Autonomy Curriculum
For
B. TECH DEGREE COURSE
In
Applied Electronics and Instrumentation Engineering

(NBA Accredited-Tier-1)

(Applicable for the Batch 2024-2028)

Haldia Institute of Technology

An Autonomous Institute, NAAC Accredited Grade 'A' Institute

Approved by: All India Council for Technical Education (AICTE)

Affiliated to: Maulana Abul Kalam Azad University of Technology (MAKAUT), West Bengal

Haldia, Purba Medinipur, West Bengal, India, 721657

Department of Applied Electronics and Instrumentation Engineering

General, Course structure & Theme
&
Semester-wise credit distribution

A. Definition of Credit:

1 Hr. Lecture (L) per week	1 credit
1 Hr. Tutorial (T) per week	1 credit
1 Hr. Practical (P) per week	0.5 credits
2 Hours Practical (Lab) per week	1 credit

B. Range of credits -A range of credits from 150 to 160 for a student to be eligible to get Under Graduate degree in Engineering. A student will be eligible to get Under Graduate degree with Honours or additional Minor Engineering, if he/she completes an additional 20 credits. These could be acquired through MOOCs.

C. Structure of Undergraduate Engineering program :

Sl.	No. Topic	Breakup of Credits	
		AEIE Curriculum	As per AICTE
1	Humanities and Social Sciences including Management	9	12
2	Basic Sciences	25	25
3	Engineering Sciences including workshop, drawing, basics of electrical/mechanical/computer etc.	21	24
4	Professional Core Subjects	55	48
5	Professional Subjects: Subjects relevant to chosen specialization/branch	18	18
6	Open Subjects: Electives from other technical and/or emerging subjects	16.5	18
7	Project work, seminar and internship in industry or else where	15.5	15
8	Mandatory Courses [Environmental Sciences, Induction Program, Indian Constitution, Essence of Indian Traditional Knowledge]	Non-credit	Non-credit
	Total	160	160*

Haldia Institute of Technology
Department of Applied Electronics and Instrumentation Engineering

Details Course Structure

Course code and definition:

Course code	Definitions
L	Lecture
T	Tutorial
P	Practical
HS	Humanities & Social Science Courses
BS	Basic Science Courses
ES	Engineering Science Courses
PC	Program Core Courses
PE	Program Elective Courses
OE	Open Elective Courses
MC	Mandatory Courses
PW	Project/ Internship/Seminar

BASIC SCIENCE COURSES

Sr. No.	Course code	Course Title	Hours / Week L:T:P	Credit	Preferred Semester
1	BS-M 101	Mathematics-I	3-1-0	4	**I**
2	BS-PH 101	Physics-I	3-1-3	5.5	**I**
3	BS-BT 101/	Biology for Engineers	2-0-0	2	**I**
4	BS-CH 201	Chemistry-I	3-1-3	5.5	**II**
5	BS-M 201	Mathematics-II	3-1-0	4	**II**
6	BS-M 301	Mathematics-III	2-1-0	3	**III**
7	BS-M 391	Numerical Methods Lab	0-0-2	1.0	**III**
Total (25 max)				**25**	

ENGINEERING SCIENCE COURSES

Sr. No.	Course code	Course Title	Hours / Week L:T:P	Credit	Preferred Semester
1	ES-EE 101	Basic Electrical & Electronics Engg.	3-1-3	5.5	I
2	ES-ME 191	Workshop Practice	0-0-3	1.5	I
3	ES-CS 201	Computer Programming for Problem solving	3-1-3	5.5	II
4	ES-ME 291	Engineering Drawing	0-0-3	1.5	II
5	ES-EI 401	Electromagnetic Theory	3-0-0	3	**IV**
6	ES-EI 501	Data Structure & Algorithm	3-0-2	4.0	V
Total (24 max)				**21.0**	

Haldia Institute of Technology
Department of Applied Electronics and Instrumentation Engineering

Details Course Structure

HUMANITIES & SOCIAL SCIENCES INCLUDING MANAGEMENT

Sr. No.	Course code	Course Title	Hours / Week L:T:P	Credit	Preferred Semester
1	HM-HU 201	English Communication	2-0-2	3	II
2	HSMC 201	Values and Ethics in Profession	2-0-0	2	II
3	HM-HU 401	Economics For Engineers	3-0-0	2	IV
4	HM-HU 801	Project Management and entrepreneurship	2-0-0	2	VIII
Total (12 max)				**9**	

MANDATORY COURSES

Sr. No.	Course code	Course Title	Hours / Week L:T:P	Credit	Preferred Semester
	XC-181	Extra-Curricular Activity (NSS, etc.)XC-181	0-0-2	NIL	I
1	MC-ES 301	Environmental Sciences,	2-0-0	NIL	III
2	MC-ES 501	Indian Constitution And Culture	1-0-0	NIL	V
		Total		**0**	

PROFESSIONAL CORE COURSES

Sr. No.	Course code	Course Title	Hours / Week L:T:P	Credit	Preferred Semester
1	PC-EI 301	Circuit Theory and Network Analysis	2-1-3	4.5	**III**
2	PC-EI 302	Sensors & Transducers	3-0-3	4.5	**III**
3	PC-EI 303	Analog Electronic Circuits	3-1-3	5.5	**III**
4	PC-EI 304	Digital Electronic Circuits	3-1-3	5.5	**III**
5	PC-EI 401	Electrical & Electronic Measurements	3-1-3	5.5	**IV**
6	PC-EI 402	Microprocessors & Microcontroller	3-1-3	5.5	**IV**
7	PC-EI 403	Control System	3-1-3	5.5	**IV**
8	PC-EI 501	Industrial Instrumentation	3-1-3	5.5	**V**
9	PC-EI 502	Process Control	3-1-3	5.5	**V**
10	PC-EI 503	Electrical Machine	3-0-0	3	**V**
11	PC-EI 593	Instrumentation System and Product Development Lab	0-0-3	1.5	**V**
12	PC-EI 601	Plant Instrumentation and Control	3-0-0	3	**VI**
Total (48 max)				**55**	

PROFESSIONAL ELECTIVE COURSES OFFERED

Sr. No.	Course code	Course Title	Hours / Week L:T:P	Credit	Preferred Semester
1	PE-EI 401	Professional Elective Course-**I**	3-0-0	3	**IV**
2	PE-EI 501	Professional Elective Course-II	3-0-0	3	V
3	PE-EI 502	Professional Elective Course-III	3-0-0	3	**V**
4	PE-EI 601	Professional Elective Course-IV	3-0-0	3	**VI**
5	PE-EI 602	Professional Elective Course-V	3-0-0	3	**VI**
6	PE-EI 701	Professional Elective Course-VI	3-0-0	3	**VII**
Total (18)				**18**	

OPEN ELECTIVE COURSES OFFERED

Sr. No.	Course code	Course Title	Hours / Week L:T:P	Credit	Preferred Semester
1.	OE-EI 601	Open Elective Course-I	3-0-3	4.5	**VI**
2.	OE-EI 602	Open Elective Course-II	3-0-3	4.5	VI
3.	OE-EI 603	Open Elective Course-III	3-0-3	4.5	**VI**
4.	OE-EI 701	Open Elective Course-IV	3-0-0	3	**VII**
Total (18 max)				**16.5**	

PROJECT WORK, SEMINAR AND INTERNSHIP

Sr. No.	Course code	Course Title	Hours / Week L:T:P	Credit	Preferred Semester
1.	PW-EI 481	Micro Project	0-0-2	1.0	**IV**
2.	PW-EI 681	Seminar	0-0-3	1.5	VI
3.	PW-EI 682	Mini Project	0-0-4	2.0	**VI**
4.	PW-EI 781	Design Project-I	0-0-6	**3**	VII
5.	PW-EI 782	Industrial Training Evaluation (Minimum duration of 1 month internship in industry)		2.0	**VII**
6.	PW-EI 881	Design Major Project * or Start-UP or 6-Month Research in Industry/ Other Academic or Research Institute*	0-0-10	5.0	VIII
7.	PW-EI 882	Internship		1.0	VIII
Total (15 max)				**15.5**	

Haldia Institute of Technology
Department of Applied Electronics and Instrumentation Engineering

Details Course Structure

SEMESTER - I

THEORY

Sr. No.	Categories	Course code	Course Title	Hours / Week L:T:P	Credit
1	Basic Science	BS-M 101	Mathematics-I	3-1-0	4
2		BS-PH 101	Physics-I	3-1-0	4
3	Engineering Science	ES-EE-101	Basic Electrical & Electronics Engineering	3-1-0	4
4	Basic Science	BS-BT 101	Biology for Engineers	3-0-0	2
Total				**14**	**14**

PRACTICAL

Sr. No.	Categories	Course code	Course Title	Hours / Week L:T:P	Credit
5	Basic Science	BS-PH 191	Physics Lab-I	0-0-3	1.5
6	Engineering Science	ES-EE-191	Basic Electrical & Electronics Engineering. Lab	0-0-3	1.5
7	Engineering Science	ES-ME 191	Workshop Practice	0-0-3	1.5
Total				**9**	**4.5**

SESSIONAL

Sr. No.	Categories	Course code	Course Title	Hours / Week L:T:P	Credit
7	Basic Science	XC-181	Extra-Curricular Activity (NSS, etc.)	0-0-2	0.0

SEMESTER - II

THEORY

Sr. No.	Categories	Course code	Course Title	Hours / Week L:T:P	Credit
1	Basic Science	BS-M 201	Mathematics-II	3-1-0	4
2		BS-CH 201	Chemistry-I	3-1-0	4
3	Engineering Science	ES-CS 201	Computer Programming for Problem solving	3-1-0	4
4	Humanities	HM-HU 201	English Language and Technical Communication	2-0-0	2
5		HS-MC 201	Values Ethics and Indian Knowledge System	2-0-0	2
Total				**16**	**16**

PRACTICAL

Sr. No.	Categories	Course code	Course Title	Hours / Week L:T:P	Credit
6	Basic Science	BS-CH 291	Chemistry Lab-I	0-0-3	1.5
7	Engineering Science	ES-CS 291	Computer Programming Lab	0-0-3	1.5
8		ES-ME 291	Engineering Drawing	0-0-3	1.5
9	Humanities	HM-HU 291	English Language and Technical Communication Lab	0-0-2	1.0
Total				**11**	**5.5**

First Year Total	**50**	**40**

Haldia Institute of Technology
Department of Applied Electronics and Instrumentation Engineering

Details Course Structure

SEMESTER - III

THEORY

Sr. No.	Categories	Course code	Course Title	Hours / Week L:T:P	Credit
1	Basic Science	BS-M 301	Mathematics -III	2-1-0	3
2	Professional Core	PC-EI 301	Circuit Theory and Network Analysis	2-1-0	3
3		PC-EI 302	Sensors & Transducers	3-0-0	3
4		PC-EI 303	Analog Electronic Circuits	3-1-0	4
5		PC-EI 304	Digital Electronic Circuits	3-1-0	4
6	Mandatory Course	MC-ES 301	Environmental Science	2-0-0	0
Total				**19**	**17**

PRACTICAL

Sr. No.	Categories	Course code	Course Title	Hours / Week L:T:P	Credit
7	Professional Core	PC-EI 391	Circuit Theory Lab	0-0-3	1.5
8		PC-EI 392	Sensors &Transducers Lab	0-0-3	1.5
9		PC-EI 393	Analog Electronics Lab	0-0-3	1.5
10		PC-EI 394	Digital Electronics Lab	0-0-3	1.5
11	Basic Science	BS-M 391	Numerical Methods Lab	0-0-2	1.0
Total				**14**	**7.0**

3rd Semester Total Hour & Credit	**33**	**24**

SEMESTER -IV

THEORY

Sr. No.	Categories	Course code	Course Title	Hours / Week L:T:P	Credit
1	Professional Core	PC-EI 401	Electrical & Electronic Measurements	3-1-0	4
2		PC-EI 402	Microprocessors & Microcontroller	3-1-0	4
3		PC-EI 403	Control System	3-1-0	4
4	Engineering Science	ES-EI 401	Electromagnetic Theory	3-0-0	3
5	Professional Elective Course-**I**	PE-EI 401	Professional Elective Course-**I** PE.I	3-0-0	3
6	Humanities	HM-HU 401	Economics For Engineers	2-0-0	2
Total				**20**	**20**

PRACTICAL

Sr. No.	Categories	Course code	Course Title	Hours / Week L:T:P	Credit
7	Professional Core	PC-EI 491	Electrical & Electronic Measurements Lab	0-0-3	1.5
8		PC-EI 492	Microprocessors & Microcontroller Lab	0-0-3	1.5
9	Professional Core	PC-EI 493	Control System Lab	0-0-3	1.5
10	Project Work	PW-EI 481	Micro Project	0-0-2	1.0
Total				**11**	**5.5**

4th Semester Total Hour & Credit	**31**	**25.5**

2nd Year Total	**64**	**49.5**

SEMESTER - V

THEORY

Sr. No.	Categories	Course code	Course Title	Hours / Week L:T:P	Credit
1	Professional Core	PC-EI 501	Industrial Instrumentation	3-1-0	4
2		PC-EI 502	Process Control	3-1-0	4
3		PC-EI 503	Electrical Machine	3-0-0	3
4	Engineering Science	ES-EI 501	Data Structure & Algorithm	3-0-0	3
5	Professional Elective Course-II	PE-EI 501	Professional Elective Course-II PE.II	3-0-0	3
6	Professional Elective Course-III	PE-EI 502	Professional Elective Course-III PE.III	3-0-0	3
7	Mandatory Course	MC-ES 501	Indian Constitution And Culture	1-0-0	0
Total				**21**	**20**

PRACTICAL

Sr. No.	Categories	Course code	Course Title	Hours / Week L:T:P	Credit
8	Professional Core	PC-EI 591	Industrial Instrumentation Lab	0-0-3	1.5
9		PC-EI 592	Process Control Lab	0-0-3	1.5
10		PC-EI 593	Instrumentation System and Product Development Lab	0-0-3	1.5
11	Engineering Science	ES-EI 591	Data Structure & Algorithm Lab	0-0-2	1.0
Total				**11**	**5.5**

5th Semester Total Hour & Credit	**32**	**25.5**

SEMESTER -VI

THEORY

Sr. No.	Categories	Course code	Course Title	Hours / Week L:T:P	Credit
1	Professional Core	PC-EI 601	Plant Instrumentation and Control	3-0-0	3
2	Professional Elective Course-IV	PE-EI 601	Professional Elective Course-IV PE.IV	3-0-0	3
3	Professional Elective Course-V	PE-EI 602	Professional Elective Course-V PE.V	3-0-0	3
4	Open Elective Course-I	OE-EI 601	Open Elective Course-I OE.I	3-0-0	3
5	Open Elective Course-II	OE-EI 602	Open Elective Course-II OE.II	3-0-0	3
6	Open Elective Course-III	OE-EI 603	Open Elective Course-III OE.III	3-0-0	3
Total				**18**	**18**

PRACTICAL& SESSIONAL

Sr. No.	Categories	Course code	Course Title	Hours / Week L:T:P	Credit
7	Open Elective Course-I	OE-EI 691A/ OE-EI 691B	Internet of Things (IoT) Lab/Data Analysis for Instrumentation System & AI Lab	0-0-3	1.5
8	Open Elective Course-II	OE-EI 692A/ OE-EI 692B	Object Oriented Programming Lab/Data Base Management System Lab	0-0-3	1.5
9	Open Elective Course-III	OE-EI 693A/ OE-EI 693B	Advance Microcontroller Lab/ VLSI & Microelectronics Lab	0-0-3	1.5
10	Seminar	PW-EI 681	Seminar	0-0-3	1.5
11	Project Work	PW-EI 682	Mini Project	0-0-4	2.0
Total				**16**	**8.0**

