Internal Marks: 30 External Marks: 20 Total Marks: 50</i>			

Hands-on and computational experiments related to the course contents of BTEE-601-18. This should include programming of numerical methods for solution of the power flow problem and stability analysis.

Visit to load dispatch centre is suggested.

Note: A student to perform any 8-10 Experiments.

Suggested List of Experiments:

1. *Short circuit calculations and calculations of circuit breaker ratings for a power system network.*
2. *a) Y-bus formation using Matlab/PSCAD/Power world.
b) Z-bus formulation using Matlab/PSCAD/Power world.*
3. *Load flow analysis by Gauss Seidal method.*
4. *Load flow analysis by Newto Raphson method*
5. *To obtain power system stability on High Voltage Alternating current (HVAC) system with the help of Flexible Alternating Current Transmission Systems (FACTS) devices using Matlab/PSCAD/Power world.*
6. *Optimal Capacitor placement on a system having variable reactive power and low voltage profile.*
7. *To obtain relay co-ordination on a power system.*
8. *To find synchronous reactances (Transient, sub-transient) during fault analysis.*
9. *To study the characteristics of a distance relay.*
10. *To study and design a synchronous machine for stability study using swing equation using Matlab/PSCAD/Power world.*

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BTEE-621-18	<i>Project -1</i>	0L:0T:6P	3 credit
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Internal Marks: 30 External Marks: 20 Total Marks: 50

Course Outcomes:

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

- (i) Apply and verify basic scientific principals and technologies.
- (ii) Identify the scope of interdisciplinary knowledge
- (iii) Make and design a prototype which is preferably a working model

Guidelines

- 1) A group of 3-4 students under the mentorship of a teacher to make a minor project.
Interdisciplinary projects to be encouraged.
- 2) The project title and scope to be decided and presented in first 2nd/3rd weeks of the semester.
- 3) The progress of the project to be evaluated (internal) in 8th/9th week of the semester.
- 4) A draft of the project report to be prepared and the project to be evaluated (internal) 12th/13th week of the semester.
- 5) The project report and the project to be submitted in the department at the time of external evaluation.

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BMPD-601-18	Mentoring and Professional Development of Students	0L:1T:0P	Non-credit
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Internal Marks: 50 External Marks: - Total Marks: 50

The assigned mentor to engage the students to in activities such as:

- 1) Identification of any one of the local environmental concern and propose workable solution for it.
- 2) Arrange an Industrial visit of 2-3 days
- 3) Expert/Invited talk pertaining to recent industrial development.
- 4) Preparation of database for placement activities.
- 5) Resume preparation.

The mentor to keep record of all activities (including those mentioned above) and assign internal marks accordingly.

Programme Electives

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VI (even)	PE-2	BTEE-603A-18	Electromagnetic Waves	3L:0T:0P	3
VI (even)	PE-2	BTEE-603B-18	Power System Dynamics and Control	3L:0T:0P	3
VI (even)	PE-2	BTEE-603C-18	Electrical Drives	3L:0T:0P	3
VI (even)	PE-2	BTEE-603D-18	Wind and Solar Energy Systems	3L:0T:0P	3
VI (even)	PE-3	BTEE-604A-18	High Voltage Engineering	3L:0T:0P	3
VI (even)	PE-3	BTEE-604B-18	Power System Reliability	3L:0T:0P	3
VI (even)	PE-3	BTEE-604C-18	Line-Commutated and Active PWM Rectifiers	3L:0T:0P	3
VI (even)	PE-3	BTEE-604D-18	Energy Efficient Systems	3L:0T:0P	3

BTEE-603A-18	Electromagnetic Waves	3L:0T:0P	3 credits
<i>Internal Marks: 40 External Marks: 60 Total Marks: 100</i>			

Course Outcomes:

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

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

Module 1: Transmission Lines (8 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 (9 hours)

Basic quantities of Electromagnetics, Basic laws of Electromagnetics: Gauss's law, Ampere's Circuital law, Faraday's law of Electromagnetic induction. Maxwell's equations, Surface charge and surface current, Boundary conditions at media interface.

Module 3: Uniform Plane Wave (9 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: Waveguides (8 hours)

Parallel plane waveguide: 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 waveguides. Introduction to antennas.

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.

BTEE-603-B-18	Power System Dynamics and Control	3L:0T:0P	3 credits
<i>Internal Marks: 40</i>	<i>External Marks: 60</i>	<i>Total Marks: 100</i>	

Course Outcomes:

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

- (i) Understand the problem of power system stability and its impact on the system.
- (ii) Analyse linear dynamical systems and use of numerical integration methods.
- (iii) Model different power system components for the study of stability.
- (iv) Understand the need and plan 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 (5 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 (10 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.

Module 5: Stability Analysis (11 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. Planning Measures for Enhancing System Stability. 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”, McGraw Hill, 1995.
3. P. Sauer and M. A. Pai, “Power System Dynamics and Stability”, Prentice Hall, 1997.

BTEE-603C-18	Electrical Drives	3L:0T:0P	3 credits
<i>Internal Marks: 40 External Marks: 60 Total Marks: 100</i>			

Course Outcomes:

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

- (i) Understand the characteristics of dc motors and induction motors.
- (ii) Understand the principles of speed-control of dc motors and induction motors.
- (iii) Apply the knowledge of power electronics to understand the working of dc-dc converters.
- (iv) Apply the knowledge of control system for the speed control of electrical machines.
- (v) Understand the working of AC and DC drives

Module 1: DC motor characteristics (6 hours)

Review of emf and torque equations of DC machine, review of torque-speed characteristics of separately excited dc motor, change in torque-speed curve with armature voltage, example load torque-speed characteristics, operating point, armature voltage control for varying motor speed, flux weakening for high speed operation, regenerative braking.

Module 2: Chopper fed DC drive (12 hours)

Review of dc chopper and duty ratio control, chopper fed dc motor for speed control, steady state operation of a chopper fed drive, armature current waveform and ripple, calculation of losses in dc motor and chopper, efficiency of dc drive, smooth starting.

Multi-quadrant DC drive : Review of motoring and generating modes operation of a separately excited dc machine, four quadrant operation of dc machine; single-quadrant, two-quadrant and four-quadrant choppers; steady-state operation of multi-quadrant chopper fed dc drive.

Module 3: Closed-loop control of DC Drive (8 hours)

Control structure of DC drive, inner current loop and outer speed loop, dynamic model of dc motor – dynamic equations and transfer functions, modeling of chopper as gain with switching delay, plant transfer function, for controller design, current controller specification and design, speed controller specification and design.

Module 4: Induction motor characteristics (6 hours)

Review of induction motor equivalent circuit and torque-speed characteristic, variation of torque-speed curve with (i) applied voltage, (ii) applied frequency and (iii) applied voltage and frequency, typical torque-speed curves of fan and pump loads, operating point, constant flux operation, flux weakening operation.

Module 5: Scalar control or constant V/f control of induction motor (8 hours)

Review of three-phase voltage source inverter, generation of three-phase PWM signals, sinusoidal modulation, space vector theory, conventional space vector modulation; constant V/f control of induction motor, steady-state performance analysis based on equivalent circuit, speed drop with loading, slip regulation.

Text / References:

1. G. K. Dubey, Power Semiconductor Controlled Drives, Prentice Hall, 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.

BTEE-603D-18	Wind and Solar Energy Systems	3L:0T:0P	3 credits
<i>Internal Marks: 40</i>	<i>External Marks: 60</i>	<i>Total Marks: 100</i>	

Course Outcomes:

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

- (i) Understand the global energy scenario and the consequent growth of the power generation from renewable energy sources.
- (ii) Understand the basic physics of wind and solar power generation.
- (iii) Apply the knowledge of electrical machines to generate electrical power from wind
- (iv) Understand the power electronic interfaces for wind and solar generation.
- (v) 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: (6 Hours)

Introduction, solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability.

Module 4: Solar energy Technologies (12 Hours)

Solar photovoltaic Technologies-Amorphous, monocrystalline, polycrystalline; V-I characteristics of a PV cell, PV module, array, Power Electronic Converters for Solar Systems, Maximum Power Point Tracking (MPPT) algorithms. Converter Control.

Solar thermal power generation: Technologies, Parabolic trough, central receivers, parabolic dish, Fresnel, solar pond, elementary analysis.

Module 5: Network Integration Issues: (7 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. Hybrid and isolated operations of solar PV and wind systems.

Text / References:

1. T. Ackermann, Wind Power in Power Systems, John Wiley and Sons Ltd., 2005.
2. G. M. Masters, Renewable and Efficient Electric Power Systems, John Wiley and Sons, 2004.
3. S. P. Sukhatme, Solar Energy: Principles of Thermal Collection & 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.

BTEE-604A-18	High Voltage Engineering	3L:0T:0P	3 credits
<i>Internal Marks: 40 External Marks: 60 Total Marks: 100</i>			

Course outcomes:

At the end of the course, the student will demonstrate

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

Module 1: Breakdown in Insulating materials (8 Hours)

Ionization processes and de-ionization processes, Types of Discharge, Gases as insulating materials, Breakdown in Uniform gap, non-uniform gaps, Townsend's theory, Streamer mechanism, Corona discharge

Module 2: Breakdown in liquid and solid (9 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 (9 Hours)

Generation of high voltages, generation of high D C and AC voltages, generation of impulse voltages, generation of impulse currents, tripping and control of impulse generators.

Module 4: Measurements of High Voltages and Currents (8 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 (8 Hours)

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

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. 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

BTEE-604B-18	Power System Reliability	3L:0T:0P	3 credits
<i>Internal Marks: 40</i>	<i>External Marks: 60</i>	<i>Total Marks: 100</i>	

Course Outcome: This course covers the following topics

- (i) Understand the basic quantitative reliability analysis
- (ii) Understand the reliability modeling and analysis of electric power systems.
- (iii) Knowledge of reliability assessment for elements of transmission system.
- (iv) Understand the risk analysis in power system planning.

Module 1: General reliability modelling and evaluation (8 hours)

Introduction to probability and stochastic processes; system modelling for reliability; methods of reliability assessment: state space, cut-set and tie-set analysis, decomposition; Monte Carlo simulation: non-sequential and sequential; synchronous and asynchronous timing, Analysis of risk in power systems; understanding of causes and remedial measures.

Module 2: Reliability modeling and analysis of electric power systems (10 hours)

Bulk power systems, distribution systems, and industrial systems. Component modeling: generator modeling, transmission line modeling, load modeling; capacity outage table; probability and frequency distributions; unit addition algorithm; load modeling algorithm. Generation adequacy assessment using discrete convolution: discrete convolution of generation and load models; generation reserve model.