6th Semester Total Hour & Credit	**34**	**26.0**

3rd Year Total Hour & Credit	**64**	**51.5**

SEMESTER - VII

THEORY

Sr. No.	Categories	Course code	Course Title	Hours / Week L:T:P	Credit
1	Professional Elective Course-VI	PE-EI 701	Professional Elective Course-VI PE.VI	3-0-0	3
2	Open Elective Course-IV	OE-EI 701	Open Elective Course-IV OE.IV	3-0-0	3
Total				**6**	**6**

PRACTICAL & SESSIONAL

Sr. No.	Categories	Course code	Course Title	Hours / Week L:T:P	Credit
3	Project Work	PW-EI-781	Design Project-I	0-0-6	**3**
4	Industrial Training	PW-EI-782	Industrial Training Evaluation (Minimum duration of 1 month internship in industry)	-	2.0
Total				**6**	**5.0**

7^{th} Semester Total Hour & Credit	**12**	**11**

SEMESTER - VIII

THEORY

Sr. No.	Categories	Course code	Course Title	Hours / Week L:T:P	Credit
1	Humanities	HM-HU 801	Project Management and Entrepreneurship	2-0-0	2
Total				**2**	**2**

PRACTICAL & SESSIONAL

Sr. No.	Categories	Course code	Course Title	Hours / Week L:T:P	Credit
1	Project Work	PW-EI881	Design Major Project (or Start-UP or 6-Month Research in Industry/ Other Academic or Research Institute	0-0-10	5.0
2	Internship	PW-EI882	Internship		1.0
Total				**12**	**6.0**

8th Semester Total Hour & Credit	**14**	**8**

4th Year Total Hour & Credit	**26**	**19**

Haldia Institute of Technology
Department of Applied Electronics and Instrumentation Engineering

Details Course Structure

Professional Elective Basket

Professional Elective	Paper Code	Paper Name	L-T-P
PE.I Professional Elective Course-I	PE-EI 401A	Signals and Systems	3-0-0
	PE-EI 401B	Computer Organisation and Architecture	3-0-0
PE.II Professional Elective Course-II	PE-EI 501A	Optical Instrumentation	3-0-0
	PE-EI 501B	Advanced Sensors	3-0-0
PE.III Professional Elective Course-III	PE-EI 502A	Analog and digital Communication	3-0-0
	PE-EI 502B	Telemetry & Wireless Sensor Network	3-0-0
PE.IV Professional Elective Course-IV	PE-EI 601A	Biomedical and Analytical Instrumentation	3-0-0
	PE-EI 601B	Advanced Control System	3-0-0
PE.V Professional Elective Course-V	PE-EI 602A	Power Electronics	3-0-0
	PE-EI 602B	Nano Electronics	3-0-0
PE.VI Professional Elective Course-VI	PE-EI 701A	Renewable Energy Sources	3-0-0
	PE-EI 701B	Non Destructive Testing	3-0-0
	PE-EI 701C	Electric Vehicle	3-0-0

Open Elective Basket

Open Elective	Paper Code	Paper Name	L-T-P
OE.I Open Elective Course-I	OE-EI 601A	Computer Networking and Internet of Things (IoT)/	3-0-3
	OE-EI 601B	Data Analysis for Instrumentation System & AI	3-0-3
OE.II Open Elective Course-II	OE-EI 602A	Object Oriented Programming	3-0-3
	OE-EI 602B	Data Base Management System	3-0-3
OE.III Open Elective Course-III	OE-EI 603A	Embedded System	3-0-3
	OE-EI 603B	VLSI & Microelectronics	3-0-3
OE.IV Open Elective Course-IV	OE-EI 701A/	Micro Electro Mechanical Systems (MEMS)/	3-0-0
	OE-EI 701B	Mechatronics	3-0-0

Mathematics III

Course Name: **Mathematics III**	**Category: Basic Science Course**
Course Code: BS-M301	**Semester: 3rd**
L-T-P: 3-0-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
Tutorial: 1 Hrs	End Semester Exam.: 70 Marks
Total Lectures: 36 Hrs	

Pre-Requisites:
Engineering Mathematics-I(Calculus, Matrix)
Engineering Mathematics-II(Differential Equation, Laplace Transform)

Course Outcomes (COs):

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

CO1: **Apply** the fundamental concepts of probability, including Bayes theorem, and analyze the characteristics, expectation, and inequalities (like Chebyshev's) of discrete and continuous random variables and their distributions (e.g., normal, exponential, gamma).

CO2: Analyze and **interpret** data statistics using measures of central tendency, dispersion, moments, skewness, Kurtosis, correlation, and regression, and utilize the method of least squares for curve fitting.

CO3: Determine the Fourier Series for various periodic functions (including special waveforms and half-range functions) by **applying** Euler's formulae and **analyze** their convergence, aiding in basic signal processing applications.

CO4: Compute the Fourier Transform, Fourier Cosine Transform, and Fourier Sine Transform of functions, and **apply** their key properties (linearity, shifting, scaling, modulation) and the Convolution Theorem to **solve** relevant engineering problems.

CO5: Explain the sources of errors in numerical computation and **apply** various interpolation techniques such as Newton forward/backward, Lagrange's, and Newton's divided difference methods to approximate function values.

CO6: Solve problems involving numerical integration using the Trapezoidal and Simpson's 1/3 rules, find roots of equations using Bisection, Regula-Falsi, and Newton-Raphson methods, and approximate solutions to Ordinary Differential Equations (ODEs) using Euler's and Runge-Kutta methods.

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Fundamentals of Probability:**	**CO1**
	Probability spaces, conditional probability, independence; Bayes theorem. Discrete random variables, Independent random variables, the multinomial distribution, Poisson approximation to the binomial distribution infinite sequences of Bernoulli trials, sums of independent random variables; Expectation of Discrete Random Variables, Chebyshev's Inequality. Continuous random variables and their properties, distribution and density functions, normal, exponential and gamma densities.	**8**
Module: 2	**Data Statistics:**	**CO2**
	Basic Statistics, Measures of Central tendency, measures of dispersions: Moments, skewness and Kurtosis, Correlation and regression – Rank correlation. Curve fitting by the method of least squares- fitting of straight lines, second degree parabolas and more general curves. **Mini Project:** Analysis of Traffic Patterns, Analysis of Health Data.	**6**
Module: 3	**Fourier Series**:	**CO3**
	Periodic functions: Properties, Even & Odd functions: Properties, Special wave forms: Square wave, Half wave Rectifier, Full wave Rectifier, Saw-toothed wave, Triangular wave. Euler's Formulae for Fourier Series, Fourier Series for functions of period 2l, Dirichlet's conditions, Sum of Fourier series. Theorem for the convergence of Fourier Series (Without Proof). Fourier Series of a function with its periodic extension. Half Range Fourier Series: Construction of Half range Sine and Cosine Series. Parseval's identity (Without Proof). **Mini Project**: Application in the domain of sound signal processing and biomedical signal processing, pattern recognition of basic signal, denoising of signals.	**6**
Module: 4	**Fourier Transform:**	**CO4**
	Fourier Integral Theorem (statement only), Fourier Transform of a function, Fourier Cosine & Sine Transforms. Fourier, Cosine & Sine Transforms of elementary functions. Properties of Fourier Transform: Linearity, Shifting, Change of scale, Modulation and applications. Fourier Transform of Derivatives. Convolution Theorem (statement only), Inverse of Fourier Transform.	**4**
Module:	**Numerical Methods-I**	**CO5**

5	Approximation in numerical computation, Truncation and rounding errors, Fixed and floating-point arithmetic. Calculus of finite differences, Newton forward/backward interpolation, Lagrange's and Newton's divided difference Interpolation.	**6**
Module: 6	**Numerical Methods-II**	**CO6**
	Trapezoidal rule, Simpson's 1/3 rule, Expression for corresponding error terms. Bisection method, Regula-Falsi method, Newton-Raphson method. Euler's, Modified Euler's and Runge-Kutta methods for solving ODE. **Mini Project:** Approximate solutions to the initial value problem using Euler's Method, the Improved Euler's Method, and the Runge-Kutta Method. Initial Value Problem.	**6**
	Total	**36**

Suggested Text/Reference Books:

1. Reena Garg, Chandrika Prasad, Advanced Engineering Mathematics, Khanna Publishers.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.
3. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers.
4. Michael Greenberg, Advanced Engineering Mathematics, Pearson.
5. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi.
6. A. Gupta, Groundwork of mathematical probability and statistics. Academic publishers.
7. Murray R Spiegel, Larry J. Stephens, Narinder Kumar. Statistics (Schaum's Outline Series), McGraw Hill Education.
8. N.G. Das, Statistical Methods (Combined Volume), Tata-McGraw Hill.
9. Gupta & Kapoor, Fundamentals of Mathematical Statistics, Gupta (Sultan Chand & Sons).
10. Jain, Iyengar, & Jain: Numerical Methods (Problems and Solution).
11. S.A.Mollah, Numerical Analysis and Computational Procedures. Books & Allied Ltd

CO-PO-PSO Mapping:

BS-M 301											
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
CO.1	3	3	2	2	1	1	-	-	-	-	1
CO.2	3	3	2	2	1	1	-	-	-	-	1
CO.3	3	3	3	3	2	2	1	-	-	1	2
CO.4	3	3	3	3	2	2	1	1	1	1	2
CO.5	3	3	3	3	2	2	1	1	1	1	2
CO.6	3	3	3	3	2	2	1	1	1	1	2

BS-M 301			
CO	**PSO1**	**PSO2**	**PSO3**
CO.1.	3	3	2
CO.2.	3	3	2
CO.3.	3	3	3
CO.4.	3	3	3
CO.5.	3	3	3
CO.6.	3	3	3

Circuit Theory and Network Analysis

Course Name: Circuit Theory and Network Analysis	**Category:** Professional Core
Course Code: PC-EI 301	**Semester:** 3^{rd}
L-T-P: 2-1-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
Tutorial: 1 hr	End Semester Exam.: 70 Marks
Total Lectures: 42	

Pre-Requisites:

To ensure effective learning and comprehension of the concepts in Circuit Theory and Network Analysis, students are expected to have foundational knowledge and skills in the following areas:

- Knowledge of matrix, KCL, KVL, Laplace Transformation (basic level) and concept of Resistance, Inductor, Capacitor.

Objectives:

This course aims to introduce with the time domain and frequency domain analysis of various electrical circuits for real time uses and also helps to solve complex networks in simpler way.

The subject aims to encourage the students with the followings:-

- **To introduce the fundamental concepts of electrical circuits and their classifications**, including network elements, source types, and basic laws used in circuit analysis.
- **To develop analytical skills using network theorems** for solving electrical networks with both independent and dependent sources in DC and AC domains.
- **To impart knowledge of transient and frequency domain analysis**, emphasizing Laplace Transform techniques for solving dynamic electrical circuits.
- **To familiarize students with graph theory as a tool** for modelling and analyzing electrical circuits using incidence, tie-set, and cut-set matrices.
- **To enable students to understand and evaluate two-port network parameters** and their applications in analyzing interconnected networks.
- **To equip students with the ability to design and analyze analog filters**, focusing on low-pass, high-pass, band-pass, and band-reject filters using operational amplifiers.

Course Outcomes (COs):

On completion of this course, the student will be able to

PC-EI 301.1. **Classify** electrical networks and **analyse** circuits using Kirchhoff's laws and basic reduction techniques
*(Cognitive Level: **Understand, Apply, Analyze**, Knowledge Category: **Conceptual, Procedural**)*

PC-EI 301.2. **Solve** DC and AC circuits using network theorems and **analyse** magnetically coupled circuits.
*(Cognitive Level: **Apply, Analyze, Evaluate**, Knowledge Category: **Conceptual,Procedural**)*

PC-EI 301.3. Analyse transient behaviour and apply Laplace Transform for circuit analysis in time and frequency domains.
*(Cognitive Level: **Understand, Apply, Analyze**, Knowledge Category: **Conceptual, Procedural**)*

PC-EI 301.4. Apply graph theory to develop and solve electrical network models using matrix representations.
*(Cognitive Level: **Apply, Analyze**, Knowledge Category: **Conceptual, Procedural**)*

PC-EI 301.5. Determine and interpret two-port network parameters for various configurations.
*(Cognitive Level: **Understand, Apply, Analyze**, Knowledge Category: **Conceptual, Procedural**)*

PC-EI 301.6. Design and analyse active analog filters using operational amplifiers.
*(Cognitive Level: **Apply, Create**, Knowledge Category: **Conceptual,Procedural**)*

Syllabus Details

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Module Name: Introduction to electrical circuits**	**CO1**
	Electrical Circuit and Network: Concept and Terminology, Classification of electrical networks- Linear and Nonlinear, Bilateral vs. Unilateral, Lumped and Distributed, Passive and Active network, R-L-C Parameters, Voltage, and current sources, Independent and dependent sources, Source transformation, Voltage current relationship for passive elements, Kirchhoff's laws, Network reduction techniques, Nodal and Mesh analysis, and loop analysis, Concept of Super-mesh and Super-node.	**5**
Module: 2	**Module Name: Electrical circuit analysis**	**CO2**
	Network Theorem: Superposition, Thevenin's, Norton's, Maximum power transfer theorem, Millman's theorem, Tellegen's theorem and its application in circuit analysis and energy distribution system. Solution of Problems with DC & AC sources along with Dependent sources. **Coupled Circuits:** Coupling, Types of coupling, Magnetic coupling, Polarity of coils, Polarity of induced voltage, Concept of Self and Mutual inductance, Coefficient of coupling, Modelling of coupled circuits, and Solution of problems.	**9**
Module: 3	**Module Name: Time and Frequency domain analysis**	**CO3**
	Circuit Transients: DC Transient in R-L & R-C circuits with and without initial charge, R-L-C circuits, Transient analysis of different electrical circuits with and without initial conditions, solution of problems.	**11**

	Laplace Transforms: Concept of complex frequency, transformation of step, exponential, over-damped surge, critically damped surge, damped sine, un-damped sine functions of Laplace Transform, linearity, real-differentiation, real-integration, Initial Value Theorem and Final Value Theorem, Inverse Laplace Transform, applications in circuit analysis, Partial Fractions expansion, Heaviside's Expansion Theorem, Impulse, Step & Sinusoidal response of RL, RC, and RLC circuits. Order of the electrical circuit, Concept of Convolution theorem and its application. Solution of Problems with DC & AC sources.	
Module: 4	**Module Name: Graph Theory**	**CO4**
	Concept of Tree, Branch, Connected and Unconnected graph, planer and non-planer graph sub-graph, rank, Tree link, junctions, Incident matrix, Tie-set matrix, Cut-set matrix, solution of problems.	**5**
Module: 5	**Module Name: Two port networks analysis**	**CO5**
	Open circuit Impedance & Short circuit Admittance parameter, Transmission parameters, Hybrid parameters and their inter relations and interconnection. Solution of Problems with DC & AC sources	**6**
Module: 6	**Module Name: Filter Circuits**	**CO6**
	Concept of Filter, Passive filter and Active filter, Analog filter and Digital filter, Radio frequency filter and Audio frequency filter. Analysis of Low pass, High pass, Band pass, Band reject, All pass filters (first and second order only) using operational amplifier. Solution of Problems.	**6**
Total		**42**

Text Books:

1. Network and Systems, D.Roychowdhury, (New Age International)
2. Network Analysis and Synthesis, S.P Ghosh, A.K. Chakraborty (McGraw Hill)

Reference Books:

1. Network Analysis, M.E.VanValkenburg (Prentice Hall)
2. Network and Systems, Ashfaq Husain, (Khanna Book Publisher)
3. Circuit Theory, A. Chakrabarty (Dhanpat Rai & Co.)
4. Network, Lines and Fields - John D. Ryder.