Module 3: Power System Reliability (8 hours)

Basic Notions of Power System Reliability- sub systems, reliability indices, outage classification, value of reliability tools, Concepts and methodologies, power system structure, Reliability based planning in power systems, Effect of failures on power system, Planning criteria, Risk analysis in power system planning, multi-state systems.

Module 4: Reliability of Generation Systems (8 hours)

Capacity outage calculations, reliability indices using the loss of load probability method, unit commitment and operating constraints, optimal reserve management, single and multi-stage expansion.

Module 5: Reliability Assessment for Elements of Transmission and Transformation Systems (8 hours)

Reliability indices of substations based on the overload capability of the transformers, evaluation and analysis of substation configurations.

Text Books:

1. C. Singh, P. Jirutitijaroen and J. Mitra, Electric Power Grid Reliability Evaluation: Models and Methods. Wiley-IEEE Press, Hoboken, NJ: 2019. ISBN: 9781119486275.
2. R. Ramakumar, Engineering Reliability: Fundamentals and Applications. Prentice Hall. J. Endrenyi, Reliability Modeling in Electric Power Systems. Wiley.
3. Shahidehpour M, Yamin H, Li z, Markey operations in electric power systems Forecasting, Scheduling, and Risk Management, John Wiley & sons
4. R. Billinton, R. Allan, Reliability evaluation of power systems, Plenum Press New York, 1996.
5. Computational Methods in Power system Reliability, D. Elmakias, Springer-Verlag

BTEE-604C-18	Line-Commutated and Active PWM Rectifiers	3L:0T:0P	3 credits
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Internal Marks: 40 External Marks: 60 Total Marks: 100

Course Outcomes:

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

- (i) Analyse controlled rectifier circuits.
- (ii) Understand the operation of line-commutated rectifiers – 6 pulse and multi-pulse configurations.
- (iii) 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 (8 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 (9 Hours)

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 waveshape.

Module 3: Multi-Pulse converter (9 Lectures)

Review of transformer phase shifting, generation of 6-phase ac voltage from 3-phase AC, 6-pulse converter and 12-pulse converters with inductive loads, steady state analysis, commutation overlap, notches during commutation.

Module 4: Single-phase AC-DC single-switch boost converter (8 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 (8 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.

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.

BTEE-604D-18	Energy Efficient Systems	3L:0T:0P	3 credits
<i>Internal Marks: 40</i>	<i>External Marks: 60</i>	<i>Total Marks: 100</i>	

Course Outcomes:

- (i) Understand the basic electricity billing and electrical load management
- (ii) Understand the refrigeration and air conditioning system
- (iii) Knowledge of light source, choice of lighting, luminance requirements, and energy conservation avenues.
- (iv) Understand the diesel generating system and energy efficient technologies.

Module 1: Introduction (7 hours)

Electrical systems: Electricity billing, electrical load management and maximum demand control, power factor improvement and its benefit, selection and location of capacitors;

Module 2: motors and compressors (7 hours)

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; Compressed Air System: Types of air compressors, compressor efficiency, efficient compressor operation

Module 3: HVAC, Refrigeration System and Pumping Systems (10 hours)

Vapour compression refrigeration cycle, refrigerants, coefficient of performance, capacity, and factors affecting Refrigeration and Air conditioning system performance and savings opportunities. Vapour absorption refrigeration system: Working principle, types and comparison with vapour compression system; Fans and blowers: Types, performance evaluation, efficient system operation, energy conservation opportunities; Pumping System: Types, performance evaluation, efficient system operation, energy conservation opportunities.

Module 3: Cooling Tower and Lighting Systems (8 hours)

Types and performance evaluation, efficient system operation, flow control strategies and energy saving opportunities assessment of cooling towers.

Lighting System: Light source, choice of lighting, luminance requirements, and energy conservation avenues.

Module 5: Diesel Generating system and Energy Efficient Technologies in Electrical Systems (10 hours)

Factors affecting selection, energy performance assessment of diesel conservation avenues. 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/References:

1. Online: <http://knowledgeplatform.in/wp-content/uploads/2017/03/Chapter-3.10-ENERGY-EFFICIENT-TECHNOLOGIES.pdf>
2. P. Venkataseshiaiah and K.V. Sharma “Energy Management and Conservation”, pp. 168, Dreamtech Press, January 2020.
3. Amlan Chakrabarti, “Energy Engineering and Management”, pp. 416, PHI Learning, 2nd revised edition, January 2019.
4. Umesh Rathore, “Energy Management”, pp. 450, SK Kataria and sons, January 2013.

Open Electives

Curriculum for Undergraduate Degree Course
Bachelor of Technology in **Electrical Engineering**
Open Electives offered by EE Department

**LIST OF OPEN ELECTIVE COURSES FOR STUDENTS OF OTHER PROGRAMMS
OFFERED BY ELECTRICAL ENGINEERING**

Prerequisite: To have passed Basic Electrical Engineering/Basic Electronics Engineering Course

Sr. No.	Course Code	Semester	Course Title	L	T	P	Hours/Week	Credits
1.	OEE-101-18	Odd	Control Systems	3	0	0	3	3
2.	OEE-102-18	Odd-	Power Electronics	3	0	0	3	3
3.	OEE-103-18	Odd	Electrical Energy Conservation & Auditing	3	0	0	3	3
4.	OEE-104-18	Odd	Renewable Energy Sources	3	0	0	3	3
5.	OEE-201-18	Even	Electric Machines	3	0	0	3	3
6.	OEE-202-18	Even	Industrial Electrical Systems	3	0	0	3	3
7.	OEE-203-18	Even	Wind and Solar Energy Systems	3	0	0	3	3
8.	OEE-204-18	Even	Power Systems	3	0	0	3	3

OEE-101-18	Control Systems	3L:0T:0P	3 credits
<i>Internal Marks: 40 External Marks: 60 Total Marks: 100</i>			

Course Outcomes:

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

- (i) Understanding the model of linear-time-invariant systems using transfer function
- (ii) Understanding state-space representations.
- (iii) Knowledge of the concept of stability
- (iv) Assessment for linear-time invariant systems.
- (v) Knowledge of non-linear systems

Module 1: Introduction to control problem (6 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.

Module 2: Time and Frequency Response Analysis (12 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.

Module 3: Frequency-response analysis (8 hours)

Relationship between time and frequency response, Polar plots, Bode plots. Nyquist stability criterion.

Module 4: State variable Analysis (8 hours)

Concepts of state variables. State space model. Diagonalization of State Matrix. Solution of state equations. Eigenvalues and Stability Analysis. Concept of controllability and observability.
Pole-placement by state feedback.

Module 5: Introduction to Optimal Control and Nonlinear Control (8 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.

OEE-102-18	Power Electronics	3L:0T:0P	3 credits
<i>Internal Marks: 40 External Marks: 60 Total Marks: 100</i>			

Course Outcomes:

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

- (i) Knowledge of power semiconductor switches
- (ii) Understand the working of various types of converters
- (iii) Apply the ac-dc and dc-dc converter in field

Module 1: Semiconductor Devices Construction and Characteristics (8 hours)

Introduction to Thyristor family: SCR, DIACs, TRIACs Power Transistors, Power MOSFET, Insulated Gate Bipolar transistors (IGBTs), Light Activated SCRs (LASCRs), Reverse Conducting Thyristor, (RCT), Asymmetrical SCR (ASCR), Gate turn-off Thyristors (GTOs), Integrated Gate- Commutated Thyristors (IGCTs), MOS controlled Thyristors (MCTs) Power Integrated circuits (PICs), Intelligent Modules

Module 2: Thyristor Fundamentals (10 hours)

Construction of SCR, Operating modes, Two transistor analogy, Static & dynamic characteristics, Gate characteristics, Turn on & turn off methods (Commutation methods), Series and Parallel operations of SCRs : Need, String efficiency, Issues, Static and Dynamic Equalizing circuit and Means to minimize the effect of mis-match Isolation of gate and base drive using pulse transformer and Optocouplers Gate Drive/Triggering circuits: R trigger, RC trigger, Cosine Triggering, UJT and Programmable UJT as an oscillator and triggering circuit based on them Ratings, Cooling and Heat sinks, Thermal Modeling, di/dt and dv/dt protection,

Module 3: Phase Controlled (AC to DC) Converters (8 hours)

Review of half-wave and full-wave diode rectifier (with RL load); Principle of phase-controlled converter operation; Operation of 1-phase half wave converter with R, RL and RLE load; 1- phase full wave converter: Center-tapped and Bridge Configuration; Gating Requirements.

Module 4: Operation and analysis of 1-phase Semi-converter/Half controlled converter (8 hours)

Operation of half wave converter; Full wave fully controlled converters: Semi-controlled converter; Dual Converter: Principle and operation; 1-phase and 3-phase configurations.

Module 5: DC to DC Converters (8 hours)

The chopper, Basic principle of DC chopper, Classification of DC choppers, Principle, operation, and analysis for Step-down (Buck), Step-up (Boost), Step up/down (Buck-Boost), Application of DC-to-DC converters.

Text/References:

1. M. D. Singh and K. B. Khanchandani, Power electronics, TMH, New Delhi, 2nd ed., 2007.
2. M. H. Rashid, Power Electronics - Circuits, Devices and Applications, Prentice Hall of India, 3rd ed., 2003.
3. V. Subramanyam, Power Electronics – Devices, Converters and Applications, New Age International Publishers Pvt. Ltd., Bangalore, 2nd ed. 2006.
4. P. S. Bimbhra, Power Electronics, Khanna Publishers, New Delhi, 2012.
5. N. Mohan, Undeland and Robbins, Power Electronics – Converters, Applications and Design, John Wiley & sons, Inc., 3rd ed., 2003.
6. V. R. Moorthi, Power Electronics, Oxford University press, 2005.
7. G. K. Dubey, S.R. Doradla, A. Joshi, and R.M.K. Sinha, Thyristorised Power Controllers, New Age International Ltd. Publishers, 1986 (Reprint 2008).
8. P.T. Krein, Elements of Power Electronics, Oxford University Press, 1998.
9. G. K. Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, New Delhi, 2nd ed. 2001.