CO-PO Mapping

COs ↓ / POs →	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PC-EI 301.1	3	3	1	1	2	-	-	-	-	-	1
PC-EI 301.2	3	3	2	1	2	-	-	-	-	-	1
PC-EI 301.3	3	3	2	2	3	-	-	2	-	-	2
PC-EI 301.4	3	3	2	3	1	-	-	-	-	-	2
PC-EI 301.5	3	3	2	2	3	-	-	2	-	-	3
PC-EI 301.6	3	3	3	3	3	2	-	3	2	-	3

CO-PSO Mapping

COs ↓ / POs →	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)
PC-EI 301.1	3	2	1
PC-EI 301.2	3	3	2
PC-EI 301.3	3	3	2
PC-EI 301.4	3	2	1
PC-EI 301.5	3	2	2
PC-EI 301.6	2	3	3

Online Resources:

Course Name	YouTube Link	NPTEL / Swayam Link
Intro, KCL/KVL, Mesh/Nodal, Sources	Basic Electrical Circuits – IIT Madras (IITM) (Digimat, enine.digimat.in, YouTube)	Introduction to Electronic Circuits – Lecture 1 (DIGIMAT)
Theorems, Dependent Sources, Coupled Circuits	Two-port Network – IIT Kharagpur L71	Network Analysis – NPTEL Course
Transient & Laplace Analysis	Week-1 Problem-Solving – Basic Electrical Circuits (NPTEL)	*(Shared with Module 1 & 2 NPTEL playlist)*
Graph Theory (trees, cuts, loops, incidence)	Graph Theory – Tie-set/Cut-set (IITCAA)	Graph Theory – Swayam NOC (IISER Pune)
Two-Port Network Parameters (Z, Y, H, ABCD)	Two-port Network – IIT Kharagpur L71–L74 and continuation L72–L74	Circuit Theory – NPTEL DIGIMAT (Lecture 21+)
Passive/Active Filters with Op-Amps	Active Filters – EEVblog	Op-Amp Practical Applications – NPTEL IISc Bangalore
Intro, KCL/KVL, Mesh/Nodal, Sources	Basic Electrical Circuits – IIT Madras (IITM) (Digimat, enine.digimat.in, YouTube)	Introduction to Electronic Circuits – Lecture 1 (DIGIMAT)
Theorems, Dependent Sources, Coupled Circuits	Two-port Network – IIT Kharagpur L71	Network Analysis – NPTEL Course
Transient & Laplace Analysis	Week-1 Problem-Solving – Basic Electrical Circuits (NPTEL)	*(Shared with Module 1 & 2 NPTEL playlist)*

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
PC-EI 301	Circuit Theory and Network Analysis	28	14	-	48	90	3

Sensors and Transducers

Course Name: Sensors and Transducers	**Category: Professional Core**
Course Code: PC-EI 302	**Semester: 3rd**
L-T-P: 3-0-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs	3- Continuous Assessment: 30Marks (CA-1, CA-2, CA-3)
Tutorial: 0 Hrs	End Semester Exam.: 70 Marks
Total Lectures: 36 Hrs	

Pre-Requisites: Prerequisites for the course of Sensors and Transducers typically include the following:

1. **Physics**: Understanding of fundamental concept of physics such as electromagnetism, thermoelectric effect, thermal expansion of matters etc.
2. **Basic Electrical and Electronics**: Familiarity with basic electrical concepts such as voltage, current, resistance, and Ohm's law, as well as bridge circuits and basic electronic components such as resistors, capacitors, diodes, and transistors, as well as simple analog circuits.
3. **Mathematics**: Knowledge of basic arithmetic, algebra and calculus.

Objectives:

The subject aims to encourage the students with the following:

1. **To introduce** the fundamental concepts of measurement systems, including the terminology, classification, and characteristics of sensors and transducers.
2. **To familiarize students** with the working principles, construction, and characteristics of various types of sensors such as resistive, inductive, capacitive, piezoelectric, thermal, magnetic, and optical sensors.
3. **To develop** the ability to categorize sensors and transducers based on transduction principles, signal types, and application requirements.
4. **To provide** knowledge of practical industrial applications of different transducers used for measuring physical parameters like force, displacement, temperature, pressure, and vibration.
5. **To enable** students to analyze the performance of sensors and select appropriate transducers for specific engineering and instrumentation applications.
6. **To build** a foundation for advanced courses and projects in instrumentation, process control, and automation through a strong understanding of sensor technologies.

Course Outcomes (COs):

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

CO.1. **Recognize** the function of sensors and transducers in measurement systems, **define** various performance characteristics of measuring instruments and **classify** sensors and transducers based on various parameters.

CO.2. **Explain** the working principles and characteristics of resistive sensors such as potentiometers and strain gauges.

CO.3. **Analyze** the operation and performance of LVDT and other inductive transducers in industrial automation related applications

CO.4. **Classify** capacitive sensors based on transduction principles and **apply** them for various industrial measurement related problems.

CO.5. **Evaluate** the suitability and accuracy of piezoelectric and various other transducers for specific engineering measurements such as force, weight, displacement, speed and vibration.

CO.6. **Design** appropriate sensor-based solutions by selecting suitable transducers from a vast group of magnetic, Hall and optical sensors.

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Module Name: Introduction**	CO1
	General concepts and terminology of measurement systems, static and dynamic characteristics of a measurement system, Definition, principles of sensing and transduction, transducer classification, general input-output configuration	**3**
Module: 2	**Module Name: Resistive Transducers**	CO2
	Potentiometric type: Forms, materials, resolution, accuracy, sensitivity **Strain Gauges:** theory, types, materials, design consideration, sensitivity, gauge factor, variation with temperature, adhesives, rosettes, applications-force, velocity and torque measurements	**8**
Module: 3	**Module Name: Inductive transducers:**	CO3
	Common types- reluctance change type, mutual inductance change type, transformer action type - brief discussion with respect to materials, construction and input output variables, Ferromagnetic plunger type-short analysis; proximity measurement **LVDT:** Construction, materials, output-input relationship, I/O curve, discussion	**5**
Module: 4	**Module Name: Capacitive sensors:**	CO4
	Variable distance- parallel plate type, Variable area- parallel plate, serrated plate/teeth type and cylindrical type, variable dielectric constant type: calculation of sensitivities; proximity measurement, differential pressure measurement	**5**

	➢ Stretched Diaphragm type microphones, response characteristics	
Module: 5	**Module Name: Piezoelectric elements; Industrial weighing systems**	CO5
	Piezoelectric elements: piezoelectric effects, charge and voltage coefficients, crystal model, materials, natural and synthetic types – their comparison, Modes of mechanical deformation: TEM, LEM, FSM, TSM, VEM: force and stress sensing, Bimorphs and Multimorphs; piezoelectric accelerometer **Seismic accelerometer:** Measurement of vibration **Industrial weighing systems :** Link–lever mechanism, Load cells – pneumatic, piezoelectric, elastic and magneto-elastic types - their mounting, pressductor, different designs of weighing systems, conveyors type, weighfeeder type.	**9**
Module: 6	**Module Name: Miscellaneous sensors**	CO6
	Magnetic sensors: Sensors based on Villari effect for assessment of force, torque, rpm meters **Tachometers** – Stroboscopes, Encoders, **Optical sensors:** LDR, Solar Cell, Photo diode, Photo Transistor, Photo Darlington Pair **Hall effect:** Hall drive, performance characteristics	**10**
	Total	**42**

Text Books:

1. D Patranabis, Sensors and Transducers, PHI, 2nd ed.
2. E. A. Doebelin, Measurement Systems: Application and Design, McGraw Hill, New York
3. H. K. P. Neubert, Instrument Transducers, Oxford University Press, London and Calcutta

Reference Books:

1. D.V.S. Murty, Transducers and Instrumentation, PHI, 2nd ed.
2. K. Krishnaswamy and S. Vijayachitra, Industrial Instrumentation, New Age International Publishers, 2nd ed.
3. B. G. Liptak, Instrument Engineers' Handbook - Process Measurement and Analysis, Vol. 1, 4th Edition, CRC Press.

CO-PO Mapping

COs ↓ / POs →	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	2	1	1	–	–	1	1	1
CO2	3	2	2	3	2	2	1	1	-	1	1
CO3	3	3	3	2	2	2	1	1	-	1	1
CO4	3	3	3	3	2	2	1	1	-	1	1
CO5	3	3	3	2	2	2	1	1	-	1	1

CO6	3	2	3	2	2	1	–	1	1	1	3

CO-PSO Mapping

	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)
CO1	2	3	1
CO2	2	3	1
CO3	2	3	1
CO4	2	3	1
CO5	2	3	1
CO6	3	2	3

Online Resources:

SWAYAM/NPTEL Courses for Integration

Course Name	Instructor	Platform	Link
Transducers For Instrumentation	Prof. Ankur Gupta (IIT Delhi)	NPTEL/SWAYAM	https://onlinecourses.nptel.ac.in/noc23_ee105/preview
Sensor Technologies: Physics, Fabrication, And Circuits	Prof.Mitradip Bhattacharjee (IISER Bhopal)	NPTEL	https://nptel.ac.in/courses/108106193

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
PC-EI 302	Sensors and Transducers	42	0	0	48	90	3

Analog Electronic Circuits

Course Name: Analog Electronic Circuits	**Category:** ProfessionalCoreCourse
Course Code: PC-EI 303	**Semester:**3rd
L-T-P:3-1-0	**Credit:** 4
Teaching Scheme	**Examination Scheme**
Theory:3 hrs./week	ContinuousAssessment: 30 Marks [CA1,CA2 & CA3]
Tutorial:1 hr/week	
Total Lectures: 56	End Semester Exam.: 70 Marks

Pre-Requisites:

Students are expected to have prior knowledge in the following areas to effectively grasp the concepts taught in this course:

- **Atomic Structure** – Understanding of energy levels, electron configurations, and atomic interactions which form the basis of semiconductor behavior.
- **Semiconductor Physics** – Basic concepts of intrinsic and extrinsic semiconductors, charge carriers, PN junction theory, and electrical characteristics of semiconductor materials.

Course Objectives:

1. **To provide foundational knowledge of semiconductor devices and their practical applications**, such as rectifiers, filters, clippers, clampers, and voltage multipliers, with an introduction to linear power supply concepts.
2. **To develop an understanding of BJT biasing techniques**, including various biasing circuits, stability considerations, compensation methods, and thermal stability, enabling analysis of transistor performance under different conditions.
3. **To analyze small-signal and power amplifier circuits**, focusing on BJT hybrid models and frequency response of amplifiers, and study different classes of transistor power amplifiers including Class A, B, AB, and C.
4. **To introduce the concept of feedback and oscillator circuits**, enabling students to design and analyze amplifier configurations using feedback topologies, and to understand oscillator design using Wien bridge and phase shift techniques.
5. **To build a solid understanding of operational amplifiers (OPAMPs) and their wide-ranging applications**, including ideal and practical characteristics, various linear and nonlinear configurations, and analog computation techniques.
6. **To expose students to advanced applications involving multi-vibrators and voltage regulators**, including IC 555-based timing circuits and IC-based linear voltage regulation for power supply design.

Course Outcomes:

PC-EI303.1: **Describe** the operation of semiconductor devices (diode, BJT) and *explain* their applications such as rectifiers, filters, clippers, clampers, and voltage multipliers.
PC-EI303.2: **Analyze** various BJT biasing circuits to *calculate* stability factors and *evaluate* their effect on thermal stability and amplifier performance.
PC-EI303.3: **Perform** small-signal analysis of CE amplifiers using hybrid-π model to *compute* voltage gain, current gain, input/output impedances, and *plot* frequency response.
PC-EI303.4: **Design** oscillator circuits (Wien Bridge, Phase Shift) using OPAMP/BJT by *applying* feedback principles and **verify** Barkhausen criteria.
PC-EI303.5: **Implement** linear and nonlinear OPAMP-based circuits (e.g., inverting, summing, integrator, comparator, Schmitt Trigger) and *evaluate* their performance parameters such as CMRR, slew rate, and offset.
PC-EI303.6: **Develop** analog systems using OPAMP, IC555, and voltage regulators to *create* power supplies and multivibrator circuits for practical applications.

Module No.	Description of Topics	Contact Hrs.	CO
Module: 1	**Semiconductor devices** Brief overview of semiconductor and junction diode. Majorapplications of diode : Rectifier , Filter, Clipper , Clamper , Voltage Multiplier , Overview to linear power supply	**10**	**CO1**
Module: 2	**Biasing of BJT** Transistor Biasing Circuits: Different types of biasing circuits for BJT, stability factors, bias compensation, dc & ac load line analysis and thermal runaway. stability factors	**12**	**CO2**
Module: 3	**Transistor Amplifier** Small Signal Analysis of BJT: Transistor hybrid model, derivation of voltage gain, current gain, input impedance and output impedance, trans-conductance, low frequency small signal analysis of CE, RC coupled amplifier using hybrid-π model and determination of voltage gain, current gain,input impedance and output impedance, Frequency Response of a RC ,Transistor Power Amplifiers: Class A, Class B, Class, AB, Class C	**14**	**CO3**
Module: 4	**FeedbackandOscillatorCircuits:** Feedback concept, Feedback topologies, classification of amplifiers, Bark-Hausen criteria. Oscillators- Wien bridge oscillator, Phase shift oscillator	**7**	**CO4**

Module: 5	**Operational Amplifier** Operational Amplifier (OPAMP): Ideal OPAMP, Block diagram of the internal circuit of OP amp, Equivalent circuit, characteristics, Inverting and non-inverting configuration (ideal & Practical), Different parameters like CMRR, slew rate, offset voltage & current, offset minimizing techniques etc. **Applications of OPAMP** **Linear applications OPAMP**: Inverting & Non inverting amplifier, differential amplifier, Instrumentation amplifier and its application, Summing amplifier, adder, scaling amplifier, subtractor , V-I and I- V converter, log and antilog amplifier, precision rectifier (half & full wave), Analog multiplier, integrator and differentiator (ideal & Practical), AC amplifier, Wave generation using opamp, Analog Computation techniques :solution of differential equation & simultaneous equations , Practical problems using OP AMP **Nonlinear applications OPAMP**: Comparator, Zero crossing detector, Schmitt Trigger	**15**	**CO5**
Module: 6	**Multi-vibrator,Regulators** Introductiontomulti-vibrator,IC555,LinearVoltageRegulator:Series and Shunt, IC based, power supply design.	**8**	**CO6**

TextBooks:

1. **Electronic circuits: Discrete and Integrated .by Donald Schilling, Charles Belove, Tuvia Apelewicz, Raymond Saccardi**
2. Adel S. Sedra & Kenneth C. Smith, Microelectronic Circuits, Oxford University Press, New Delhi.
3. Jacob Millman & Christos C. Halkias, Integrated Electronics, McGraw Hill.
4. **Ramakant A. Gayakwad, Op-Amps and Linear Integrated Circuits, PHI Learning, New Delhi**.

ReferenceBooks:

1. SergioFranco,DesignwithOperationalAmplifiersandAnalogIntegratedCircuits,3rdEdition, McGraw Hill.
2. Robert L. Boylestad & Louis Nashelsky, Electronic Devices and Circuit Theory, Pearson/PHI, New Delhi.
3. OperationalAmplifiers&LinearIntegratedCircuits -R.F.CoughlinandF.F.Driscoll

CO-PO-PSO Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	2	2	1	1	-	-	-	-	2
CO 2	3	3	2	2	1	1	-	-	-	-	2
CO 3	3	3	3	3	2	1	-	-	-	-	2
CO 4	3	3	3	3	2	1	-	-	-	-	2
CO 5	3	3	3	3	2	1	-	-	-	-	2
CO 6	3	3	3	3	2	1	-	-	-	-	2

PC-EI 303			
CO	PSO1	PSO2	PSO3
1	3	3	2
2	3	3	2
3	3	3	3
4	3	3	3
5	3	3	3
6	3	3	3

Video Lectures:

Course Name	Instructor	Platform	Link
Analog Electronic Circuits	Prof. Shanti Pavan [NT Alexander Chair Professor]	NPTEL	Link
Analog Electronic Circuits	Prof. S.C.DuttaRoy (IIT Delhi)	NPTEL/SWAYAM	Link

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
PC-EI 303	Analog Electronic Circuits	42	14	N/A	64	120	4

Digital Electronic Circuits

Course Name: Digital Electronics Circuits	**Category: Professional Core**
Course Code: PC-EI 304	**Semester: 3rd**
L-T-P: 3-1-0	**Credit: 4**
Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
Tutorial: 1 Hrs	End Semester Exam.: 70 Marks
Total Lectures: 56 Hrs	

Pre-Requisites: Prerequisites for the Digital Electronics subject typically include the following:

1. **Basic Electrical Engineering**: Understanding of fundamental electrical concepts such as voltage, current, resistance, and Ohm's law, as well as basic circuit theory.
2. **Introduction to Electronics**: Familiarity with basic electronic components such as resistors, capacitors, diodes, and transistors, as well as simple analog circuits.
3. **Mathematics**: Knowledge of algebra, binary numbers, and basic mathematical logic etc.

Objectives:

The subject aims to encourage the students with the following:

1. **Develop Fundamental Knowledge:** To build a strong foundation in digital logic, including number systems, coding techniques, and the design of basic combinational and sequential circuits.
2. **Enhance Problem-Solving Skills:** To apply Boolean algebra, Karnaugh maps, and other simplification techniques in solving complex digital design problems.
3. **Hands-on Experience:** To provide practical experience in constructing, testing, and analyzing digital circuits through laboratory exercises and simulations.
4. **Foster Analytical Thinking:** To encourage students to analyze and interpret circuit behavior, performance metrics, and troubleshooting issues in digital systems.
5. **Design Capabilities:** To enable students to design and implement digital systems, integrating multiple components to achieve desired functionalities.
6. **Prepare for Advanced Learning:** To prepare students for advanced courses in electronics embedded systems and computer architecture by solidifying their understanding of digital electronics principles.

Course Outcomes (COs):

On completion of this course, the student will be able to

CO1. Apply number systems, binary arithmetic, and code conversion techniques for solving basic digital logic problems.

CO2. Analyze and minimize logical expressions using Boolean algebra, Karnaugh and Quine-McClausky maps to simplify digital circuits.

CO3. Design combinational logic circuits such as adders, multiplexers, encoders, and comparators using standard logic gates.

CO4. Design sequential circuits using flip-flops, counters, and registers for specified timing and control operations.

CO5. Evaluate different analog-to-digital and digital-to-analog converter architectures for data conversion applications.

CO6. Design digital circuits using logic families and programmable devices such as PAL, PLA, and FPGA.

CO Design Notes:

- **CO1** focuses on the mathematical and binary foundation of digital systems.
- **CO2** ties directly to Boolean algebra and K-map techniques from Module 2.
- **CO3** benefits from overlap between combinational logic (Module 3) and Boolean expression simplification (Module 2).
- **CO4** is clearly aligned with sequential logic design and timing elements in Module 4.
- **CO5** addresses ADC/DAC, which are conceptually self-contained.
- **CO6** spans digital logic families and PLDs (Module 6), building on the implementation concepts from Modules 3 & 4.

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Module Name: Introduction to Digital Electronics & Number systems**	**CO1**
	➢ Introduction to Digital system, Data and number systems, Analog vs. Digital ➢ Systems, Applications of Digital Electronics ➢ Decimal, binary, octal and hexadecimal number systems and their arithmetic operations; conversion of one number system to another. ➢ Binary codes, natural BCD codes, weighted, non-weighted, sequential, self-complementing, cyclic, Excess-3, Alphanumeric, Gray codes, Code conversion- from one code to another, Binary Multiplication, Binary Division. ➢ Signed binary number representation with 1's and 2's complement methods, ➢ Binary arithmetic	**8**
Module:	**Module Name: Boolean algebra**	**CO2**

<table>
<tr><td>2</td><td>➢ Logic Operation-NOT, AND, OR, NAND, NOR, XOR and XNOR – operations, truth tables, Electrical analogy of gates, Venn diagram.
➢ All Postulates and laws of Boolean algebra with proof, De Morgan's theorem. Minimization of Logic Expressions using Algebraic method.
➢ Canonical forms of expressions, minterms and maxterms, SOP and POS forms.
➢ Simplification and minimization of Logic Expressions using K- map method (up to 4 variables). Concept of don't care and use of don't care terms in K-map method, POS based minimization.
➢ Limitation of K-map and Quine-McClausky (Q-M) method of minimization of logic functions and concept of PI, EPI</td><td>8</td></tr>
<tr><td rowspan="2">Module: 3</td><td>Module Name: Combinational Logic Design</td><td>CO3</td></tr>
<tr><td>➢ Adders: Half Adder, Full Adder, Binary parallel adder, Composite adder, Carry look ahead adder, BCD adder.
➢ Multiplexers and Demultiplexer: basic 2:1, 4:1, 8:1 multiplexer equation and circuit diagram. Implementation of higher order MUX using lower order MUX, function implementation using MUX, basic 1:2 and 1:4 DEMUX equation and circuit diagram. function implementation using DEMUX, application of MUX and DEMUX
➢ Encoder & Decoders: basic 2:4, 3:8, 4:16 decoder equation and circuit diagram. Implementation of higher order decoder using lower order decoder, function implementation using decoder.
➢ 4:2 Encoders and Priority Encoders equation with circuit diagram. Application of DECODER and ENCODER
➢ 3 bit and 4 bit EVEN and ODD Parity Generator and checkers, 1 bit, 2 bits,4 bits Magnitude Comparators with equation and circuit diagram
➢ Code converter: Binary to Gray and Gray to Binary, BCD to XS-3 and XS-3 to BCD, BCD to Binary and Binary to BCD</td><td>12</td></tr>
<tr><td rowspan="2">Module: 4</td><td>Module Name: Sequential Logic Design</td><td>CO4</td></tr>
<tr><td>➢ Concept of Sequential circuit, difference between combinational and sequential circuit, Introduction to latches (S-R Latch, both NOR and NAND) with characteristic table, truth table, equation and circuit diagram.
➢ Introduction to different types of Flip-Flop (S-R, D, J-K, T) with characteristic table, Excitation table, equation and circuit diagram.
➢ Triggering of flip-flops, Asynchronous inputs in FF, race around condition, Master-slave configuration; Conversion of Flip-flop and application of FF, mealy and moore machine.
➢ Asynchronous & Synchronous counters - Full-sequence length counter, Binary up and down counter, Bidirectional counter, Modulo-N counter (both Synchronous and asynchronous) Arbitrary sequence counter.</td><td>12</td></tr>
</table>

	➢ **Registers:** SISO, SIPO, PIPO, PISO, Bi-directional and universal shift registers, Ring and Johnson (twisted ring) counters, application of register.	
Module: 5	**Module Name: Analog-to-Digital and Digital-to-Analog Converters**	**CO5**
	➢ Introduction to analog- digital data conversion, specification of D/A converter. ➢ D/A conversion- R-2R ladder type, weighted resistor type. ➢ Specification of A/D converter; A/D conversion- Flash type, successive approximation type and dual-slope type, **sigma delta converters (introduction)**	**8**
Module: 6	**Module Name: Introduction to Digital Logic Families and Programmable Logic Devices**	**CO6**
	Classification of Digital Logic Families; characteristics of Digital ICs. ➢ TTL: characteristics, Totem-Pole output, Open Collector output, Tri-state output, ➢ ECL: characteristics, OR/NOR gate. ➢ MOS: characteristics, PMOS, NMOS. CMOS: characteristics NAND, NOR, logic circuit realization ➢ Introduction to Memory Devices ➢ RAM, ROM, PROM, EPROM, EEPROM: Static vs. Dynamic RAM ➢ Logic Devices (PLDs): Introduction to PLDs (PAL, PLA, CPLD, FPGA) ➢ Basic Architecture and Applications of PLDs, Design and Implementation Using PLDs, Design Examples Using PAL and PLA	**8**
	Total	**48**

Text Books:

1. Digital Fundamentals by T.L. Floyd &R.P.Jain (Pearson).
2. Fundamental of digital circuits by A. Anand Kumar (PHI).
3. Digital Electronics, RishabhAnand (Khanna Publishing House)
4. Digital Integrated Electronics by H. Taub& D. Shilling (TMH).
5. Digital Design, M. Morris Mano, Michael D. Ciletti, (Pearson)

Reference Books:

1. Digital Circuit & Design by S. Aligahanan&S.Aribazhagan (Bikas Publishing)
2. Digital Electronics by A.K. Maini (Wiley-India)
3. Digital Circuits-Vol-I & II by D. RayChaudhuri (Platinum Publishers)
4. Modern Digital Electronics by R.P. Jain (McGraw Hill)

CO-PO Mapping

COs ↓ / POs →	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	–	–	–	–	–	–	–	–	–
CO2	3	3	2	–	–	–	–	–	–	–	–
CO3	3	2	3	–	2	–	–	1	1	–	–
CO4	3	2	3	2	2	–	–	1	1	–	–
CO5	3	2	2	2	2	–	–	–	–	–	–
CO6	3	2	3	2	3	1	–	1	1	1	1

CO-PSO Mapping

	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)
CO1	3	2	1
CO2	3	2	1
CO3	3	3	2
CO4	3	3	2
CO5	2	3	2
CO6	3	2	3

Online Resources:

SWAYAM/NPTEL Courses for Integration

Course Name	Instructor	Platform	Link
Digital Circuits	Prof. S. Srinivasan (IIT Madras)	NPTEL/SWAYAM	Link
Digital System Design	Prof. Santanu Chattopadhyay (IIT Kharagpur)	NPTEL/SWAYAM	Link
Digital Electronics	Dr. Hardik Joshi (NITTTR Bhopal)	SWAYAM	Link
Digital Circuits and Systems	Prof. D. Das (IIT Roorkee)	NPTEL/SWAYAM	Link

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme				
		Classroom Instructions (CI) (in hours/sem.)	Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)

		L	T	P	SL		
PC-EI 304	Digital Electronic Circuits	42	14		64	120	4
PC-EI 394	Digital Electronics Lab			42	3	45	1.5

Environmental Science

Course Name : Environmental Science	**Category: Mandatory Courses**
Course Code : MC-ES 301	**Semester: 3rd**
L-T-P: 2-0-0	**Credit: 0**
Teaching Scheme	**Examination Scheme**
Theory: 2 hrs./week	3- Continuous Assessment: 30 Marks
Tutorial: Nil	PPT Presentation and Quizes: 70 Marks
Total Lectures: 30	
Pre-Requisites: No-prerequisite	

Objective:

The subject aims to encourage the students with the following:

1. To develop an understanding of environmental systems including the interrelationship between man, society, and environment, and the fundamental components of ecosystems.
2. To analyze environmental issues related to population growth, resource utilization, and environmental degradation for both natural and anthropogenic.
3. To introduce the scientific principles behind ecological structures and functions, biogeochemical cycles, and biodiversity conservation, with specific focus on regional relevance such as the Sundarbans.
4. To provide a technical understanding of air and water pollution, their sources, effects, and control measures, including standards and treatment methods.
5. To explain solid waste and noise pollution management strategies, with emphasis on disposal techniques and environmental impact mitigation.
6. To familiarize students with environmental legislation, impact assessments, and major international protocols and agreements.
7. To cultivate awareness and responsibility toward sustainable development and environmental protection as part of the engineering profession.

Course Outcome (Cos):

On completion of this course, the students will be able to

MC-ES 301.1. Explain the fundamental concepts of environment and sustainability.

MC-ES 301.2. Apply ecological systems and biodiversity conservation.

MC-ES 301.3. Analyze atmospheric phenomena and air pollution issues.

MC-ES 301.4 Assess the causes and control of water pollution.

MC-ES 301.5. Classify solid waste sources and **analyze** management techniques.

MC-ES 301.6. Examine the causes of noise pollution and **evaluate** existing environmental regulations and policies.

<table>
<tr><th>Module No.</th><th>Description of Topics</th><th>Contact Hrs.</th><th>CO</th></tr>
<tr><td>Module: 1</td><td>Environmental Fundamentals & Energy Conservation:
Basic ideas of environment, basic concepts, man, society & environment, their interrelationship. Mathematics of population growth and associated problems, Importance of population study in environmental engineering, definition of resource, types of resource, renewable, non-renewable, potentially renewable, effect of excessive use vis-à-vis population growth, Sustainable development. Materials balance: Steady state conservation system, steady state system with non conservative pollutants.
Environmental degradation: Natural environmental Hazards like Flood, earthquake, Landslide-causes, effects and control/management; Anthropogenic degradation like Acid rain- cause, effects and control. Nature and scope of Environmental Science and Engineering.

Energy Resources and Energy Conservation:
Conventional and non-conventional energy sources
Energy crisis and environmental implications
Principles of energy conservation
Energy efficiency and demand-side management
Role of engineers in energy conservation and sustainable practices</td><td>4</td><td>1</td></tr>
<tr><td>Module: 2</td><td>Ecology and Biodiversity:
Elements of ecology: System, open system, closed system, definition of ecology, species, population, community, definition of ecosystem components types and function.
Structure and function of the following ecosystem: Forest ecosystem, Grassland ecosystem, Desert ecosystem, Aquatic ecosystems, Mangrove ecosystem (special reference to Sundarban); Food chain [definition and one example of each food chain], Food web. Biogeochemical Cycle- definition, significance, flow chart of different cycles with only elementary reaction [Oxygen, carbon, Nitrogen, Phosphate, Sulphur].
Biodiversity- types, importance, Endemic species, Biodiversity Hotspot, Threats to biodiversity, Conservation of biodiversity.</td><td>4</td><td>2</td></tr>
</table>

Module: 3	**Atmospheric Science and Air Pollution:** Atmospheric Composition: Troposphere, Stratosphere, Mesosphere, Thermosphere, Tropopause and Mesopause. Energy balance: Conductive and Convective heat transfer, radiation heat transfer, simple global temperature model [Earth as a black body, earth as albedo]. Global climate and consequently on sea water level, agriculture and warming. Lapse rate: Ambient lapse rate Adiabatic lapse rate, atmospheric stability, temperature inversion (radiation inversion). Atmospheric dispersion: Maximum mixing depth, ventilation coefficient, effective stack height, smokestack plumes and Gaussian plume model. Definition of pollutants and contaminants, Primaryand secondary pollutants: emission standard, criteria pollutant.Sources and effect of different air pollutants- Suspended particulatematter, oxides of carbon, oxides of nitrogen, oxides of sulphur, particulate, PAN. Smog, Photochemical smog and London smog. Depletion Ozone layer: CFC, destruction of ozone layer by CFC, impact of other green house gases, effect of ozone modification. Standards and control measures: Industrial, commercial and residential air quality standard, control measure (ESP. cyclone separator, bag house, catalytic converter, scrubber (ventury).	**8**	**3**
Module: 4	**Water Pollution and Treatment:** Hydrosphere, Hydrological cycle and Natural water. Pollutants of water, their origin and effects: Oxygen demanding wastes, pathogens, nutrients, Salts, thermal application, heavy metals, pesticides, volatile organic compounds. River/Lake/ground water pollution: River: DO, 5 day BOD test, Seeded BOD test, BOD reaction rate constants, Effect of oxygen demanding wastes on river[deoxygenation, reaeration], COD, Oil, Greases, pH. Lake: Eutrophication [Definition, source and effect]. Ground water: Aquifers, hydraulic gradient, ground water flow. (Definition only) Standard and control: Waste water standard [BOD, COD, Oil, Grease], Water Treatment system [coagulation and flocculation, sedimentation and filtration, disinfection, hardness and alkalinity, softening] Waste water treatment system, primary and secondary treatments [Trickling filters, rotating biological contractor, Activated sludge, sludge treatment, oxidation ponds] tertiary treatment definition.Water pollution due to the toxic elements and their biochemical effects: Lead, Mercury, Cadmium, and Arsenic.	**6**	**4**
Module: 5	**Solid Waste Management:** Lithosphere; Internal structure of earth, rock and soil Solid Waste: Municipal, industrial, commercial, agricultural, domestic, pathological and hazardous solid wastes; Recovery and disposal method- Open dumping, Land filling, incineration, composting, recycling. Solid waste management and control (hazardous and biomedical waste).	**3**	**5**
Module: 6	**Noise Pollution & Environmental Governance:** Definition of noise, effect of noise pollution, noise classification [Transport noise, occupational noise, neighborhood noise] Definition of noise frequency, noise pressure, noise intensity, noise threshold		

	limit value, equivalent noise level, noise pollution control. Environmental impact assessment, Environmental Audit, Environmental laws and protection act of India, Different international environmental treaty/ agreement/ protocol.	**5**	**6**

References:

1. Masters, G. M., "Introduction to Environmental Engineering and Science", Prentice-Hall ofIndia Pvt. Ltd., 1991.
2. De, A. K., "Environmental Chemistry", New Age International.