OEE-103-18	Electrical Energy Conservation & Auditing	3L:0T:0P	3 credits
<i>Internal Marks: 40 External Marks: 60 Total Marks: 100</i>			

Course Outcome: After learning the course the students should be able to,

- (i) Knowledge of the energy conservation/saving opportunities in different electric system
- (ii) Knowledge of energy conservation opportunities in thermal system
- (iii) Understand the Demonstrate skills required for energy audit and management.
- (iv) Understand the Suggest cost-effective measures towards improving energy efficient and energy conservation.

Module 1: Energy Conservation in Power Generation, Transmission and Distribution (6 hours)

Performance improvement of existing power plant: co-generation, small hydro, DG Set, Demand side management, Load response programmes, Types of tariff and restructuring of electric tariff.

Module 2: Energy Audit Methodology and recent trends (10 hours)

General Philosophy need of Energy Audit and Management, EC Act, Definition and Objective of Energy Management, General Principles of Energy Management. Energy Management Skills, Energy Management Strategy. Economics of implementation of energy optimization projects, it's constraints, barriers and limitations, Report-writing, preparations and presentations of energy audit reports, Post monitoring of energy conservation projects, MIS, Case-studies / Report studies of Energy Audits. Impact of renewable energy on energy audit recommendations.

Module 3: Thermal Systems (10 hours)

Boilers- performance evaluation, Loss analysis, Water treatment and its impact on boiler losses, integration of different systems in boiler operation. Furnaces- Types and classifications, applications, economics and quality aspects, heat distributions, draft controls, waste heat recovering options, Furnaces refractory- types and sections. Thermic Fluid heaters need and applications, Heat recovery and its limitations.

Module 4: Energy Audit (8 hours)

Energy audit and its benefits, Energy flow diagram, Preliminary, Detailed energy audit., Methodology of preliminary energy audit and Detailed energy audit – Phase I, Pre audit, Phase II- Audit and Phase III- Post audit, Energy audit report., Electrical Measuring Instruments - Power Analyser, Combustion analyser, fuel efficiency monitor, thermometer-contact, infrared, pitot tube and manometer, water flowmeter, leak detector, tachometer and luxmeter, IE rules and regulations for energy audit, Electricity act.

Module 5: Energy Conservation Approaches in Industries (8 hours)

Energy saving opportunities in electric motors, Benefits of Power factor improvement and its techniques-Shunt capacitor, Synchronous Condenser etc., Effects of harmonics on – Motors, and remedies leading to energy conservation, Area Sealing, Insulating the Heating / cooling fluid pipes, automatic door closing- Air curtain, Thermostat / Control., Lighting techniques – Natural, CFL, LED lighting sources and fittings. Introduction to green buildings

Textbooks:

1. Energy Audit and Management, Volume-I, IECC Press
2. Energy Efficiency in Electrical Systems, Volume-II, IECC Press
3. W. R. Murphy, G. McKay, Energy Management: Butterworths Scientific
4. C. B. Smith, Energy Management Principles, Pergamon Press
5. D.A. Reay, Industrial Energy Conservation, Pergamon Press
6. W.C. Turner, Energy Management Handbook, John Wiley and Sons, A Wiley Interscience
7. L.C. Witte, P.S. Schmidt, D.R. Brown, Industrial Energy Management and Utilization, Hemisphere Publication, Washington, 1988.
8. Handbook of Energy Audits, Albert Thumann, P.E., C.E.M. William J. Younger, C.E.M., CRC Press.

OEE-104-18	Renewable Energy Sources	3L:0T:0P	3 credits
<i>Internal Marks: 40 External Marks: 60 Total Marks: 100</i>			

Course Outcomes:

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

- (i) Knowledge of the basic properties of different renewable sources of energy and technologies
- (ii) Knowledge of the main elements of technical systems designed for utilization of renewable sources of energy
- (iii) Understand the advantages and disadvantages of different renewable sources of energy
- (iv) Understand the energy potential of renewable sources of energy,

Module 1: Solar Radiation and Solar Energy Collection (12 hours)

Role and potential of new and renewable source, the solar energy option, Environmental impact of solar power, physics of the sun, the solar constant, extraterrestrial and terrestrial solar radiation, solar radiation on tilted surface, instruments for measuring solar radiation and sun shine, solar radiation data.

Flat plate and concentrating collectors, classification of concentrating collectors, orientation and thermal analysis, advanced collectors. Solar Applications- solar heating/cooling technique, solar distillation and drying, photovoltaic energy conversion.

Module 2: Wind Energy (8 hours)

Energy availability of wind, wind resources, principle of wind energy conservation. Wind turbine site and its site selection, classification of wind turbine, characteristics of wind turbine.

Module 3: Bio-Mass (8 hours)

Principles of Bio-Conversion, Anaerobic/aerobic digestion, types of Bio-gas digesters, gas yield, combustion characteristics of bio-gas, utilization for cooking.

Module 4: Geothermal Energy (6 hours)

Resources, types of wells, methods of harnessing the energy, potential in India.

Module 5: Ocean Energy (8 hours)

OTEC, Principles utilization, setting of OTEC plants, thermodynamic cycles. Tidal and wave energy: Potential and conversion techniques, mini-hydel power plants, and their economics.

Text/References:

1. Non-Conventional Energy Sources /G.D. Rai, Khanna Publishers
2. Renewable Energy Resources – Twidell &Wier, CRC Press (Taylor & Francis)
3. Renewable energy resources/ Tiwari and Ghosal/ Narosa.
4. Ramesh & Kumar, Renewable Energy Technologies / /Narosa
5. D. P. Kothari, K. C. Singhal, Renewable energy sources and emerging technologies, P.H.I.

OEE-201-18	Electric Machines	3L:0T:0P	3 credits
<i>Internal Marks: 40 External Marks: 60 Total Marks: 100</i>			

Course Outcomes:

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

- (i) Summarize the basics of Single-Phase Machines
- (ii) Acquire knowledge about testing and applications of induction motors.
- (iii) Understand the concepts of Steeper Motors, construction, modes of operation and characteristics
- (iv) Understand the basic concept of DC Machines and its torque slip characteristics
- (v) Explain the basic concepts of universal and repulsion motors, construction, application.

Module 1: Poly-phase AC Machines (9 hours)

Construction of three phase induction motors, types of three-phase induction motors, rotor induced emf, power flow in induction motor, equivalent circuit of induction motor, Torque -speed characteristics, condition of maximum torque, tests on induction motor: measurement of DC resistance, No-load test, blocked rotor test. Braking: Plugging, rheostatic braking and regenerative braking.

Module 2: Single phase Induction Motors (8 hours)

Pulsating magnetic field, double revolving field, starting methods of single-phase induction motor, Construction, starting characteristics and applications of split phase, capacitor start, capacitor run, capacitor-start capacitor-run and shaded pole motors. Servo motors: DC Sevomotor and AC servo motor,

Module 3: Stepper Motors (8 hours)

Principle of operation, variable reluctance, permanent magnet and hybrid stepper motors, characteristics, drive circuits and applications. Switched Reluctance Motors: Construction; principle of operation; torque production, modes of operation, drive circuits.

Module 4: Permanent Magnet Machines (9 hours)

Types of permanent magnets and their magnetization characteristics, demagnetizing effect, permanent magnet dc motors, sinusoidal PM ac motors, brushless dc motors and their important features and applications, PCB motors. Single phase synchronous motor; construction, operating principle and characteristics of reluctance and hysteresis motors; introduction to permanent magnet generators and applications

Module 5: Special Machines (8 hours)

Construction, principle of operation of: Single phase AC commutator motor, Switched Reluctance motor, brushless dc motor, hysteresis Motor, Synchronous reluctance motor, Linear induction motor.

Text / Reference Books:

1. P.S. Bimbhra, Generalized Theory of Electrical Machines, Khanna Publishers.
2. P.C. Sen, Principles of Electrical Machines and Power Electronics, John Wiley & Sons, 2001
3. G. K. Dubey, Fundamentals of Electric Drives, Narosa Publishing House, 2001.
4. C. G. Veinott, Fractional and Sub-fractional horsepower electric motors, McGraw Hill International, 1987
5. M.G. Say, Alternating current Machines, Pitman & Sons.

OEE-202-18	Industrial Electrical Systems	3L:0T:0P	3 credits
<i>Internal Marks: 40 External Marks: 60 Total Marks: 100</i>			

Course Outcomes:

- (i) At the end of this course, students will demonstrate the ability to
- (ii) Understand the electrical wiring systems for residential, commercial, and industrial consumers, representing the systems with standard symbols and drawings, SLD.
- (iii) Understand various components of industrial electrical systems.
- (iv) Analyze and select the proper size of various electrical system components.

Module 1: Electrical System Components (10 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.,

Module 2: Residential and Commercial Electrical Systems (9 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 (9 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 premise, flood lighting.

Module 4: Industrial Electrical Systems I (9 Hours)

HT connection, industrial substation, Transformer selection, Industrial loads, motors, starting of motors, Cable and Switchgear selection, 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: Electrical Protection (5 Hours)

Lightning protection, Earthing, circuit breakers, isolators.

Text/Reference Books

- 6. S. L. Uppal and G. C. Garg, Electrical Wiring, Estimating & Costing, Khanna publishers, 2008.
- 7. K. B. Raina, Electrical Design, Estimating & Costing, New age International, 2007.
- 8. S. Singh and R. D. Singh, Electrical estimating, and costing, Dhanat Rai and Co., 1997.
- 9. Web site for IS Standards.
- 10. H. Joshi, Residential Commercial and Industrial Systems, McGraw Hill Education, 2008.

OEE-203-18	Wind and Solar Energy Systems	3L:0T:0P	3 credits
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Internal Marks: 40 External Marks: 60 Total Marks: 100

Course Outcomes:

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

- (i) Understand the energy scenario and the consequent growth of the power generation from renewable energy sources.
- (ii) Understand the basic physics of wind and solar power generation.
- (iii) Understand the power electronic interfaces for wind and solar generation.
- (iv) Understand the issues related to the solar technologies and wind topologies.

Module 1: Physics of Wind Power (8 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 (14 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 (6 Hours)

Introduction, solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability.

Module 4: Solar photovoltaic (8 Hours)

Technologies-Amorphous, monocrystalline, polycrystalline; V-I characteristics of a PV cell, PV module, array, Power Electronic Converters for Solar Systems, Maximum Power Point Tracking (MPPT) algorithms.

Module 5: Solar thermal power generation (4 Hours)

Technologies, Parabolic trough, central receivers, parabolic dish, Fresnel, solar pond, elementary analysis.

Text / References:

1. T. Ackermann, Wind Power in Power Systems, John Wiley and Sons Ltd., 2005.
2. G. M. Masters, Renewable and Efficient Electric Power Systems, John Wiley and Sons, 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.

OEE-204-18	Power Systems	3L:0T:0P	3 credits
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Internal Marks: 40 External Marks: 60 Total Marks: 100

Course Outcomes:

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

- (i) Awareness of supply system
- (ii) Understanding of the material used and construction of transmission lines
- (iii) Enable the students to do analysis of power transmission line parameters.
- (iv) Understand the cables used in power system
- (v) Knowledge of neutral grounding.

Module 1: Supply System (8 hours)

Introduction to Transmission and Distribution systems, Comparison between DC and AC systems for Transmission and Distribution, comparison of cost of conductors, choice of working voltage for transmission and distribution, economic size of conductors - Kelvin's law, Radial and mesh distribution networks, Voltage regulation.

Module 2: Conductors and Transmission Line Construction (8 hours)

Conductor materials; solid, stranded, ACSR, hollow and bundle conductors. Different types of supporting structures for overhead lines. Elementary ideas about transmission line construction and erection. Stringing of conductors, spacing, sag and clearance from ground, overhead line insulators, concept of string efficiency.

Module 3: Transmission Line Parameters (10 hours)

Introduction to line parameters, Resistance of transmission line, inductance of single phase two wire line, concept of G.M.D., Inductance of three phase line, Use of bundled conductor, transposition of power lines, capacitance of 1-phase and 3-phase lines. effect of earth on capacitance of conductors.

Module 4: Underground Cables (8 hours)

Classification of cables based upon voltage and dielectric material, insulation resistance and capacitance of single core cable, dielectric stress, Capacitance of 3 core cables, methods of laying, heating effect, Maximum current carrying capacity, cause of failure, comparison with overhead transmission lines.

Module 5: Neutral grounding (8 hours)

Necessity of neutral grounding, various methods of neutral grounding, earthing transformer, grounding practices

Text/Reference Books:

11. W. D. Stevenson, Element of Power System Analysis, McGraw Hill.
12. C. L. Wadhwa, Electrical Power Systems, New age international Ltd. Third Edition
13. Asfaq Hussain, 'Power System, CBS Publishers and Distributors.
14. B. R. Gupta, Power System Analysis and Design, Third Edition, S. Chand & Co.
15. M. V. Deshpande, Electrical Power System Design, Tata Mc Graw Hill. Reference Books.
16. S.N. Singh, "Electric Power Generation, Transmission& distribution." PHI Learning

Curriculum for Undergraduate Degree Course
Bachelor of Technology in **Electrical Engineering**
Humanities & Social Sciences Including Management

List of Humanities & Social Sciences Including Management

Sr. No.	Course Code	Course Title	Hours per week	Credit
1.	HSMC-103-18	Education, Technology and Society	3L:0T:0P	3
2.	HSMC-104-18	History of Science and Technology in India	3L:0T:0P	3
3.	HSMC-113-18	Values and Ethics	3L:0T:0P	3
4.	HSMC-118-18	Introduction to Women's and Gender Studies	3L:0T:0P	3
5.	HSMC-123-18	Human Relations at Work	-	-
6.	HSMC-124-18	Sanskrit Bhasa	3L:0T:0P	3
7.	HSMC (MME-303)	Law and Engineering	3L:0T:0P	3
Note: (a) On account of a prerequisite, course HSMC-123-18 Human Relations at Work not to be considered. (b) As per AICTE Humanities & Social Sciences Including Management are 3 credit course hence Hours per week to be 3L:0T:0P.				

Curriculum for Undergraduate Degree Course
Bachelor of Technology in **Electrical Engineering**
Humanities & Social Sciences Including Management

HSMC-103-18	Education, Technology and Society	3L:0T:0P	3 credits
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Internal Marks: 40 External Marks: 60 Total Marks: 100

OBJECTIVES:

The goal of the proposed course is to enable students:

- i. To 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.
- ii. To understand the requirement of (a) education for becoming an effective member of the society (b) To fulfill the potential of a learner to the fullest without too much thought of an individual's responsibility towards the contemporary society.

COURSE TOPICS:

Unit 1: Necessity of education for human life, Impact of education on society

Unit 2: Nature and scope of education (Gurukul to ICT driven), Emotional intelligence Domains of learning, Approaches to learning, Learning outcomes

Unit 3: Role of education in technology advancement.

Unit 4: Technology and society; management of technology; technology transfer

Unit 5: Ethical and value implications of education and technology on individual and society

COURSE OUTCOME:

On successful completion of this course, the students will be able to integrate their technical education for betterment of society as well motivates them to lead a good human life.

REFERENCE BOOKS:

Education and Social order by Bertr and Russel

Theories of learning by Bower and Hilgard

Technology and Society by Jan L Harrington

Curriculum for Undergraduate Degree Course
Bachelor of Technology in **Electrical Engineering**
Humanities & Social Sciences Including Management

HSMC-104-18	History of Science and Technology in India	3L:0T:0P	3 credits
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Internal Marks: 40 External Marks: 60 Total Marks: 100

Unit-I CONCEPTS AND PERSPECTIVES

- Meaning of History
- Objectivity, Determinism, Relativism, Causation, Generalization in History; Moral judgment in history
- Extent of subjectivity, contrast with physical sciences, interpretation and speculation, causation verses evidence, concept of historical inevitability, Historical Positivism.
- Science and Technology-Meaning, Scope and Importance, Interaction of science, technology & society, Sources of history on science and technology in India.

Unit-II: HISTORIOGRAPHY OF SCIENCE AND TECHNOLOGY IN INDIA

- Introduction to the works of D.D. Kosambi, Dharmapal, Debiprasad Chattopadhyay, Rehman, S. Irfan Habib, Deepak Kumar, Dhruv Raina, and others.

Unit-III: SCIENCE AND TECHNOLOGY IN ANCIENT INDIA

- 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.

Unit-IV: SCIENCE AND TECHNOLOGY IN MEDIEVAL INDIA

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

Unit-V: SCIENCE AND TECHNOLOGY IN COLONIAL INDIA

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

Unit-VI: SCIENCE AND TECHNOLOGY IN A POST-INDEPENDENT INDIA

- 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

Curriculum for Undergraduate Degree Course
Bachelor of Technology in **Electrical Engineering**
Humanities & Social Sciences Including Management

HSMC-113-18	Values and Ethics	3L:0T:0P	3 credits
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Internal Marks: 40 External Marks: 60 Total Marks: 100

1. Definition and classification of values: Extrinsic values, Universal and Situational values, Physical, Environmental, Sensuous, Economic, Social, Aesthetic, Moral and Religious values.
2. Concepts related to values: Purusartha, Virtue, Right, duty, justice, Equality, Love and Good.
3. Egoism, Altruism and universalism.
4. The Ideal of Sarvodaya and Vasudhaiva Kutumbakam. The Problem of Sustenance of value in the process of Social, Political and Technological changes.
5. The Problem of hierarchy of values and their choice, The views of Pt. Madan Mohan Malviya and Mahatma Gandhi.

BOOKS SUGGESTED

1. डॉनित्यानंदमिश्र : नीतिशास्त्र (Motilal Banarasidas, 2005)
2. डॉवेदप्रकाशवर्मा : नीतिशास्त्रकेमूलसिद्धांत, (Allied Publication, Delhi, 1977)
3. डॉसंगमलालपांडे : नीतिशास्त्रकासर्वेक्षण (सेंट्रलपब्लिशिंगहादस, इलाहाबाद-2005)
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)

Curriculum for Undergraduate Degree Course
Bachelor of Technology in **Electrical Engineering**
Humanities & Social Sciences Including Management

HSMC-118-18	Introduction to Women's and Gender Studies	3L:0T:0P	3 credits
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Internal Marks: 40 External Marks: 60 Total Marks: 100

Unit-I : Concepts

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.

Unit-II: *Feminist Theory*

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

Unit-III: *Women's Movements: Global, National and Local*

Rise of Feminism in Europe and America.

Women's Movement in India.

Unit-IV: *Gender and Language*

Linguistic Forms and Gender.

Gender and narratives.

Unit-V: *Gender and Representation*

Advertising and popular visual media.

Gender and Representation in Alternative Media.

Gender and social media.

Curriculum for Undergraduate Degree Course
Bachelor of Technology in **Electrical Engineering**
Humanities & Social Sciences Including Management

HSMC-124-18	Sanskrit Bhasa	3L:0T:0P	3 credits
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Internal Marks: 40 External Marks: 60 Total Marks: 100

- शब्दस्वरूप एवंभेद
- उच्चारण—स्थान एवंप्रयत्न
- पदसंरचना
 - (क) पदस्वरूप, भेद एवंप्रयोग
 - (ख) सुवन्तपद
 - (ग) तिङन्तपद
- वाक्यसंरचना
 - (क) वाक्यस्वरूप, भेद एवंप्रयोग
 - (ख) कर्तृवाच्य
 - (ग) कर्मवाच्य
 - (घ) भाववाच्य
- शब्द—अर्थ—सम्बन्ध
 - (क) शक्ति
 - (ख) लक्षणा
 - (ग) गौणी, व्यञ्जना, तात्पर्यआदि
- कारकपरिचय
 - (क) कारकस्वरूप, भेद एवंप्रयोग
 - (ख) विभक्तियोंकाअर्थ
- सन्धिपरिचय—सन्धिस्वरूप, भेद एवंप्रयोग
- स्मासपरिचय—स्वरूप, भेद एवंप्रयोग
- शाब्दबोध—प्रक्रिया एवंकारण
 - आकांक्षा, योग्यता, आसत्ति, तात्पर्यज्ञान
- संस्कृतसम्भाषण

Curriculum for Undergraduate Degree Course
Bachelor of Technology in **Electrical Engineering**
Humanities & Social Sciences Including Management

HSMC (MME-303)	Law and Engineering	3L:0T:0P	3 credits
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Internal Marks: 40 External Marks: 60 Total Marks: 100

The aim of this course is to provide a basic understanding of the legal concepts and issues relevant to those wishing to practice as Engineers.