SWAYAM/NPTEL Courses for Integration

Course Name	Instructor	Platform	Link
Environmental Science & Engineering	Prof. Ligy Philip (IIT Madras)	NPTEL/SWAYAM	https://nptel.ac.in/courses/120108004
Introduction to Environmental Science & Engineering	Prof. Bhanu Prakash Vellanki(IIT Roorki)	NPTEL/SWAYAM	https://swayam.gov.in/nd1_noc20_ce15
Air Pollution and Control	Prof.Mukesh Sharma (IIT Kanpur)	NPTEL/SWAYAM	https://nptel.ac.in/courses/105104160
Wastewater Treatment	Prof. Manish Kumar Goyal (IIT Indore)	NPTEL/SWAYAM	https://nptel.ac.in/courses/105108123
Environmental Impact Assessment	Prof. T V Ramachandra (IISC Bangalore)	NPTEL/SWAYAM	https://nptel.ac.in/courses/105107211

CO-PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MC-ES 301.1	1	1	–	–	–	3	3	2	1	2	1
MC-ES 301.2	1	2	–	–	–	3	3	2	1	1	1
MC-ES 301.3	2	2	1	1	1	3	3	2	1	1	1
MC-ES 301.4	2	2	1	1	1	3	3	2	1	1	1
MC-ES 301.5	1	2	1	–	–	3	3	2	1	1	1
MC-ES 301.6	–	1	–	–	–	3	3	3	1	2	1

CO-PSO Mapping

CO \ PSO	PSO1 (Electronics & Computing)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Research)
MC-ES 301.1	–	–	1
MC-ES 301.2	–	–	1
MC-ES 301.3	1	1	2
MC-ES 301.4	1	1	2
MC-ES 301.5	–	1	2
MC-ES 301.6	–	–	2

Numerical Methods Lab

Name of the Course: Numerical Methods Lab	**Category: Basic science Courses**
Course Code: BS-M 391	**Semester:3rd**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination scheme:**
Tutorial: Nil	External Assessment:60
Practical: 2 hrs./week	Internal Assessment:40
Credit Points: 1	

Course Outcomes:	
CO. 1	Implement various interpolation techniques, including Newton's forward/backward and Lagrange's methods, to approximate function values
CO. 2	Apply numerical integration methods such as Trapezoidal, Simpson's 1/3, and Weddle's rules to evaluate definite integrals.
CO. 3	Solve systems of linear algebraic equations and find roots of non-linear algebraic equations using iterative and direct numerical methods.
CO. 4	Utilize computational software packages (e.g., Matlab/Python) to implement numerical algorithms for solving ordinary differential equations and other mathematical problems
Pre-Requisite:	
1	BS-M101, BS-M202, BS-M301

Experiment No.	**Laboratory Experiments**	COs
1	Assignments on Newton forward /backward, Lagrange's interpolation.	CO.1
2	Assignments on numerical integration using Trapezoidal rule, Simpson's 1/3 rule, Weddle's rule.	CO.2
3	Assignments on numerical solution of a system of linear equations using Gauss elimination and Gauss-Seidel iterations Assignments on numerical solution of Algebraic Equation by Regular falsi and Newton Raphson methods.	CO.3
4	Assignments on ordinary differential equation: Euler's and Runga-Kutta methods. Introduction to Software Packages: Matlab / Python/ Labview / Mathematica	CO.4

Text and reference books:

1. C. Xavier: C Language and Numerical Methods.
2. E. Balagurusamy: Numerical Methods, Scitech.
3. R.S. Salaria: Numerical Methods, Khanna Publishing House
4. Rudra Pratap, Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers, Oxford University Press.
5. Mark Lutz and David Ascher, Learning Python, Published by O'Reilly & Associates.

CO-PO-PSO Mapping

BS-M 391											
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
CO.1.	3	3	2	2	1	1	-	-	-	2	2
CO.2.	3	3	2	2	1	1	-	-	-	2	2
CO.3.	3	3	3	3	2	2	1	-	-	2	2
CO.4.	3	3	3	3	2	2	1	1	1	2	2
avg	3	3	2.5	2.5	1.5	1.5	1	1	1	2	2

BS-M 391			
COs	**PSO1**	**PSO2**	**PSO3**
CO.1.	3	3	3
CO.2.	3	3	3
CO.3.	3	3	3
CO.4.	3	3	3
avg	3	3	3

<u>Circuit Theory Laboratory</u>

Course Name: Circuit Theory Laboratory	**Category: Professional Core**
Course Code: PC-EI 391	**Semester: 3rd**
L-T-P: 0-0-3	**Credit: 1.5**
Teaching Scheme	**Examination Scheme**
Practical: 3 hrs./week	2 –Practical Continuous Assessment: 40 Marks (PCA-1 andPCA-2)
	End Semester Exam.: 60 Marks

Pre-Requisites:

To ensure effective learning and comprehension of the concepts in Circuit Theory Laboratory, students are expected to have foundational knowledge and skills in the following areas:

- Understanding of fundamental electrical elements (resistor, inductor, capacitor), Ohm's Law, and Kirchhoff's Laws.

Objectives:

The subject aims to encourage the students with the following:

- To study and analyse the transient behaviour, two-port parameters, and frequency response of basic electrical networks through simulation and hardware experiments.
- To apply computational tools such as MATLAB for generating signals and evaluating system responses using Laplace-transform–based analysis.

Course Outcomes (COs):

On completion of this course, the student will be able to

PC-EI 391.1 Understand and analyze the transient behavior of electrical circuits using simulation and hardware tools.

*(Cognitive Level: **Understand, Analyze**, Knowledge Category: **Procedural**)*

PC-EI 391.2 Determine and interpret two-port network parameters for given electrical networks.

*(Cognitive Level: **Evaluate**, Knowledge Category: **Procedural**)*

PC-EI 391.3 **Analyze** the frequency response of different types of filters and their characteristics.

*(Cognitive Level: **Analyze**, Knowledge Category: **Procedural**)*

PC-EI 391.4 Generate and evaluate standard signals and Laplace transforms using MATLAB tools.

*(Cognitive Level: **Apply,Evaluate**, Knowledge Category: **Procedural**)*

Syllabus details

Experiment No.	Experiment Name	Mapped CO
01	Transient response in R-L Network: Simulation/hardware	**PC-EI 391.1**
02	Transient response in R-C Network: Simulation/hardware	**PC-EI 391.1**
03	Transient response in R-L-C Series circuits Network: Simulation/hardware	**PC-EI 391.1**
04	Determination of Impedance (Z) parameters of two port network	**PC-EI 391.2**
05	Determination of Admittance(Y) parameters of two port network	**PC-EI 391.2**
06	Frequency response of LP and HP filters	**PC-EI 391.3**
07	Frequency response of HP filters	**PC-EI 391.3**
08	Frequency response of BP filters	**PC-EI 391.3**
09	Generation of Periodic, Exponential, Sinusoidal, Damped sinusoidal, Step, Impulse, and Ramp signals usingMATLAB in both discrete and analog form.	**PC-EI 391.4**
10	Determination of Laplace transform and inverse Laplace transformation using MATLAB	**PC-EI 391.4**

Online Resources:

Laboratory Name	Platform	Link
Electric Circuits Virtual Lab	Amrita Vishwa Vidyapeetham (VLabs)	https://vlab.amrita.edu/?brch=75&sub=1
Two-Port Network Virtual Lab	IIT Kharagpur (VLabs)	https://asnm-iitkgp.vlabs.ac.in/exp/two-port-network/
Active FiltersVirtual Lab	IIT Kharagpur (VLabs)	https://asnm-iitkgp.vlabs.ac.in/exp/second-order-active-filters/theory.html

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		

PC-EI 391	Circuit Theory Laboratory			36	9	45	1.5

CO-PO Mapping

COs ↓ / POs →	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PC-EI 391.1	3	3	3	1	3	2	-	3	3	-	3
PC-EI 391.2	3	3	3	2	3	-	-	3	3	-	3
PC-EI 391.3	3	3	3	2	3	2	-	3	3	-	3
PC-EI 391.4	3	3	3	2	3	-	2	3	3	-	3

CO-PSO Mapping

COs ↓ / POs →	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)
PC-EI 391.1	3	3	2
PC-EI 391.2	3	3	2
PC-EI 391.3	3	3	3
PC-EI 391.4	3	3	3

Sensors and Transducers Lab

Course Name: Sensors and Transducers Lab		**Category:** Professional Core
Course Code: PC-EI 392		**Semester:** 3rd
Duration: 6 months		**Maximum Marks: 100**
Teaching Scheme		**Examination scheme: Maximum marks:**
Tutorial: Nil		External Assessment:60
Practical: 3 hrs./week		Internal Assessment:40
Credit Points: 1.5		
Pre-Requisite:		
1	Fundamentals of Mathematics	
2	Fundamentals of Physical science	

On completion of this course, the student will be able to

Course Outcomes:	
CO. 1	**Evaluate** the performance of capacitive and LVDT transducers for precise displacement measurement.
CO. 2	**Analyze** mechanical sensing techniques using strain gauge and load cell for force and torque quantification.
CO. 3	**Interpret** the behavior of proximity and light sensors to assess displacement and luminance levels.
CO. 4	**Demonstrate** sensor-based speed measurement techniques using stroboscope and Hall-effect sensors in dynamic systems.

Experiment No.	**Laboratory Experiments**	COs
1.	Displacement measurement by using a capacitive transducer.	CO1
2.	Displacement measurement by using LVDT.	CO1
3.	Study of a load cell with tensile and compressive load.	CO2
4.	Torque measurement using Strain gauge transducer.	CO2
5.	Displacement measurement using Hall proximity sensor.	CO3
6.	Study of the characteristics of a LDR.	CO3
7.	Speed measurement using a Stroboscope.	CO4
8.	Speed measurement using Hall sensor.	CO4

CO-PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	2	2	1	1	1	2	2	1
CO2	3	3	2	3	3	1	1	1	2	2	1
CO3	2	2	1	2	2	1	1	1	2	2	1
CO4	2	2	1	2	3	1	1	1	2	2	2

	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)
CO1	2	3	1
CO2	2	3	1
CO3	2	3	1
CO4	2	3	1

Analog Electronics Lab

Course Name: Analog Electronics Lab	**Category:** Professional Core
Course Code: PC-EI 393	**Semester:** 3rd
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination scheme: Maximum marks:**
Tutorial: Nil	External Assessment:60
Practical: 3 hrs./week	Internal Assessment:40
Credit Points: 1.5	

Course Outcomes:	
CO. 1	**Set up** and **perform** standard experimental procedures using appropriate instruments to evaluate performance characteristics of various analog electronic circuits.
CO. 2	**Analyze** and **interpret** experimental results for amplifier, oscillator, and timer circuits, identifying causes of deviations between theoretical and practical values.
CO. 3	**Design** and **implement** analog subsystems such as voltage regulators, DAC/ADC interfaces, and signal-generation circuits considering safety and economy.
CO. 4	**Develop** and **demonstrate** a mini-project integrating analog components to solve a practical problem through systematic experimentation and documentation.
Pre-Requisite:	
1	Basic Electronics

Experiment No.	**Laboratory Experiments**	COs
1.	Study of characteristics curves of BJT & FET.	CO1
2.	Construction of a two-stage RC coupled amplifier & study of its gain and bandwidth.	CO2
3.	Study of timer circuit using NE555 & configuration for monostable & astable-multivibrator.	CO3
4.	Study of class A & class B power amplifiers.	CO3
5.	Study of Switched Mode Power Supply & construction of a linear voltage regulator using regulator IC chip.	CO4
6.	Construction of a simple function generator using IC.	CO4
7.	Study of DAC & ADC.	CO3
8.	Mandatory Design and Implementation of Mini Project.	CO4
Beyond Syllabus		
9.	Realization of current mirror & level shifter circuit using Operational Amplifiers.	CO3
10.	Realization of a Phase Locked Loop using Voltage Controlled Oscillator (VCO).	CO3
11.	Construction & study of Bistable-multivibrator using NE555.	CO2
12.	Study of class C & Push-Pull amplifiers.	CO1

CO-PO Matrix

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	–	2	3	–	–	1	–	–	–
CO2	3	3	2	2	2	–	–	–	–	–	–
CO3	3	2	3	2	3	–	1	1	–	–	–
CO4	3	2	3	2	2	–	1	1	2	2	2

CO-PSO Matrix

CO-PSO	PSO1	PSO2	PSO3
CO1	3	2	1
CO2	3	2	1
CO3	3	3	2
CO4	3	2	2

Digital Electronics Lab

Course Name: Digital Electronics Lab	**Category:** Professional Core
Course Code: PC-EI 394	**Semester:** 3rd
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination scheme: Maximum marks:**
Tutorial: Nil	External Assessment:60
Practical: 3 hrs./week	Internal Assessment:40
Credit Points: 1.5	

On completion of this course, the student will be able to

Course Outcomes:	
CO. 1	**Design and implement** basic combinational circuits including **logic gates, code converters, arithmetic circuits**, and **parity/comparator units** using digital ICs and universal gates.
CO. 2	**Construct and analyze** combinational logic systems such as **multiplexers, decoders**, and **seven-segment drivers** using logic gates and multiplexing techniques.
CO. 3	**Design and simulate** sequential circuits including **flip-flops, counters**, and **registers** using universal logic gates and flip-flop ICs.
CO. 4	**Develop and test** complex sequential circuits like **universal registers** and **serial adder units** by integrating shift registers, multiplexers, and arithmetic components.
Pre-Requisite:	
1	Mathematics Fundamentals

Experiment No.	**Laboratory Experiments**	COs
1.	Realization of basic gates using Universal logic gates.	CO1
2.	Code conversion circuits- BCD to Excess-3 & vice-versa.	CO1
3.	Construction of simple arithmetic circuits-Adder, Subtractor.	CO1
4.	4-bit parity generator & comparator circuits.	CO1
5.	Construction of simple Decoder & Multiplexer circuits using logic gates.	CO2
6.	Design of combinational circuit for BCD to decimal conversion to drive 7-segment display using multiplexer.	CO2
7.	Realization of RS-JK & D flip-flops using Universal logic gates.	CO3
8.	Realization of Asynchronous Up/Down counter.	CO3
9.	Realization of Synchronous Up/Down counter.	CO3
10.	Realization of Universal Register using JK flip-flops & logic gates.	CO4
11.	Realization of Universal Register using multiplexer & flip-flops.	CO4
12.	Construction of Adder circuit using Shift Register & full Adder.	CO4
13.	Realization of Ring counter & Johnson's counter.	CO4
14.	Construction of adder circuit using Shift Register & full Adder.	CO4

CO–PO Mapping Table

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	3	1	3	–	–	–	2	1	–
CO2	3	2	3	1	3	–	–	–	2	1	–
CO3	3	3	3	2	3	–	–	–	2	1	–
CO4	3	3	3	2	3	–	–	–	3	1	1