1. THE LEGAL SYSTEM: SOURCES OF LAW AND THE COURT STRUCTURE:
 - 1.1 Enacted law -Acts of Parliament are of primary legislation, Common Law or Case law- Principles taken from decisions of judges constitute binding legal rules.
 - 1.2 The Court System in India and Foreign Courts. (District Court, District Consumer Forum, Tribunals, High Courts, Supreme Court)
 - 1.3 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.
2. BASIC PRINCIPLES OF CONTRACT LAW
3. SALE OF GOODS LAW
4. BUSINESS ORGANISATIONS:
 - 4.1 SOLE TRADERS (Business has no separate identity from you, all business property belongs to you)
 - 4.2 PARTNERSHIPS: There are three types of Partnerships: Limited Liability Partnership, General Partnership, Limited Partnerships
 - 4.3 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.
5. LAWS RELATING TO INDUSTRIAL POLLUTION ACCIDENT, ENVIRONMENTAL PROTECTION, HEALTH AND SAFETY AT WORK.
6. PATENT LAW.
7. INFORMATION TECHNOLOGY LAW AND CYBERCRIMES.
8. LAW AND SOCIETY: INTERDISCIPLINARY NATURE OF LAW, LEGAL IDEOLOGIES/PHILOSOPHY/ SCHOOLS OF JURISPRUDENCE.
9. CONSTITUTIONAL LAW: THE SUPREME LAW OF THE LAND.
10. CASE STUDIES: IMPORTANT LEGAL DISPUTES AND JUDICIAL LITIGATIONS.



Semester: VII/VIII [Fourth Year]



BTEE-721-18	Project-2	0L:0T:12P	6 credits
Internal Marks: 120		External Marks: 80	Total Marks: 200

Course Outcomes:

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

CO 1 Apply and verify basic scientific principals and technologies.

CO 2 Application of interdisciplinary knowledge

CO 3 To identify possible product that can be made from the project for commercial purpose.

The objective of Project-2 including dissertation is to enable the student to extend further the investigative study taken up under Project-1, either fully theoretical/practical or involving both theoretical and practical work, under the guidance of a supervisor from the department alone or jointly with a supervisor drawn from R&D laboratory/industry/other department in the institute. This is expected to provide a good training for the student (s) in R&D work and technical leadership. The assignment to normally include:

- 1) In depth study of the topic assigned in the light of the report prepared under Project-1
- 2) Review and finalization of the approach to the assigned topic
- 3) Preparing an action plan for conducting the investigation, including teamwork
- 4) Need based detailed analysis/modelling/simulation/design/problem solving/experiment.
- 5) Final development of product/process, testing, results, conclusions and future directions/scope
- 6) Preparing a dissertation in the standard format for being evaluated by the department.
- 7) Final seminar presentation before a departmental committee.
- 8) Preparing a paper for conference presentation/publication in journals, if possible.

Note: The report submitted should be within the philosophy of science and ethics and publication ethics. Proper citation to be done so as to avoid plagiarism.



BMPD-701-18	Mentoring and Professional Development of Students	0L:1T:0P	0 credits S/US
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Internal Marks: 50

External Marks: 00

Total Marks: 50

The assigned mentor to engage the students to in activities such as:

- 1) Identification of any one of the local social concern and propose workable solution for it.
- 2) Expert/Invited talk pertaining to recent industrial development.
- 3) Explore scope of higher education: GATE/GRE/CAT/civil services/engineering services etc.
- 4) Resume finalization.

The mentor to keep record of all activities (including those mentioned above) and assign internal marks accordingly.



Programme Electives



BTEE-701A-18	Electrical Energy Conservation and Auditing	3L:0T:0P	3 credits
Internal Marks: 40	External Marks: 60	Total Marks: 100	

Course Outcomes:

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

- CO 1** Understand the current energy scenario and importance of energy conservation. Understand the concepts of energy management.
- CO 2** Understand the methods of improving energy efficiency in different electrical systems.
- CO 3** 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: 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 3: 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 4: 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 5: Energy Efficient Technologies in Electrical Systems (8Hours)

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 Book-3, Electrical Utilities (available online).
3. S. C. Tripathy, "Utilization of Electrical Energy and Conservation", McGraw Hill, 1991.
4. Success stories of Energy Conservation by BEE, New Delhi (www.bee-india.org).



BTEE-701B-18	Computer Aided Power System Analysis	3L:0T:0P	3 credits
Internal Marks: 40	External Marks: 60	Total Marks: 100	

Course Outcomes:

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

- CO 1** To introduce computer applications in the analysis of power systems.
- CO 2** To understand the solution methods and techniques used in power system studies.
- CO 3** To solve numerically the complex IEEE bus networks and the energy flows.

Module 1: Graphical Concepts and Network Matrices (8 Hours)

Overview of graph theory -tree, co-tree and incidence matrix, development of network matrices from Graph theoretic approach. Review of solution of linear system of equations by Gauss Jordan method, Gauss elimination, LDU factorization.

Ybus and Zbus formulation through graphical concepts. Bus building algorithm for Zbus formation.

Module 2: Power Flow Studies (16 Hours)

Inversion of YBUS for large systems using LDU factors, Tinney's Optimal ordering. Review of Gauss-Seidel Iteration using YBUS, Newton-Raphson method, Fast Decoupled Load Flow (FDLF) DC load flow, Three-phase load flow.

Module 3: Optimal Power Flow (6 Hours)

Basics concepts, active/reactive power objectives (Economic dispatch, MW and MVAR loss minimization)-applications-security constrained optimal power flow.

Module 4: Fault Analysis (10 Hours)

Network fault calculations using ZBUS and YBUS Table of factors, Algorithm for calculating system conditions after fault-three phase short circuit, three-phase to ground, double line to ground, line to line and single line to ground fault.

Module 5: Contingency Evaluation (6 Hours)

Contingency evaluation using ZBUS and YBUS Table of factors. State estimation-least square and weighted least square estimation methods for linear systems.

Text/References

1. A. R. Bergen, and V. Vittal, "Power Systems Analysis", Pearson Higher Education, 2nd edition.
2. G. L. Kusic, "Computer Aided Power System Analysis", Prentice Hall of India, 1989.
3. J. J. Grainger, and W. D. Stevenson, "Power System Analysis", Tata McGraw-Hill Series in Electrical and Computer Engineering.
4. M. A. Pai, "Computer Techniques in Power Systems Analysis", Tata McGraw-Hill, 2nd edition, 2005.
5. D P Kothari and I J Nagrath, Modern Power System Analysis, Tata Mc Graw Hill, Fourth Edition, 2013.



BTEE-701C-18	Power Quality and FACTS	3L:0T:0P	3 credits
Internal Marks: 40	External Marks: 60	Total Marks: 100	

Course Outcomes:

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

- CO 1** To introduce the fundamental concepts relevant to harmonics and grounding.
- CO 2** To enable the students to understand the factors that cause the power quality and harmonics problems in the distribution system.
- CO 3** To provide basic understanding of the emerging power electronics technologies for power utility applications.
- CO 4** To enable students to design power electronics circuit that can control active and reactive power flow.

Module 1: Introduction (4 Hours)

Introduction to power quality, voltage quality. Overview of power quality, Power quality phenomena and classification of power quality issues.

Module 2: Power Quality Measures and Standards (6 Hours)

THDTIF-DIN-message weights-flicker factor transient phenomena-occurrence of power quality problems-power acceptability curves-IEEE guides, EMC standards and recommended practices.

Module 3: Harmonic device modelling (10 Hours)

Harmonics background, basic concepts, Fourier analysis. Harmonics-individual and total harmonic distortion-RMS value of harmonic waveform-triplex harmonic-important harmonic introducing devices-Transformer, Three-phase power converters arcing devices-saturable devices. Harmonic distortion due to fluorescent lamps. Effect of power system harmonics on power system equipment and loads

Module 4: Fundamentals of transmission system (8 Hours)

Fundamentals of AC power transmission, transmission problems and needs, emergence of FACTS-FACTS control considerations, FACTS controllers.

Module 5: Shunt Compensation & Series Compensation (14 Hours)

Principles of shunt compensation: Variable impedance type and switching converter type- Static Synchronous Compensator (STATCOM) configuration, characteristics and control.

Design principles of static series compensation: Series compensation using GCSC, TCSC and TSSC, applications, Static Synchronous Series Compensator (SSSC).

Text/References

1. R. C. Dugan, S. Santoso, M. F. McGranaghan, and H. W. Beaty, "Electrical Power System Quality", McGraw Hill, 2003.
2. A. Ghosh, and G. Ledwich, "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2012.
3. C. Sankaran, "Power Quality", CRC Press, 2002.
4. S. Sivanagaraju, and S. Satyanarayana, "Electric Power Transmission and Distribution Pearson Education", Dorling Kindersley Pvt. Ltd., Pearson Education, 2009.
5. G. Narain, N. Hingorani, and L. Gyugyi, "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems", Wiley, 2000.



BTEE-701D-18	Electrical and Hybrid Vehicles	3L:0T:0P	3 credits
Internal Marks: 40	External Marks: 60	Total Marks: 100	

Course Outcomes:

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

- CO 1** Understand the conventional vehicles models and electric trains.
- CO 2** Understand the different possible ways of energy storage.
- CO 3** Compare the different strategies related to energy storage systems and knowledge of the implementation issues

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 3: 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 4: 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.



BTEE-702A-18	Computational Electromagnetics	3L:0T:0P	3 credits
Internal Marks: 40	External Marks: 60	Total Marks: 100	

Course Outcomes:

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

CO 1 Understand the basic concepts of Electrostatics and Electromagnetics.

CO 2 Understand computational techniques for computing fields.

CO 3 Apply the techniques to simple real-life problems.

Module 1: Introduction (7 hours)

Conventional design methodology, Computer aided design aspects-Advantages. Review of basic fundamentals of Electrostatics and Electromagnetics. Development of Helmholtz equation, energy transformer vectors- Poynting and Slepian, magnetic Diffusion-transients and time-harmonic.

Module 2: Analytical Methods (7 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 and Applications (12 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.

Applications: 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.



BTEE-702B-18	Microcontroller and PLC	3L:0T:0P	3 credits
Internal Marks: 40	External Marks: 60	Total Marks: 100	

Course Outcomes:

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

CO 1 To understand the working of a microprocessor/controller.

CO 2 To learn configuring and using different peripherals in a digital system.

CO 3 To compile and debug a Program in PLC

Module 1: Introduction (8 Hours)

Microprocessor, Micro-controllers and their comparison. The 8051 Architecture: Introduction, 8051 micro-controller hardware, input/output, pins, ports and circuits, external memory, counters and timers, serial data input/ output, interrupts

Module 2: 8051 Assembly Language Programming (8 Hours)

The mechanics of programming, assembly language programming process, programming tools and techniques, instruction set (data moving, logical operations, arithmetic operations, jump and call instructions)

Module 3: 8051 Microcontroller Design (8 Hours)

Micro-controller specification, external memory and memory space decoding, reset and clock circuits, expanding input and output (I/O), memory mapped I/O, memory address decoding, memory access times, testing the design, timing subroutines, lookup tables for the 8051, serial data transmission

Module 4: Microcontroller Applications (8 Hours)

Interfacing keyboards, displays, Digital-to-Analog (D/A) and Analog-to-Digital (A/D), multiple interrupts, serial data communications, introduction to the use of assemblers and simulators Embedded Systems: Introduction to PLDs and FPGA- architecture, technology and design issues, implementation of 8051 core.

Module 5: Programmable Logic Controllers (PLC) (8 Hours)

Introduction, operation of PLC, difference between PLC and Hardwired system, difference between PLC and Computer, relay logic and ladder logic, ladder commands and examples of PLC ladder diagram realization, PLC timers, PLC counters, PLC classification.

Text/References books

1. K. J. Ayala, "The 8051 Micro Controller-Architecture, Programming and Application", Penram International Publication, 2000.
2. J. B. Peatman, "Design with PIC Micro Controller", Prentice Hall of India, 1998.
3. A. K. Ray, and K. M. Bhurchandi, "Advanced Microprocessors and Peripherals; Architecture, Programming and Interfacing", Tata McGraw Hill, 3rd edition, 2013.
4. M. A. Mazidi, and J. G. Mazidi, "The 8051 Micro-controller and Embedded System", Pearson Education, 2007.
5. V. Udayashankara, and M. S. Mallikarjunaswamy, "8051 Microcontroller Hardware, Software and Applications", TataMcGraw Hill Education Pvt. Ltd., 2010.
6. S. Bhanot, "Process Control", Oxford Higher Education, 2007.
7. J. D. Otter, and J. Dan, "Programmable Logic Controller", P.H. International, Inc, 1988.
8. J. F. Hooper, "Introduction to PLCs", Carolina Academic Press, 2006.



BTEE-702C-18	Control Systems Design	3L:0T:0P	3 credits
Internal Marks: 40		External Marks: 60	Total Marks: 100

Course Outcomes:

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

- CO 1** Understand various design specifications.
- CO 2** Design controllers to satisfy the desired design specifications using simple controller structures (P, PI, PID, compensators).
- CO 3** Design controllers using the state-space approach.

Module 1: 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 (12 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.

Various types of non-linearities. Effect of various non-linearities on system performance. Singular points. Phase plot analysis.

Text and Reference Books

1. N. S. 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 of India, 2010.
5. B. C. Kuo, "Automatic Control system", Prentice Hall of India, 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.



BTEE-702D-18	Distributed Generation	3L:0T:0P	3 credits
Internal Marks: 40	External Marks: 60	Total Marks: 100	

Course Outcomes:

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

CO 1 To impart knowledge about distributed generation technologies

CO 2 Their interconnection in grid

CO 3 To understand relevance of power electronics in DG, to understand concept of microgrid

Module 1: Distributed Generation (DG) Technologies (8 Hours)

Introduction, Comparative study between conventional and non-conventional methods of power generation: energy crisis due to scarcity of fossil fuel, distributed generation (DG) overview and technology trend. Working principle, architecture and application of renewable DG technologies: Solar PV, bioenergy, wind energy, hydroelectricity, tidal power, wave energy, geothermal energy etc. Non-conventional technology based DGs: Fuel cells, CHP based microturbine, IC engines, etc. Storage based DGs: Storage technology: Battery, super capacitor, flywheel etc.

Module 2: Interconnection Issues and Standards of DGs (8 Hours)

Concept of distributed generations (DG) or distributed energy resources (DERs), topologies, selection of source, dependence on storage facilities, regulatory standards/framework, standards for interconnecting DGs to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Grid code and Islanding & non-islanding system

Module 3: Operational Features of Grid Connected DG Systems (8 Hours)

Grid interconnection issues for grid connected operation of various types of DG systems. Constraints on operational parameters: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Reliability, stability and power quality issues involved in grid connected operation of various DGs.

Module 4: Power Electronics and DG Systems (8 Hours)

Relevance of power electronics in DG applications, Power quality requirements and source switching using SCR based static switches, Distribution system loading, line drop model, series voltage regulators and on-line tap changers, power converter topologies, model and specifications for DG applications, issues filter designs, harmonic reduction,

Module 5: Control and Protection in DG Systems (6 Hours)

Control of DG inverters, phase locked loops, current control and DC voltage control for stand-alone and grid parallel operations. Protection of converters, power quality implication, acceptable ranges of voltage and frequency, reactive power compensation and active filtering.

Text/References

1. Renewable Energy-Power for a sustainable future, third edition, Edited by Godfrey Boyle, Oxford University Press, 2013.
2. A. Yezdani, and R. Iravani, "Voltage Source Converters in Power Systems: Modeling, Control and Applications", IEEE John Wiley Publications, 2009.
3. D. Neacsu, "Power Switching Converters: Medium and High Power", CRC Press, Taylor & Francis, 2006.



BTEE-703A-18	Industrial Electrical Systems	3L:0T:0P	3 credits
Internal Marks: 40	External Marks: 60	Total Marks: 100	

Course Outcomes:

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

- CO 1** Understand the electrical wiring systems for residential, commercial and industrial consumers, representing the systems with standard symbols and drawings, SLD.
- CO 2** Understand various components of industrial electrical systems.
- CO 3** 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 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 (12 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.

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. H. Joshi, "Residential Commercial and Industrial Systems", McGraw Hill Education, 2008.
5. Web site for IS Standards.



BTEE-703B-18	Restructured Power Systems	3L:0T:0P	3 credits
Internal Marks: 40	External Marks: 60	Total Marks: 100	

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

- CO 1** To impart knowledge about the restructuring and deregulation of power sector.
- CO 2** To introduce the fundamental concepts relevant to transmission pricing, models of deregulation,
- CO 3** To introduce the fundamental concepts relevant to ancillary services and international experience of deregulation.
- CO4** To enable the students to understand the basic concepts of deregulation.

Module 1: Introduction (7 Hours)

Basic concept and definitions, privatization, restructuring, transmission open access, Fundamentals of Deregulation, Restructuring Models and Trading Arrangements, Different Models of Deregulation, Operation and control, wheeling charges and pricing, Motivations for Restructuring the Power Industry; Understanding the restructuring process, entities involved, the levels of competition, marketplace mechanisms, sector-wise major changes required.

Module 2: The Philosophy of Market Models (9 Hours)

Monopoly model, Single buyer model, Wholesale competition model, Retail competition model, distinguishing features of electricity as a commodity, Four pillars of market design, Cournot, Bertrand and Stackelberg competition model. Independent System Operator (ISO), Open Access Transmission Systems

Module 3: Transmission Congestion Management (10 Hours)

Transfer capability, Importance of congestion management, Effects of congestion, Classification of congestion management methods, ATC, TTC, TRM, CBM, ATC calculation using DC and AC model, Nodal pricing, Locational Marginal Prices (LMPs), Implications of nodal pricing, Price area congestion management.

Module 4: Ancillary Service Management (10 Hours)

Type and Classification of ancillary services, Sources of reactive power, Black start capability service, Provisions of ancillary services, Markets for ancillary services, Co-optimization of energy and reserve services, Loss of opportunity cost, International practices of ancillary services.

Module 5: Deregulation Scenario (6 Hours)

Differential Models of Deregulation UK model, California Model, China, California, Australian and New Zealand Models, Deregulation in Asia including India.

Text/References:

1. Kankar Bhattacharya, Math H J. Bollen and Jaap E. Daalder, "Operation of Restructured Power Systems", Springer, 2001.
2. M. Shahidehpour and M. Alomoush, "Restructured Electric Power Systems – Operations, Trading and Volatility", CRC Press, 2001.
3. Loi Lei Lai (Ed), "Power System Restructuring and Deregulation: Trading, performance and Information Technology," John Wiley publications, 2001.
4. D. Krischen and G. Strabac "Fundamentals of Power System Economics" New York, Wiley 2004



BTEE-703C-18	Advanced Electric Drives	3L:0T:0P	3 credits
Internal Marks: 40	External Marks: 60	Total Marks: 100	

Course Outcomes:

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

- CO 1** Understand the operation of power electronic converters and their control strategies.
- CO 2** Understand the vector control strategies for ac motor drives
- CO 3** 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-Q drive.

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)

Modelling of synchronous machines, open loop v/f control, vector control, direct torque control, CSI fed synchronous motor drives.

Module 4: Permanent magnet motor drives (10 hours)

Introduction to various PM motors, BLDC and PMSM drive configuration, comparison, block diagrams, Speed and torque control in BLDC and PMSM. Evolution of switched reluctance motors, various topologies for SRM drives, comparison, Closed loop speed and torque control of SRM.

Module 5: 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, 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.



BTEE-703D-18	Energy Storage System	3L:0T:0P	3 credits
Internal Marks: 40	External Marks: 60	Total Marks: 100	

Course Outcomes:

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

- CO 1** Understand the different possible ways of energy storage.
- CO 2** Understand the different strategies related to energy storage systems.
- CO 3** Link the real-life examples with various industry related case studies.

Module 1: Introduction to Energy Storage (8 Hours)

Relevance and scenario. Perspective on development of Energy storage systems. Energy storage criteria, General concepts. Conventional batteries-fundamentals and applications. Grid connected and Off grid energy storage systems and requirements.

Module 2: Thermal and Mechanical storage (10 Hours)

Thermal properties of materials, Principle of operations, Efficiency factors, large scale and medium scale operations, Pros and Cons. Advances in thermal storage. Mechanical storage: Types of systems, Principle of operations, Emerging advances and technologies. case study: flywheel.

Module 3: Electrochemical Storage (8 Hours)

Materials, Principle of Operation, Challenges and research survey, Positive electrode materials, negative electrode materials, electrolytes.

Module 4: Fuel Cells and Hydrogen storage (8 Hours)

Principle of operation, challenges and Case studies. Magnetic storage: Principle of operation, emerging challenges, devices and technology review.

Module 5: Electro-optic and Optical storage (8 Hours)

Principles of operation, device fabrication, emerging devices and upcoming technologies. Supercapacitors: Principle of operation, device fabrication, challenges and technical review.

Text/Reference Books

1. R. Huggins, "Energy Storage", Springer science and business media, 2010.
2. Y. Wu, "Lithium-Ion Batteries: Fundamentals and Applications (Electrochemical Energy Storage and Conversion)", CRC Press, 2015,
3. T. M. Letcher, "Storing Energy: with Special Reference to Renewable Energy Sources", Elsevier science, 2016.
4. P. T. Moseley, and J. Garche, "Electrochemical Energy Storage for Renewable Sources and Grid Balancing", Newnes, 2014.
5. D. Wang, and G. Cao, "Nanomaterials for Energy Conversion and Storage", World Scientific Publishing Company, 2017.