CO–PSO Mapping Table

CO \ PSO	PSO1	PSO2	PSO3
CO1	3	1	1
CO2	3	1	1
CO3	3	2	1
CO4	3	2	2

Recommended Virtual Labs & Online Tools for Digital Electronics Laboratory

Sl. No.	Platform / Tool	Website	Key Features / Applications	Recommended Usage
1	**Virtual Labs (IIT Bombay)**	vlab.co.in Direct Link	MHRD-Govt of India initiative. Includes digital circuit simulations, quizzes, theory resources.	Official lab assignments, NEP/NBA aligned
2	**Tinkercad Circuits**	tinkercad.com	Beginner-friendly simulator for logic gates, counters, 7-segment displays, Arduino integration.	Self-learning, lab prototyping
3	**Logisim Evolution**	GitHub	Open-source offline simulator for FSM, counters, MUX, registers, custom logic.	Lab assignments, circuit design
4	**Falstad Simulator**	falstad.com/circuit	Web-based, animated simulations of logic gates, FFs, counters. Very interactive and intuitive.	Conceptual demos, classroom use
5	**Multisim Live (NI)**	multisim.com	Industry-grade online tool for advanced digital and mixed-	Sequential/combinational design labs

			signal circuits.	
6	**Every Circuit**	everycircuit.com	Visual simulation with animation. Great for mobile access and quick testing.	Concept visualization, mobile use
7	**Circuit Verse**	circuitverse.org	Collaborative logic simulator supporting FSM, counters, PLDs. Ideal for assignments.	Online teamwork, virtual lab reports

<u>**Electrical & Electronic Measurements**</u>

Course Name: Electrical & Electronics Measurements	**Category: Professional Core**
Course Code: PC-EI 501	**Semester: 4th**
L-T-P: 3-1-0	**Credit: 4**
Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
Tutorial: 1 Hrs	End Semester Exam.: 70 Marks
Total Lectures: 48 Hrs	

Pre-Requisites:

The students are expected to have the knowledge and skills in the following areas:

- Basic Electrical Engineering
- Basic Electronics Engineering
- Circuit Theory & Networks

Objectives:

The subject aims to encourage the students with the following:

1. **Understand the Fundamentals of Measurement Systems**: To develop a foundational understanding of measurement principles, instrument classification, accuracy, precision, and error analysis.
2. **Gain Proficiency with Analog Instruments**: To study the construction, operation, and torque equations of analog instruments such as moving coil, moving iron, electrodynamometer, and induction-type devices.
3. **Bridge and Potentiometer Techniques**: To explore the application of D.C. and A.C. bridges and potentiometers for measuring resistance, inductance, capacitance, and frequency.
4. **Analyze Power and Energy Measurement Methods**: To understand the operation and limitations of wattmeters, energy meters, and instrument transformers in power and energy measurement applications.
5. **Develop Competence in Using Electronic Instruments**: To learn the principles and practical use of modern electronic instruments like oscilloscopes, digital multimeters, LCR meters, and spectrum analyzers.
6. **Prepare for Industry and Advanced Studies**: To equip students with the skills required for real-world applications advanced electronics courses, and instrumentation-related roles in industry.

Course Outcomes (COs):

On completion of this course, the student will be able to

PC-EI401.1: **Apply** the fundamental concepts of measurement systems, **differentiate** between types of instruments and **classify** various types of errors in measurements.
PC-EI401.2: **Explain** the construction, working principle and range extension methods of analog indicating instruments.

PC-EI401.3: **Apply** DC and AC bridge circuits and potentiometers to measure resistance, inductance, capacitance, and frequency.
PC-EI401.4: **Analyze** the working principles of electrodynamic and induction-type wattmeters, **evaluate** the use of instrument transformers in power measurement, and **apply** correction techniques for associated errors.
PC-EI401.5: **Evaluate** and **analyze** the working and testing procedures of single-phase AC energy meters.
PC-EI401.6: **Utilize** electronic instruments such as oscilloscopes, digital meters and analyzers.

Syllabus Details

Module No.	Description of Topics	Contact Hrs.	CO
Module: 1	**Module Name: Introduction to measurement System** • Methods of measurement, • Measurement system, • Classification of Instruments. • Definition of accuracy, precision, resolution, Speed of response • Errors in measurement, classification of errors. • Loading effect due to shunt and series connected instruments.	**9**	**CO1**
Module: 2	**Module Name: Analogmeter** • General features, Construction, principle of operation and torque equation of moving coil, moving iron, electrodynamometer, Induction, and Electrostatic type instruments. • Principle of operation of the thermoelectric, rectifier type instruments. • Extension of instrument ranges using shunt, multipliers.	**7**	**CO2**
Module: 3	**Module Name: Bridges (D.C and A.C):** • Measurement of resistances like low, medium and high. Megger. • Potentiometers: Principle of operation and application of Crompton's DC potentiometer, Polar and coordinate type of AC potentiometers. • Measurement of inductances, capacitance and frequency by A.C Bridge.	**11**	**CO3**
Module: 4	**Module Name: Measurement of power:** • Disadvantages of shunt & multipliers, Advantages of Instrument Transformers, Principle of operation of current & potential transformer and errors. • Principle of operation of Electrodynamic & induction type wattmeter and wattmeter errors.	**11**	**CO4**
Module:5	**Module Name: Measurement of energy:** • Construction, theory and operation of AC energy meter. • Testing of Energy meters.	**6**	**CO5**
Module:6	**Module Name: Electronic instruments:** • Measurement of Voltage, current, frequency & phase by oscilloscope. Frequency limitation of CRO, Double beam CRO. • Sampling and storage oscilloscope. • Digital voltmeter. Digital multimeter. Digital frequency meter. • LCR meter. Impedance analyzer.	**12**	**CO6**

	• Vector Network Analyzer. • Spectrum Analyzers.		

Text Books:

- A course in Electrical & Electronic Measurements & Instrumentation; A.K. Sawhney, Dhanpat Raiand sons.
- Electrical MeasurementsandMeasuringInstruments;E.WGolding&F.C.Wides,Wheeler Publishing
- Electronic Instrumentation; H.S.Kalsi,TataMcGrawhill, 2ndedition

Reference Books:

- Digital Instrumentation; A.J.Bouwens, Tata Mc GrawHill
- Modern Electronic Instrumentation &Measuring Instruments; A.D.Heltrick & W.D. Cooper, W heeler Publishing.

CO-PO Mapping

COs ↓ / POs →	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PC-EI 401.1	3	2	-	1	2	-	-	-	-	-	2
PC-EI 401.2	3	2	2		2	-	-	-	-	-	2
PC-EI 401.3	3	3	2	2	3	-	-	-	-	-	2
PC-EI 401.4	3	2	2	2	3	-	-	-	-	-	2
PC-EI 401.5	3	2	2	2	3	1	1	1	-	-	2
PC-EI 401.6	3	2	2	2	3	-	-	-	1	1	3

CO-PSO Mapping

COs ↓ / POs →	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)
PC-EI401.1	2	3	1
PC-EI401.2	2	3	1
PC-EI401.3	3	3	1
PC-EI401.4	3	3	1
PC-EI401.5	2	3	1
PC-EI401.6	3	3	2

SWAYAM/NPTEL Courses for Integration

Course Name	Instructor	Platform	Link
Electrical Measurement and Electronic Instruments	Prof. Avishek Chatterjee (IIT Kharagpur)	NPTEL/SWAYAM	https://nptel.ac.in/courses/108105153

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/ 30)
		L	T	P	SL		
PC-EI 401	Electrical & Electronics Measurements	42	14	-	64	120	4

Microprocessor and Microcontroller

Course Name: Microprocessor and Microcontroller	**Category: Professional Core**
Course Code: PC-EI 402	**Semester: 4^{th}**
L-T-P: 3-1-0	**Credit: 4**
Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs.	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
Tutorial: 1 Hr.	End Semester Exam.: 70 Marks
Total Lectures: 48 Hrs	

Pre-Requisites: Prerequisites for the Optical Instrumentation subject typically include the following:

1. **Digital Electronics**: Knowledge of Digital Electronics, including logic gates, flip-flops, counters, memory elements, and basic digital system architecture.
2. **Basic Computer Organization**: Understanding of basic computer organization, such as CPU structure, instruction execution cycle, memory and I/O operations.
3. **Programming Fundamentals:** Familiarity with fundamental programming concepts, including loops, conditionals, and flow control using C or assembly-level syntax.

Objectives:

The subject aims to encourage the students with the following:

1. Introduce the fundamental architecture and operation of microprocessors (8085, 8086) and microcontrollers (8051).
2. Develop the ability to write and debug assembly language programs for microprocessors and microcontrollers.
3. Explain memory organization, interrupt handling, and timing diagrams for understanding system-level processor operations.
4. Familiarize students with peripheral interfacing techniques including PPI (8255), ADCs, DACs, displays, timers, and serial communication.
5. Enable students to design basic embedded systems using microcontrollers for real-time applications.
6. Build a foundation for advanced topics in embedded systems, robotics, and automation.

Course Outcomes (COs):

On completion of this course, the student will be able to

CO No.	Course Outcome Statement
CO1	*Explain the architecture, memory organization, and interrupt structure of the 8085 microprocessor.*
CO2	*Develop Assembly Language Programs (ALP) using loops, subroutines, and stack operations in 8085.*
CO3	*Analyze the configuration and interfacing techniques of the 8255 Programmable Peripheral Interface.*

CO4	*Use instruction sets and addressing modes to write programs for data manipulation in 8051.*
CO5	*Evaluate peripheral interfacing methods such as timers, ADC, DAC, and interrupts in 8051-based systems.*
CO6	*Summarize the architectural features and memory organization of the 8086 microprocessor.*

Course Details:

Module No.	Description of Topics	Contact Hrs.
Module 1	**Introduction to 8085 Microprocessor:**	**CO 1**
	Hardware Architecture, pinouts – Functional Building Blocks of Processor – Memory organization and interfacing–I/O ports and data transfer concepts– Timing Diagram – Interrupts.	**13**
Module 2	**Programming of 8085 Microprocessor:**	**CO 2**
	Instruction -format and addressing modes – Assembly language format – Data transfer, data manipulation & control instructions – Programming: Loop structure with counting & Indexing –Look up table – Subroutine instructions – stack.	**13**
Module 3	**Peripheral Interfacing:**	**CO 3**
	Architecture, configuration and interfacing, with 8255.	**5**
Module 4	**8051 Micro Controller:**	**CO 4**
	Schematic diagram of intel-8051, microcontroller registers, oscillators, ports, memory, timers/counters, special function registers, Addressing modes. Instructions related to Data Transfer and Manipulation, Arithmetic, Logical and Brunch operations. Explanation with examples of programming related to topic.	**11**
Module 5	**8051 Micro Controller and Peripheral Interfacing:**	**CO 5**
	Introduction to the Timer/Counter, Serial Communication and Interrupts: operations, special function registers and programming on required. Interfacing with Peripheral Input/Output Devices: ADC, DAC, Display.	**10**
Module 6	**Architecture of Typical 16-Bit Microprocessors (Intel 8086):**	**CO 6**
	Introduction to a 16 bit microprocessor, Architecture and Register Organization, Memory address space and data organization.	**4**
	Total	**56**

Text Books:

1. Ramesh S. Gaonkar, Microprocessor Architecture, Programming and Applications with the 8085A /8080A, WILEY EASTERN LIMITED.
2. Mohamed Ali Mazidi, Janice Gillispie Mazidi, Rolin McKinlay, "The 8051 Microcontroller and Embedded Systems: Using Assembly and C", Second Edition, Pearson education, 2011.
3. A.H. Mukhopadhyay, Microprocessor, Microcomputer and Their Applications, 3rd Edition Alpha Science International, Ltd. Digital Fundamentals by T.L. Floyd & R. P. Jain (Pearson).

Reference Books:

1. Soumitra Kumar Mandal, Microprocessor & Microcontroller Architecture, Programming &Interfacing using 8085, 8086, 8051, McGraw Hill Edu., 2013.

Online Resources:

SWAYAM/NPTEL Courses

Course Name	Instructor	Platform
Microprocessors And Microcontrollers	Prof. Santanu Chattopadhyay (IIT Kharagpur)	NPTEL/SWAYAM
Microprocessors and Interfacing	Prof. Shaik Rafi Ahamed (IIT Guwahati)	NPTEL/SWAYAM
Digital Electronics & Microprocessor	Dr. V. Jeyalakshmi (College of Engineering, Anna University, Chennai)	NPTEL/SWAYAM

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
PC-EI 402	Microprocessor & Microcontroller	42	14		64	120	4

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	1	1	1	-	-	-	-	2
CO2	3	3	2	1	2	1	-	1	1	1	2
CO3	3	3	2	2	2	2	-	1	1	1	2
CO4	3	2	2	1	2	1	-	1	1	1	2
CO5	3	3	3	2	2	2	-	1	1	1	2
CO6	3	2	1	1	1	1	-	-	-	-	2

CO-PSO Mapping:

COs	PSO1 Electronics & Computer Systems	PSO2 Instrumentation & Industrial Automation	PSO3 Interdisciplinary, Research & Higher Studies
CO1	3	2	1
CO2	3	2	1
CO3	3	3	1
CO4	3	2	1
CO5	3	3	2
CO6	3	2	1

Control System

Course Name: Control System	**Category: Professional Core**
Course Code: PC-EI 403	**Semester: 4th**
L-T-P: 3-1-0	**Credit: 4**
Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs	3- Continuous Assessment: 30Marks (CA-1, CA-2, CA-3)
Tutorial: 1 Hrs	End Semester Exam.: 70 Marks
Total Lectures: 48 Hrs	

Pre-Requisites: Prerequisites for the Digital Electronics subject typically include the following:

1. **Basic Electrical and Electronics Engineering**: Understanding of fundamental electrical concepts such as voltage, current, resistance, and Ohm's law, as well as basic circuit theory.
2. **Mathematics**: Knowledge of algebra, matrix, Laplace transform

Objectives:

The subject aims to encourage the students with the following:

1. To introduce the fundamental concepts of control systems including open-loop and closed-loop systems, feedback, and system modeling.

2. To develop the ability to model and represent dynamic systems (electrical, mechanical, and electromechanical) using transfer functions and block diagrams.

3. To equip students with tools to analyze system behaviour in time and frequency domains, focusing on stability, steady-state error, and transient response.

4. To provide knowledge of classical methods such as Routh–Hurwitz, root locus, Bode plots, and Nyquist plots for analyzing and designing control systems.

5. To impart skills for designing and tuning controllers and compensators (P, PI, PD, PID, lead/lag), ensuring desired system performance.

6. To introduce simulation tools and practical applications in control systems using MATLAB/Simulink or equivalent platforms for real-world validation.

Course Outcomes (COs):

On completion of this course, the student will be able to

CO1. Understand the basic concepts of feedback control systems, types of control systems, and their practical applications.

CO2. Model electrical, mechanical, and electromechanical systems using differential equations, transfer functions, and block diagrams.

CO3. Analyze time-domain behavior of first- and second-order systems, and compute steady-state errors and transient response specifications.

CO4. Evaluate system stability using Routh–Hurwitz, root locus.

CO5.Evaluatesystem stability usingBode plot, and Polar plot and Nyquist stability criteria.

CO6.Designcontrollers and compensators (P, PI, PD, PID, lead, lag) to meet desired system performance specifications.