One Semester Training



Semester VII/VIII [Fourth year]				Branch: Electrical Engineering			
BTEE-721-18 One Semester Training	Marks					Total Marks	Credits
	Internal				External		
	Mid- semester		End-semester				
Evaluation by	Institute	Industry	Institute	Industry	External Examiner		
Software Training & Project	50	25	50	25	200	500	16
Industrial Training & Project	50	25	50	25			
Total	300				200	500	16

Note: In case a student goes for pre-placement training and such a training could be only software based or only hardware based or a combination of both. The report/evaluation in such a case to be made accordingly.



Semester: VIII

[Fourth Year]



BTEE-801-18	Smart Grids	3L:0T:0P	3 credits
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Internal Marks: 40 External Marks: 60 Total Marks: 100

Course Outcomes:

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

- CO 1** Understand technologies for smart grid.
- CO 2** Appreciate the smart transmission as well distribution systems.
- CO 3** Realize the distribution generation and smart consumption.
- CO 4** Know the regulations and market models for smart grid.

Module 1: Introduction to Smart Grids (8 Hours)

Definition, justification for smart grids, smart grid conceptual model, smart grid architectures, Interoperability, communication technologies, role of smart grids standards, intelli-grid initiative, national smart grid mission (NSGM) by Govt. of India

Module 2: Smart Transmission Technologies (8 Hours)

Substation automation, Supervisory Control and Data Acquisition (SCADA), Energy Management system (EMS), Phasor Measurement Units (PMU), Wide Area Measurement Systems (WAMS)

Module 3: Smart Distribution Technologies (10 Hours)

Distribution automation, outage management systems, Automated Meter Reading (AMR), Automated Metering Infrastructure (AMI), Fault Location Isolation and Service Restoration (FLISR), Outage Management Systems (OMS), Energy storage, Renewable integration

Module 4: Distributed Generation and Smart Consumption (8 Hours)

Distributed Energy Resources (DERs), smart appliances, Low Voltage DC (LVDC) distribution in homes/buildings, Home Energy Management System (HEMS), Net metering, Building to Grid B2G, Vehicle to grid V2G, Solar to grid, Microgrid

Module 5: Regulations and Market Models for Smart Grid (8 Hours)

Demand response, Tariff design, Time of the day pricing (TOD), Time of use pricing (TOU), Consumer privacy and data protection, consumer engagement etc. Cost benefit analysis of smart grid projects.

Text/References:

1. C. W. Gellings, "The Smart Grid, Enabling Energy Efficiency and Demand Side Response", CRC Press, 2009.
2. J. Momoh, "Smart Grid: Fundamentals of Design and Analysis", IEEE Computer Society Press, 2012.
3. E. J. Jenkins, N. Liyanage, K. Wu, and J. Yokoyama, "Smart Grid: Technology and applications", Wiley Publications.
4. J. Momoh, "Smart Grid: Fundamentals of design and analysis", John Wiley & Sons, 2012.
5. T. Flick, and J. Morehouse, "Securing the smart grid: Next generation power grid security", Elsevier, 2010.
6. India smart grid knowledge portal.



BTEE-802-18	Artificial Intelligence Techniques	3L:0T:0P	3 credits
Internal Marks: 40	External Marks: 60	Total Marks: 100	

Course Outcomes:

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

- CO 1** Demonstrate knowledge of the building blocks of AI as presented in terms of intelligent agents.
- CO 2** Develop intelligent algorithms for constraint satisfaction problems and also design intelligent systems for Game Playing
- CO 3** Attain the capability to represent various real life problem domains using logic based techniques and use this to perform inference or planning.

Module 1: Overview of Biological Neurons (8 Hours)

Structure of biological neurons relevant to Artificial Neural Networks (ANN)s. Fundamental concepts of ANN: Models of ANNs; Feed forward & feedback networks; learning rules; Hebbian learning rule, perception learning rule, delta learning rule, Widrow-Hoff learning rule, correction learning rule, Winner-take all learning rule.

Module 2: Single layer Perceptron Classifier (8 Hours)

Classification model, Features & decision regions, training & classification using discrete perceptron, algorithm, and single layer continuous perceptron networks for linearly separable classifications.

Module 3: Single layer Feedback Networks (6 Hours)

Basic Concepts, Hopfield networks, Training & examples. Self-organizing networks: unsupervised learning of clusters, winner-take-all learning, recall mode, Initialization of weights, separability limitations.

Module 4: Multi-layer Feed Forward Networks (8 Hours)

Linearly non-separable pattern classification, Error back-propagation training, learning factors, Examples.

Module 5: Fuzzy Systems (12)

Introduction, need and Advantages of fuzzy-logic based systems over conventional systems. Fuzzy sets, Triangular, trapezoidal, sigma, Zed-Type Gaussian type fuzzy sets/membership function. operations on fuzzy sets: t-norms, s-norms, inverting, Fuzzy relations.

Fuzzification, rule base, rule composition, rule implication, aggregation and defuzzification modules. Defuzzification, weighted average method, centroid /centre of gravity/centre of area method, centre of sums, centre of largest area, max-membership based method, middle (mean) of maxima, first (last) of maxima.

Text/References

1. J. Ross, "Fuzzy logic with Engineering Applications", John Wiley & Sons, 2008.
2. J. Y. R. Langari, "Fuzzy Logic: Intelligence, Control, and Information", Pearson Education, 1999.
3. S. Haykin, "Neural Networks-A Comprehensive Foundation", Macmillan Publishing Co., 2009.
4. Drinnkov, "Fuzzy Logic Control", Narosa Publishers, 2003.
5. P. D. Wasserman, "Neural computing: Theory & Practice", Auza Research Inc. Van Nostrand, 1993.
6. R. C Berkan and S. Truebatch, "Fuzzy system design principles: building if then rule base", John willey, 2000.
7. Michal Negnevitsky, Artificial Intelligence: A Guide to Intelligent Systems, second edition 2008, Pearson Education.
8. Referred journals/peer reviewed conferences (IEEE/Elsevier/Springer). (IEEE/Elsevier/Springer).



BTEE-803-18	Indian Electricity Standards and Practices	3L:1T:0P	4 credits
Internal Marks: 40	External Marks: 60	Total Marks: 100	

Course Outcomes:

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

- CO 1** To know various definitions used in Indian electricity rules
- CO 2** Students will now know how to get a new connection and enhancement or reduction of load, recovery of electricity charges and intervals for billing of electricity charges, disconnection, reconnection and restoration of supply of electricity.
- CO 3** Authority and responsibility associated with power inspectors.

Module 1: Introduction (8 Hours)

Various definitions used in Indian electricity rule 1956 i.e., appointment and authority of Inspectors and officers under government, license and contents of draft license. Service lines and apparatus on consumer's premises. Cut-out on consumer's premises, Identification of earthed and earthed neutral conductors and position of switches and cut-outs, Earthed terminal on consumer's premises, Accessibility of bare conductors, Danger notices, Handling of electric supply lines and apparatus, Cables for portable or transportable apparatus, Cables protected by bituminous materials, Street boxes,.

Module 2: General conditions relating to supply and use of energy (9 Hours)

Testing of consumer's installation, Precautions against leakage before connection, Leakage on consumer's premises, Supply and use of energy, Provisions applicable to medium, high or extra-high voltage installations, Cost of inspection and test of consumer's installation, Declared voltage of supply to consumer, Declared frequency of supply to consumer, Sealing of meters, and cut-outs,

Module 3: Electric supply lines, systems and apparatus for high and extra-high voltages (10 Hours)

Approval by Inspector, Use of energy at high and extra-high voltage, Testing, Operation and Maintenance, Metal sheathed electric supply lines, Connection with earth, General conditions as to transformation and control of energy, Supply to X-ray and high frequency installation.

Module 4: Overhead lines, under-ground cables and generating stations (10 Hours)

Material and strength, Maximum stresses, Clearance above ground of the lowest conductor, Clearance between conductors and trolley wires, Clearances from buildings of low and medium voltage lines and service lines, Clearances from buildings of high and extra-high voltage lines, Conductors at different voltages on same supports, Erection of or alternation to buildings, structures, flood banks and elevation of roads, Clearances, Routes, Maximum interval between supports, Conditions to apply where telecommunication lines and power lines are carried on same supports, Lines crossing or approaching each other, Service-lines from overhead lines

Module 5: Protection (5 Hours)

Earthing, Safety and protective devices, Protection against lightning, Unused overhead lines. Additional rules for electric traction, Introduction to electric supply in mines and oil fields.

Text/References

1. Indian Electricity Rules, 1956, Manak Bhavan, New Delhi.
2. P. S. Satnam, "Substation Design and Practice", Dhanpat Rai and Sons, 2001.



BTEE-811-18	Modelling and Simulation Lab	0L:0T:4P	2 credits
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Internal Marks: 30 External Marks: 20 Total Marks: 50

Course Outcomes:

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

- CO 1** design of primary and secondary transmission systems by analyzing power flows at various point of common couplings through simulations.
- CO 2** to distinguish power flows and conversion systems among HVAC and HVDC systems.

List of Experiments

1. To design a 5-bus transmission system having voltage levels of 220kV by taking appropriate values of different buses.
2. To design a 5-bus transmission system having voltage levels of 133kV by taking appropriate values of different buses.
3. To design a 5-bus transmission system having voltage levels of 66kV by taking appropriate values of different buses.
4. To design a 5-bus transmission system having voltage levels of 11kV by taking appropriate values of different buses.
5. Compute power (P and Q) flows in each line for experiment 1 and analyze the power flow.
6. Design a transmission system delivering a load of 500 MW using HVAC system.
7. Design a transmission system delivering a load of 500 MW using HVDC system.
8. A major project on designing of IEEE 14 bus system.



BTEE-812-18	Technical Report Writing and Presentation	0L:0T:8P	4 credits
Internal Marks: 40	External Marks: 60	Total Marks: 100	

Guidelines:

1. The teaching load of the subject to be equally distributed among all the faculty members of the department.
2. A team of maximum 3 students to write a technical report based on Case Study of an Industry / Industrial project/ Study or implementation of IEEE/IEC/Indian standard / Product design.
3. The report is to be written under the supervision of Faculty member of concerned department, a Co-supervisor from Industry can be taken, if needed. (it should be different from that of the Project-1/Minor project and project-2/major project report.
4. Basic report structure
 - Title page.
 - Summary.
 - Table of contents.
 - Introduction.
 - Body of the report.
 - Conclusions and recommendations.
 - References and appendices.
 - Appendix: Slides of the presentation
5. The presentation of the report is to be made in the Department prior to the External Evaluation.
6. Effort to be made for the publication in Conference/an article in a periodical.



BMPD-801-18	Mentoring and Professional Development of Students	0L:1T:0P	0 credits S/US
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Internal Marks: 50

External Marks: 00

Total Marks: 50

The assigned mentor to engage the students to in activities such as:

- 1) Identification of any one of the local social concern and propose workable solution for it.
- 2) Expert/Invited talk pertaining to recent industrial development.
- 3) Explore scope of self-employment/entrepreneurship.

The mentor to keep record of all activities (including those mentioned above) and assign internal marks accordingly.

List of e-books for Under Graduate programme of (Electrical Engineering/Electrical and Electronics Engineering/Electronics and Electrical Engineering).

Title	Author(s)	Publisher
Control Systems, 2nd ed	Anand Kumar	PHI Learning
Advanced Control Systems	Sarkar	PHI Learning
Analog And Digital Communications	TI Singal	Tata McGraw-Hill Education Private Ltd
Analog Communication	Ramakishna Rao	Tata McGraw-Hill Education Private Ltd
Basic Electrical & Electronics Engineering	Muthusubramanian	Tata McGraw-Hill Education Private Ltd
Basic Electrical And Electronic Eng I	Chakrabarti	Tata McGraw-Hill Education Private Ltd
Basic Electrical And Instrumentation Engineering	Salivahnan	Tata McGraw-Hill Education Private Ltd
Basic Electrical Engineering, 3/E	Kothari	Tata McGraw-Hill Education Private Ltd
Basic Electrical, Electronics And Measurement Engineering (Au)	Salivahnan	Tata McGraw-Hill Education Private Ltd
Basic Electronics And Devices Jntu 2018	Salivahan	Tata McGraw-Hill Education Private Ltd
Circuit Analysis	Nagoorkani	Tata McGraw-Hill Education Private Ltd
Circuit Theory (Au 2016)	Nagoorkani	Tata McGraw-Hill Education Private Ltd
Circuit Theory (Au)	Nagoorkani	Tata McGraw-Hill Education Private Ltd
Circuit Theory And Networks	Sp Gosh And Ak Chakraborty	Tata McGraw-Hill Education Private Ltd
Circuit Theory And Networks (MU 2018)	Singh	Tata McGraw-Hill Education Private Ltd
Circuit Theory: Continuous and Discrete-time Systems Elements of Network Synthesis	Kuriakose	PHI Learning
Computer Techniques In Power System Analysis	Pai	Tata McGraw-Hill Education Private Ltd
Control Engineering: Theory and Practice	Bandyopadhyay	PHI Learning
Control System Components	Desai	PHI Learning
Control Systems Wbut Jun'13	Purkait	Tata McGraw-Hill Education Private Ltd
Digital Communication	P Ramakrishna Rao	Tata McGraw-Hill Education Private Ltd
Digital Electronics - Au 2018	Mandal	Tata McGraw-Hill Education Private Ltd
Digital Image Processing	Jayaraman, S.	Tata McGraw-Hill Education Private Ltd

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Title	Author(s)	Publisher
Digital Signal Processing	Salivahanan	Tata McGraw-Hill Education Private Ltd
Digital Signal Processors	Venkataramani	Tata McGraw-Hill Education Private Ltd
Electric Drives: Concepts & Appl, 2/E	Subrahmanyam	Tata McGraw-Hill Education Private Ltd
Electric Machines	Kothari	Tata McGraw-Hill Education Private Ltd
Electric Power Distribution	Pabla	Tata McGraw-Hill Education Private Ltd
Electrical Cir Ana-I JNTUK14	Sudhakar	Tata McGraw-Hill Education Private Ltd
Electrical Circuit Analysis (Jntu)	Sudhakar, A.	Tata McGraw-Hill Education Private Ltd
Electrical Circuit Analysis, 2nd ed.	Mahadevan & Chitra	PHI Learning
Electrical Circuit Analysis, 2nd ed.	Mahadevan & Chitra	PHI Learning
Electrical Machines	Chakrabarti	Tata McGraw-Hill Education Private Ltd
Electrical Machines	Bhattacharya, S. K.	Tata McGraw-Hill Education Private Ltd
Electrical Machines	Bhattacharya, S. K.	Tata McGraw-Hill Education Private Ltd
Electrical Machines, 3/E	Bhattacharya, S. K.	Tata McGraw-Hill Education Private Ltd
Electrical Networks	Singh, Ravish	Tata McGraw-Hill Education Private Ltd
Electrical Power Distribution Systems	Kamaraju	Tata McGraw-Hill Education Private Ltd
Electronic Circuits - 1 - Au 2018	Salivahanan	Tata McGraw-Hill Education Private Ltd
Electronic Circuits I - Au'15	Salivahanan	Tata McGraw-Hill Education Private Ltd
Electronic Devices & Circuit Jntu A 2014	Salivahanan	Tata McGraw-Hill Education Private Ltd
Electronic Devices And Circuits	Salivahanan	Tata McGraw-Hill Education Private Ltd
Electronic Devices And Circuits	Venkata Rao	Tata McGraw-Hill Education Private Ltd
Electronic Devices And Circuits Jntu 2018	Salivahnan	Tata McGraw-Hill Education Private Ltd
Electronic Instrumentation, 3e	Kalsi	Tata McGraw-Hill Education Private Ltd
Electronic Principles, 7/E	Malvino	Tata McGraw-Hill Education Private Ltd

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Title	Author(s)	Publisher
Handbook Of Switchgears	Bhel	Tata McGraw-Hill Education Private Ltd
High Voltage Engineering	Naidu	Tata McGraw-Hill Education Private Ltd
Hvdc Transmission	Kamakshaiah	Tata McGraw-Hill Education Private Ltd
Instrumentation And Control Systems	Raju	Tata McGraw-Hill Education Private Ltd
Introduction to Electrical Engineering	Ganguly	PHI Learning
Linear IC Applications	Salivahnan	Tata McGraw-Hill Education Private Ltd
Linear Integrated Circuits	Salivahanan	Tata McGraw-Hill Education Private Ltd
Microprocessors And Microcontrollers	Nagoorkani	Tata McGraw-Hill Education Private Ltd
Microwave Engineering	Vasuki	Tata McGraw-Hill Education Private Ltd
Microwave Engineering	Das, Annapurna	Tata McGraw-Hill Education Private Ltd
Modern Control Engineering	Roy Choudhury	PHI Learning
Modern Digital Electronics, 4/E	Jain	Tata McGraw-Hill Education Private Ltd
Modern Power System Analysis	Kothari, Nagrath	Tata McGraw-Hill Education Private Ltd
Network Analysis & Synth	Ghosh	Tata McGraw-Hill Education Private Ltd
Network Analysis and Synthesis	Anand Kumar	PHI Learning
Network Analysis and Synthesis	Anand Kumar	PHI Learning
Network Theory (Bput)	Satpathy, P. K.	Tata McGraw-Hill Education Private Ltd
Power Electronics	Hart, Daniel	Tata McGraw-Hill Education Private Ltd
Power Electronics	Asghar	PHI Learning
Power Electronics	Singh	Tata McGraw-Hill Education Private Ltd
Power Electronics, 1e	Soumitra Kumar Mandal	Tata McGraw-Hill Education Private Ltd
Power Electronics: Devices and Circuits, 2nd ed.	Jagannathan	PHI Learning
Power System Engineering	Kothari	Tata McGraw-Hill Education Private Ltd

List of e-books for Under Graduate programme of (Electrical Engineering/Electrical and Electronics Engineering/Electronics and Electrical Engineering).

Title	Author(s)	Publisher
Power System Protection & Switchgear	Oza	Tata McGraw-Hill Education Private Ltd
Power System Protection And Switchgear	Badri Ram, Dn Vishwakarma	Tata McGraw-Hill Education Private Ltd
Principles of Electronics	Ganguly	PHI Learning
Renewable Energy Sources: Their Impact on Global Warming and Pollution	Abbasi & Abbasi	PHI Learning
Signals & Systems 2e	Nagrath	Tata McGraw-Hill Education Private Ltd
Signals And Systems	Nagoor Kani, A.	Tata McGraw-Hill Education Private Ltd
Signals And Systems	Nagoorkani	Tata McGraw-Hill Education Private Ltd
Theory and Problems of Basic Electrical Engineering, 2nd ed.	Kothari & Nagrath	PHI Learning
Training Manual For Industrial Training Institutes And Centres	Dge&T	Tata McGraw-Hill Education Private Ltd
Transformers	Bhel	Tata McGraw-Hill Education Private Ltd
VLSI Design	Sahu	Tata McGraw-Hill Education Private Ltd

Procedure for (a) Minor Degree (b) Honors Degree

- (a) Student to opt for Minor degree in relevant programme in 3rd semester
- (b) Students having no backlog up till 3rd/4th Semester will be eligible for opting for Honors Degree in the relevant Programme in the 5th Semester.

From the available relevant on-line SWAYAM/ MOOCS courses for the session, the list of the courses to be considered for Minor degree/Honors degree in relevant programme to be approved by BoS.

The number of credits for SWAYAM/MOOCS courses for Minor degree in in relevant programme to be as per the credits mentioned on the certificate of the respective SWAYAM/ MOOCS course.

The following step are proposed to be followed for credits earned through SWAYAM/MOOCS courses:

- i) For each semester the student to take up online SWAYAM/MOOCS courses approved by the BoS.
- ii) Take permission (written) from Institute/Department for registration.
- iii) On successful completion of each SWAYAM/MOOCS in each semester the student to submit self-attested copy of certificate (on-line/hard) to Institute/ Department.
- iv) The Institute/Department to verify the certificate and there after Institute/ Department to convey to the Examination Branch through the office of Dean Academics.
- v) On obtaining the minimum credits the student will be eligible for Minor Degree in relevant programme.

In case of non-availability of SWAYAM/MOOCS courses the student can earn the minimum credits for (a) Minor Degree from Professional Core / Elective Courses (b) Honors degree from Professional Elective Courses other than those taken up for the concerned B.Tech Programme

The list of (i) Professional Core Courses (ii) Professional Elective Courses, clearly indicating odd and even semester is available in the Teaching Scheme.