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Module Name: Introduction to Control Systems**	**CO1**
	➢ Introduction to Digital system, Data and number systems,Analog vs. Digital ➢ Open-loop vs. closed-loop control ➢ Classification: Linear, Non-linear; Time-variant/invariant; Continuous/discrete systems ➢ Transfer function and system representation ➢ Feedback concept and advantages	**6**
	Text Book Resources: **Book name, Chapter No.** Online Resources: If applicable	
Module: 2	**Module Name: Mathematical Modeling of Physical Systems**	**CO2**
	➢ Modeling of electrical systems (RLC circuits) ➢ Modeling of mechanical systems (mass-spring-damper) ➢ Analogies between mechanical and electrical systems ➢ Transfer function derivation from differential equations ➢ Block diagram representation and reduction techniques ➢ Signal flow graphs and Mason's Gain Formula	**6**
	Text Book Resources: **Book name, Chapter No.**	
Module: 3	**Module Name: Time Domain Analysis**	**CO3**
	➢ Standard test signals: step, ramp, impulse, parabolic ➢ First-order and second-order system response ➢ Time-domain specifications: Rise time, settling time, peak time, peak overshoot ➢ Effect of damping ratio and natural frequency ➢ Steady-state error and error constants (position, velocity, acceleration) ➢ System type and order	**12**
	Text Book Resources: **Book name, Chapter No.**	
Module: 4	**Module Name: Stability and Root Locus Analysis**	**CO4**

	➢ Concepts of stability: BIBO and asymptotic stability ➢ Routh–Hurwitz stability criterion ➢ Relative stability measures ➢ Root locus technique: Basic rules, construction, breakaway points, angle and magnitude criteria ➢ Effect of pole-zero addition on root locus	**12**
	Text Book Resources: Book name, Chapter No.	
Module: 5	**Module Name: Frequency Domain Analysis**	**CO5**
	➢ Frequency response basics ➢ Bode plot: Construction, phase/gain margins. ➢ Polar plot and Nyquist criterion ➢ Correlation between time and frequency domain ➢ Concept of bandwidth, resonance, and quality factor	**6**
	Text Book Resources: Book name, Chapter No.	
Module: 6	**Module Name: Control System Design and Compensation**	**CO6**
	➢ Performance criteria: Transient response, steady-state error, stability ➢ Design of controllers: P, PI, PD, PID. ➢ Design of lead, lag, lead-lag compensators ➢ Tuning of PID controllers (Ziegler-Nichols method) ➢ Introduction to state-space representation (optional) ➢ Controllability and observability (brief intro)	**6**
	Text Book Resources: Book name, Chapter No.	
	Total	**48**

Text Books:

Text/References:

1. Automatic Control System: Basic analysis and design by William A. Wolovich, The Oxford Series in Electrical and Computer Engineering.

2. B. C. Kuo, "Automatic Control System", 10th McGraw Hill.

3. K. Ogata, "Modern Control Engineering", Prentice Hall, 5th edition.

4. I. J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International, 2009

5. Control Systems Engineering, 6th edition, ISV (WSE), by Norman Nise, Wiley

6. Control Systems, Ambikapathy, Khanna Publishing House, 2018.

7. Control Systems, N K Sinha, New Age International Pvt, 2013.

SWAYAM/NPTEL Courses for Integration

S.No	Course Title	Instructor	Institution	Platform	Link

1	Control Engineering	Prof. S.D. Agashe	IIT Bombay	NPTEL/SWAYAM	View Course
2	Control Systems	Prof. M. Gopal	IIT Madras	NPTEL/SWAYAM	View Course
3	Control Engineering	Prof. A. N. Jha	IIT Roorkee	NPTEL/SWAYAM	View Course
4	Feedback Control System	Prof. B. Bandyopadhyay	IIT Bombay	NPTEL/SWAYAM	View Course
5	Advanced Control Systems	Prof. Madan Gopal	IIT Kanpur	NPTEL	View Course
6	Modern Control Systems	Prof. C.S. Shankar Ram	IIT Madras	NPTEL	View Course
7	Classical and Modern Control Systems Analysis	Prof. S. Doolla	IIT Bombay	NPTEL/SWAYAM	View Course

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
PC-EI 403	Control System	42	14		64	120	4

CO-PO Mapping

COs ↓ / POs →	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	-	–	–	–	–	–	–	–	–	–
CO2	3	3		–	–	–	–	–	–	–	–
CO3	3	2	-	3	-	–	–	-	-	–	–
CO4	-	2	-	2	1	–	–	-	-	–	–
CO5	-	-	3	-	2	–	–	–	–	–	2
CO6	3	3	3	-	3	2	2	2	-	-	1

CO-PSO Mapping

	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)

CO1	3	2	1
CO2	3	2	1
CO3	3	3	2
CO4	3	3	2
CO5	2	3	2
CO6	3	2	3

Justification of CO-PO Mapping

CO Code	Mapped POs	Justification
CO1Understand basic concepts of control systems and types of feedback.	**PO1,**	- PO1: Provides foundational knowledge in engineering principles to understand control system behavior
CO2Model electrical and mechanical systems using transfer functions and block diagrams.	**PO1, PO2,**	- PO1: Uses mathematical fundamentals. PO2: Involves problem formulation and abstraction through system modeling.
CO3Analyze time-domain response and calculate performance indices.	**PO1, PO2, PO4**	- PO1: Applies engineering fundamentals. PO2: Solves well-defined engineering problems. PO4: Interprets impact of system parameters.
CO4Evaluate system stability using Routh, root locus, Bode, and Nyquist methods.	**PO2, PO4, PO5**	- PO2: Critical evaluation of stability. PO4: Investigates complex engineering problems. PO5: Uses modern tools (e.g., MATLAB) for analysis.
CO5Design PID controllers and compensators to meet system performance..	**PO3, PO5**	- PO3: Design of solutions for complex control systems. PO5: Involves software tools for controller tuning.
CO6Simulate and validate control systems using MATLAB/Simulink or equivalent tools.	**PO1-3, PO5-PO8, PO11**	- PO1-3,PO5: Use of simulation tools. PO12: Recognizes need for lifelong learning through tool-based experimentation.

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
Engineering Knowledge	Problem Analysis	Design/ Dev. Solutions	Investigations	Engineering Tool Usage	Engineer and The World	Ethics	Collab. Team Work	Communication	Project Mgmt	Life-Long Learning

Rubrics for CO Attainment

Assessment Method	Attainment Level 1 (Low)	Attainment Level 2 (Moderate)	Attainment Level 3 (High)
Internal Test	Avg. score < 40% of max marks	Avg. score between 40% – 60%	Avg. score > 60%
End Semester Exam	Avg. score < 40% of max marks	Avg. score between 40% – 60%	Avg. score > 60%

Module-wise Structure & Learning Outcomes

Module	Topic	Contact	Module Learning Outcomes

No.		Hrs	
1	Introduction to Control Systems	6	- Understand the difference between open-loop and closed-loop systems - Describe various types of control systems and their practical applications. - Explain the concept of feedback and its advantages in system stability and accuracy
2	Mathematical Modeling of Systems	6	- Derive differential equations for electrical and mechanical systems. - Develop transfer function models from physical system representations.
3	Time Domain Analysis	12	- Analyze the transient and steady-state behavior of first- and second-order systems -Calculate time-domain specifications like rise time, settling time, and overshoot. - Determine steady-state errors using static error constants.
4	Stability and Root Locus Analysis	12	- Evaluate system stability using the Routh-Hurwitz criterion. - Determine gain and pole-zero positions that satisfy desired performance.
5	Frequency Domain Analysis	6	- Plot and interpret Bode plots for gain and phase analysis. - Correlate frequency domain specifications with time domain performance.
6	Controllers and Compensators	6	- Design basic PID controllers to achieve desired time response. - Select and implement compensators (lead, lag, lead-lag) for performance improvement.

Electromagnetic Theory

Course Name: Electromagnetic Theory	**Category: Professional Core**
Course Code: ES-EI 401	**Semester: 4th**
L-T-P: 3-0-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs/week	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
Tutorial: 0 Hrs	End Semester Exam.: 70 Marks
Total Lectures: 36 Hrs	

Pre-Requisites: Differential and integral calculus

Objectives:

The subject aims to encourage the students with the following:

1. To introduce the basic mathematical concepts related to electromagnetic vector fields.
2. To impart knowledge on the concepts of Electrostatic fields, electrical potential, energy density and their applications.
3. To impart knowledge on Magnetostatic fields, magnetic flux density, vector potential and its applications.
4. To study different methods of e.m.f. generation and Maxwell's equations.
5. To understand Electromagnetic waves and characterizing parameters.

Course Outcomes (COs):

On completion of this course, the student will be able to

PC-EI 403.1 Understand the basic laws of electromagnetism.

PC-EI 403.2 Obtain the electric and magnetic fields for simple configurations under static conditions.

PC-EI 403.3 Analyze Maxwell's equations in time varying electric and magnetic fields.

PC-EI 403.4 Understand the propagation of EM waves.

PC-EI 403.5 Analyze transmission line parameters, propagation constant and characteristic impedance.

PC-EI 403.6 Apply vector calculus and electromagnetic theory concepts to practical engineering problems

CO Design Notes:

- **CO1** focuses on the fundamental laws of electromagnetism and lays the foundation for further modules.
- **CO2** ties directly to electrostatics and Magnetostatics, emphasizing field computation under static conditions.
- **CO3** links to Maxwell's equations and their applications in time varying fields.
- **CO4** is aligned with EM wave propagation, reflection, and polarization concepts.
- **CO5** connects with transmission line analysis, propagation constants, and impedance matching.
- **CO6** integrates vector calculus with electromagnetic concepts to solve practical engineering problems.

Module No.	Description of Topics	Contact Hrs.
	Module Name: Coordinate Systems and Vector Calculus	CO1
Module: 1	➢ Introduction to Field Theory ➢ Co-ordinate systems and transformation: Cartesian coordinates Circular cylindrical coordinates, Spherical coordinates & their transformation. Differential length, area and volume in different coordinate systems. Solution of problems. ➢ Introduction to Vector calculus: DEL operator, Gradient of a scalar, Divergence of a vector & Divergence theorem, Curl of a vector & Strokes theorem, Laplacian of a scalar, Classification of vector fields, Helmholtz's theorem. Solution of problems.	**9**
	Module Name: Electrostatics	CO2
Module: 2	➢ Coulomb's Law and concept of Electric Field ➢ The Divergence Theorem and Gauss' Law ➢ Concept of Electrostatic Potential, Poisson's Equation ➢ Energy Density in the Electrostatic Field ➢ Dielectrics, dielectric boundary conditions ➢ Solution of Laplace's Equation and Poisson's Equation	**6**
	Module Name: Magnetostatics	CO3
Module: 3	➢ Force due to a Magnetic field, , Biot-Savart Law. ➢ Calculation of Magnetic Field for simple coil configurations. ➢ Magnetic flux density Ampere's Law, calculation of magnetic flux density. ➢ Force due to combined Electric and Magnetic fields. ➢ Magnetic materials, magnetic boundary conditions, Solution of problems.	**6**

Module: 4	**Module Name: Electromagnetism**	**CO4**
	➢ Electromagnetic fields, Faraday's law, Transformer and motional e.m.f. ➢ Displacement current, Maxwell's equations ➢ Time varying Potential, Time harmonic fields. ➢ Solution of problems.	**4**
Module: 5	**Module Name: Electromagnetic wave propagation**	**CO5**
	➢ Wave equation, Wave propagation in lossy dielectric, Plane waves in loss less dielectric, Plane wave in free space, Plane wave in good conductor, Skin effect, Skin depth, Power & Poynting vector. ➢ Reflection of a plane wave at normal incidence, reflection of a plane wave at oblique incidence, Reflection of a plane wave at normal incidence, Polarization. ➢ Solution of problems.	**7**
Module: 6	**Module Name: Transmission line**	**CO6**
	➢ Concept of lump & distributed parameters, Line parameters of transmission line, Transmission line equation & solutions. ➢ Propagation constants, Characteristic impedance, Wavelength, Velocity of propagation of transmission line. ➢ Solution of problems.	**4**
	Total	**36**

Text Books:

1. Principles and Applications of Electromagnetic Fields - Plonsey, R.and Collin, R.E., McGraw Hill.1961.
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

Reference Books:

1. M. N. O. Sadiku, "Elements of Electromagnetics", Oxford University Publication, 2014.
2. Engineering Electromagnetics - William H. Hayt, Jr. FifthEdition.TMH.1999.

Signals and Systems

Course Name: Signals and Systems	**Category: Professional Elective Course-I**
Course Code: PE-EI 401A	**Semester: 4th**
L-T-P: 2-1-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
Tutorial: 1 hr	End Semester Exam.: 70 Marks
Total Lectures: 36	

Pre-Requisites:

To ensure effective learning and comprehension of the concepts in Signal and System, students are expected to have foundational knowledge and skills in the following areas:

- Knowledge of basic calculus, differential equations, linear algebra, circuit theory, introductory signals and systems, and complex number operations.

Objectives:

This course aims to introduce fundamental signal and system concepts, mathematical analysis, practical signal processing techniques, and prepares students for advanced studies and professional engineering practice.

The subject aims to encourage the students with the followings:-

1. **Understand Signals and Systems:** To introduce fundamental concepts of signals, their representations, and basic system classifications.
2. **Master Mathematical Tools:** To develop proficiency in using Fourier and Laplace transforms for signal and system analysis.
3. **Analyze and Design Systems:** To enhance understanding of system behavior and design, focusing on efficient signal transmission and processing.
4. **Apply Signal Processing Techniques**: To explore practical applications of signal processing, including sampling, convolution, and system realization.
5. **Prepare for Advanced Studies:** To prepare students for further studies and professional practice in signal processing and related fields.

Course Outcomes (COs):

On completion of this course, the student will be able to

PE-EI 401A.1. **Represent** and **classify** various types of signals and systems while performing standard operations and basic realizations.
*(Cognitive Level: **Understand**, Knowledge Category: **Conceptual**)*

PE-EI 401A.2. **Analyze** the behavior of linear time-invariant systems using convolution, correlation, and system properties.
*(Cognitive Level: **Analyze**, Knowledge Category: **Procedural**)*

PE-EI 401A.3. **Examine** signals and systems in the frequency domain using Fourier series, Fourier transform, and DFT techniques.
*(Cognitive Level: **Analyze**, Knowledge Category: **Procedural**)*

PE-EI 401A.4. **Apply** Laplace transform to model, interpret, and **solve** continuous-time system responses and system characteristics.
*(Cognitive Level: **Apply**, Knowledge Category: **Procedural**)*

PE-EI 401A.5. **Apply** Z-transform for discrete-time system modeling, stability analysis, and frequency response evaluation.
*(Cognitive Level: **Apply**, Knowledge Category: **Procedural**)*

PE-EI 401A.6. **Evaluate** sampling techniques and **design** appropriate reconstruction methods while assessing aliasing effects.
*(Cognitive Level: **Evaluate**, Knowledge Category: **Procedural**)*

Syllabus Details

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Module Name: Introduction to Signal and System:**	PE-EI 401A.1
	Classification of Signals, Operation on Continuous Signals and Discrete Signals, Properties of Signals. Classification of Systems and Properties of Systems. **Signal Approximation and Fourier Series:** Orthogonal functions, Fourier series (trigonometric & exponential), complex coefficients, periodic signal representation.	5
Module: 2	**Module Name: Linear Time-Invariant System**	PE-EI 401A.2
	Discrete-Time LTI Systems: The Convolution sum, Continuous-Time LTI systems: The Convolution Integral, Properties of LTI systems: causality, memory, stability, invertibility etc. Representation of Causal LTI using Differential and Difference equations. Convolution of Finite Sequences, Correlation, Energy density spectrum, Parseval's theorem, Power density spectrum, Relation between convolution and correlation	7
Module: 3	**Module Name: Frequency Analysis of Signal and Systems**	PE-EI 401A.3
	Frequency Analysis of Continuous-Time Signals, Frequency Analysis of Discrete-Time Signals, Properties of The Fourier Transformation For Continuous- time and Discrete-Time (DTFT) Signals, Frequency-Domain Characteristics of LTI Systems. Structural realization of discrete systems – Direct form – I, Direct form-II, Cascade and parallel forms **Discrete Fourier Transform:** Concept and relations for DFT, Twiddle factors and their properties, computational burden on direct DFT, multiplication of DFTs, circular convolution.	7
Module:	**Module Name: Laplace Transform and System Analysis:**	PE-EI

4		401A.4
	The Laplace transform, Properties of the Laplace transforms, Inversion of the Laplace transform, System Analysis using Laplace Transform: Representation of Linear Time-Invariant (LTI) systems in the Laplace domain Transfer function and its interpretation, Poles and Zeros of a system and their significance in system behavior, Analysis of system stability and causality using pole-zero plots and ROC, Response of LTI systems (zero-input and zero-state) using Laplace Transform	5
Module: 5	**Module Name: Z-Transform and Discrete System Analysis**	PE-EI 401A.5
	Definition of **Bilateral (two-sided)** and **Unilateral (one-sided)** Z-Transform, Region of Convergence (ROC):Definition and types of ROC, ROC for right-sided, left-sided, and two-sided signals, Conditions for causality and stability. Properties of Z-Transform, **Poles and Zeros:** Definition and graphical representation in the z-plane, Pole-zero plot interpretation for system behaviour, Relation between pole locations and system stability. **Inverse Z-Transform, Application to Discrete-Time LTI Systems:** Solving **difference equations** using Z-Transform, **System function (Transfer Function)** in z-domain, **Frequency response** computation from system function, Stability and causality analysis using pole-zero locations and ROC.	7
Module: 6	**Module Name: Sampling and Reconstruction:**	PE-EI 401A.6
	The Sampling Theorem and Its Implications: Spectra of sampled signals. Graphical and analytical proof for Band Limited Signals, Impulse Sampling, Natural and Flat top Sampling. Reconstruction: Ideal interpolator, zero-order hold, first-order hold, and so on. Reconstruction of signal from its samples, Effect of under sampling — Aliasing and its effects. Introduction to Band Pass Sampling, Relation between continuous and discrete time systems.	5
Total		**36**

Text Books:

1. Text Books: 1. I. J. Nagrath, S. N. Sharan, " Signals and Systems" , Tata Mc Graw Hill Publication
2. Alan V Oppenheim, Alan S Willsky and A Hamid Nawab, "Signal and Systems", Pearson Education Asia/ PHI.

Reference Books:

1. B. P. Lathi, "Linear Systems and Signals", Oxford University Press.
2. Ganesh Rao and Satish Tunga, "Signals and Systems", Sanguine Technical Publishers.
3. N. G. Palan, "Digital Signal Processing", Tech Max Publication.
4. Proakis, Digital Signal Processing: Principles, Algorithms and Applications.(PHI).

Online Resources:

Course Name	Instructor	Platform	Link
Introduction to Signals & Systems + Fourier Series	Signals and Systems – NPTEL by Prof. Aditya K. Jagannatham (IIT Kanpur)	YouTube (NPTEL)	Watch Lecture 1–5

	Signals and Systems – NPTEL by Prof. S. C. Dutta Roy (IIT Delhi)	NPTEL	Lecture Series
LTI Systems, Convolution & Correlation	LTI Systems – NPTEL (IIT Kanpur)	YouTube	Watch Lecture 6–10
	Signal Processing Basics (MIT OpenCourseWare)	YouTube	Watch here
Frequency Analysis & DFT	Fourier Transform & DTFT (IISER Bhopal NPTEL)	NPTEL SWAYAM	Week 4–6
	DFT & Twiddle Factors – IITKgp	Digimat/NPTEL	Watch DFT Lectures
Laplace Transform & System Analysis	Laplace Transform – IIT Kanpur (Signals and Systems)	YouTube	Watch Lecture 11–13
	Laplace Transform – IIT Kharagpur (Digital Systems)	NPTEL	Lecture Link
Z-Transform & Discrete Systems	Z-Transform – IIT Kanpur	YouTube	Watch Lecture 14–16
	Z-Transform & Pole-Zero Analysis – IIT Kharagpur	Digimat	Watch here
Sampling & Reconstruction	Sampling Theorem – IITK (NPTEL)	YouTube	Lecture on Sampling
	Reconstruction & Aliasing – Prof. Aditya K. Jagannatham	YouTube	Aliasing Explained

CO-PO Mapping

COs ↓ / POs →	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PE-EI 401A.1	3	3	1	1	2	–	–	–	–	–	1
PE-EI 401A.2	3	3	2	1	2	–	–	–	–	–	1
PE-EI 401A.3	3	3	2	2	3	–	–	2	–	–	2
PE-EI 401A.4	3	3	2	3	1	–	–	–	–	–	2
PE-EI 401A.5	3	3	2	2	3	–	–	2	–	–	3
PE-EI 401A.6	3	3	3	3	3	2	–	3	2	–	3

CO-PSO Mapping

COs ↓ / POs →	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)
PC-EI 501.1	3	2	1
PC-EI 501.2	3	3	1
PC-EI 501.3	3	2	2
PC-EI 501.4	3	3	2
PC-EI 501.5	3	3	2
PC-EI 501.6	2	3	2

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
PE-EI 401A	Signals and Systems	28	14	-	48	90	3

Computer Organization and Architecture

Course Name: Computer Organization and Architecture	Category: Professional Elective
Course Code: PE-EI 401B	**Semester: 4th**
L-T-P: 3-0-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs.	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
Tutorial: NIL	End Semester Exam.: 70 Marks
Total Lectures: 36 Hrs	

Pre-Requisites: Prerequisites for the Optical Instrumentation subject typically include the following:

1. **Basic knowledge of Digital Logic Design:** Number systems, Boolean algebra, Logic gates, Combinational & Sequential circuits.
2. **Fundamental Programming Concepts:** Variables, Instructions, Flow of control.
3. **Basic Mathematical Skills:** Binary math & algebraic manipulation.

Objectives:

The subject aims to encourage the students with the following:

1. Introduce the functional organization of modern computer systems.
2. Explain how data is represented, processed, and stored in digital systems.
3. Develop understanding of CPU architecture, instruction formats, and addressing modes.
4. Familiarize students with arithmetic operations implemented at hardware level.
5. Describe memory hierarchy, cache concepts, and virtual memory organization.
6. Explain input–output interfaces, communication methods, and performance enhancements through pipelining and multiprocessing.

Course Outcomes (COs):

On completion of this course, the student will be able to

CO No.	Course Outcome Statement
CO1	*Describe the fundamental functional units of a computer system and explain basic data representation and execution flow.*
CO2	*Apply arithmetic algorithms to perform integer and floating-point operations used in digital computation.*
CO3	*Analyze CPU organization, instruction formats, addressing modes, and distinguish between CISC and RISC architectures.*
CO4	*Explain register transfer operations and evaluate arithmetic, logical, and shift micro-operations within a CPU.*
CO5	*Compare different memory technologies, cache mapping techniques, and assess virtual memory organization.*
CO6	*Illustrate I/O communication techniques, describe basic pipelining concepts, and outline multiprocessing fundamentals.*

Course Details:

Module No.	Description of Topics	Contact Hrs.
Module 1	**Introduction to Computer Organization:**	**CO 1**
	Functional units of a computer: CPU, Memory, I/O, Control Unit. Von Neumann architecture & system bus structure. Instruction execution cycle, performance measures. Data representation: number systems, signed numbers, floating-point.	**7**
Module 2	**Computer Arithmetic:**	**CO 2**
	Integer arithmetic: addition & subtraction. Multiplication: shift-add, Booth's algorithm. Division: restoring & non-restoring. Floating-point arithmetic.	**8**
Module 3	**CPU Organization & Instruction Set Architecture:**	**CO 3**
	Instruction formats and types. Addressing modes. Register organization & stack organization. CISC vs. RISC. Control Unit: Hardwired control vs. Micro programmed control.	**10**
Module 4	**Register Transfer & Micro-operations:**	**CO 4**
	Register Transfer Language. Arithmetic, Logic & Shift micro-operations. ALU structure — conceptual view.	**7**
Module 5	**Memory Organization & Hierarchy:**	**CO 5**
	Memory hierarchy — concept. Main memory (RAM), ROM basics. Cache memory: mapping (direct, associative, set-associative). Replacement strategies. Virtual memory: paging & segmentation.	**9**
Module 6	**I/O Organization, Pipelining & Multiprocessing:**	**CO 6**
	I/O Interface basics. I/O techniques: programmed I/O, interrupt-driven, DMA. Pipelining fundamentals: speedup, hazards. Introduction to multiprocessing: basic architecture concept.	**7**
	Total	**42**

Text Books:
1. Computer System Architecture – M. Moris Mano, Third Edition, Pearson/PHI.

Reference Books:
1. Computer Organization and Architecture – William Stallings Sixth Edition, Pearson/PHI.
2. Structured Computer Organization – Andrew S. Tanenbaum, 4th Edition, PHI/Pearson.
3. Computer Organization – Car Hamacher, Zvonks Vranesic, Safea Zaky, Vth Edition, McGrawHill.

Online Resources:

SWAYAM/NPTEL Courses

Course Name	Instructor	Platform
Computer Architecture and Organization	Prof. Indranil Sengupta & Prof. Kamalika Datta (IIT Kharagpur)	NPTEL/SWAYAM
Computer Organization & Architecture	Prof. Kamakoti (IIT Madras)	NPTEL/SWAYAM
Computer Architecturer	Prof. Madhu Mutyam (IIT Madras)	NPTEL/SWAYAM

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
PE-EI 401B	Computer Organization and Architecture	42	-	-	48	90	3

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	1	1	-	-	1	1	1	2
CO2	3	2	1	1	1	-	-	1	1	1	2
CO3	3	3	2	2	2	1	-	1	1	2	2
CO4	3	2	1	1	2	-	-	1	1	1	2
CO5	3	2	1	1	2	1	-	1	1	1	2
CO6	3	3	2	2	2	1	-	2	1	2	2

CO-PSO Mapping:

COs	PSO1 Electronics & Computer Systems	PSO2 Instrumentation & Industrial Automation	PSO3 Interdisciplinary, Research & Higher Studies
CO1	3	1	1
CO2	3	1	1
CO3	3	2	2
CO4	3	2	1
CO5	2	2	1
CO6	2	2	2

Economics for Engineers

Course Name: Economics for Engineers	**Category:** Humanities & Social Sciences
Course Code: HM HU 401	**Semester: 4th**
L-T-P: 3-0-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Continuous Assessment: 30Marks
Tutorial: Nil	End Semester Exam.: 70 Marks
Total Lectures: 36	
Pre-Requisites: Mathematics	

Course Objectives:

1. Understand basic economic concepts and their relevance to engineering decision-making and apply economic principles to analyse engineering projects and assess their feasibility.
2. Develop skills in cost estimation, project evaluation, and risk analysis and gain insights into the economic implications of engineering decisions on society and the environment.

Course Outcomes (CO):

HM HU 401.1	Students will **recall** and **explain** fundamental concepts of engineering economics.
HM HU 401.2	Students will **apply** economic principles and techniques to analyze engineering projects and make informed decisions based on economic criteria.
HM HU 401.3	Students will **analyze** project cost structures, estimate costs using appropriate methods, and evaluate cost-effectiveness of the engineering projects using NPV, IRR, BCR etc.
HM HU 401.4	Students will **integrate** economic sustainability considerations into engineering design and decision-making processes by assessing project risk.

Module	**Description of Topics**	**Hrs/ Unit**	**COs**
1.	**Introduction to Engineering Economy:** Origin of Engineering Economy, Principles of Engineering Economy, Role of Engineers in Decision Making	5	1
2.	**Time Value of Money :** .Introduction to Time Value of Money, Simple Interest, Compound Interest, Nominal Interest rate, Effective Interest rate, Continuous Compounding, Economic Equivalence, Development of Interest Formulas, The Five Types of Cash flows, Single Cash flow Formulas, Uneven Payment Series, Equal Payment Series	**8**	3,4

3.	**Methods of comparison of alternatives:** NPV, Profitability Index or Benefit Cost Ratio, Payback Period Method, Equivalent Worth Methods, Present Worth Method, Future Worth Method, Annual Worth Method, Rate of Return Methods (IRR and ARR)	**8**	3,4
4.	**Engineering Costs:** Elements of cost (Fixed, Variable, Marginal & Average Costs, Sunk Costs, Opportunity Costs, Recurring And Nonrecurring Costs, Incremental Costs, Cash Costs vs Book Costs, Life-Cycle Costs)	3	2
5.	**Engineering Costs Estimation:** cost estimation models (Per-Unit Model, Segmenting Model, Cost Indexes, Power-Sizing Model, Improvement & Learning Curve), Concept of Revenue, Break even analysis, Cost sheet.	5	2
6..	**Inflation And Price Change:** Definition, Effects, Causes, Price Change with Indexes, Types of Index, Composite vs Commodity Indexes, Use of Price Indexes In Engineering Economic Analysis, Cash Flows that inflate at different Rates.	7	2

1. Donald Newnan, Ted Eschembach, Jerome Lavelle: Engineering Economics Analysis, OUP
2. R. Paneer Seelvan: Engineering Economics, PHI
3. Sullivan and Wicks: Engineering Economy, Pearson
4. John A. White, Kenneth E. Case, David B. Pratt: Principle of Engineering Economic Analysis, John Wiley
5. James L. Riggs, David D. Bedworth, Sabah U. Randhawa: Economics for Engineers 4e,Tata Mc Graw – Hill

CO–PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
HM HU 401.1	2	2	1	–	–	1	1	1	–	1	2
HM HU 401.2	2	3	2	–	–	2	1	1	–	1	3
HM HU 401.3	2	3	3	1	1	1	1	1	–	1	3
HM HU 401.4	1	3	3	–	–	2	2	1	–	1	3

CO–PSO Mapping

CO \ PSO	PSO1 (Electronics & Computing)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Sustainable Engineering)
HM HU 401.1	–	–	1
HM HU 401.2	1	1	2
HM HU 401.3	1	1	2
HM HU 401.4	–	1	3

Electrical & Electronic Measurements Lab

Course Name: Electrical & Electronic Measurements Lab	**Category:** Professional Core
Course Code: PC-EI 491	**Semester:** 4th
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination scheme:**
Tutorial: Nil	External Assessment:60
Practical: 3 hrs./week	Internal Assessment:40
Credit Points: 1.5	

Course Outcomes:	
PC-EI 491. 1	**Design** and **implement** bridge circuits to measure inductance, capacitance, resistance, and frequency.
PC-EI 491. 2	**Evaluate** calibration accuracy of analog measuring instruments using potentiometric methods.
PC-EI 491. 3	**Analyze** static and dynamic characteristics of measuring systems for improved measurement accuracy and reliability.
PC-EI 491. 4	**Apply** theoretical and practical skills to innovate solutions using spectrum analyzers and digital multimeters.
Pre-Requisite:	
	Basic Electrical Engg., Network Theory, Mathematics etc.

Experiment No.	Laboratory Experiments	COs
1.	Calibration of dynamometer type Ammeter and voltmeter by Potentiometer.	CO2
2.	Measurement of Low Resistance using Kelvin Double Bridge.	CO1
3.	Measurement of frequency by Wien Bridge.	CO1
4.	Measurement of inductance by Anderson Bridge.	CO1
5.	Measurement of capacitance by De-Sauty Bridge.	CO1
6.	Study the Static Characteristics of a Measuring Instrument.	CO3
7.	Study the Dynamic Characteristics of a Measurement System.	CO3
8.	Wave and Spectrum Analysis using Q – Meter.	CO4
9.	Acquaintance with basic Structure of Digital Multi Muter and Measurement of Different Electrical Parameters.	CO4
10.	Study the static and dynamic characteristics of VCO.	CO3

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
PC-EI 491	Electrical & Electronic Measurements Lab			42	3	45	1.5

CO-PO Mapping

COs ↓ / POs →	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PC-EI 491. 1	3	2	3	2	2	1	1	-	1	1	2
PC-EI 491. 2	3	3	2	3	2	1	1	1	1	2	2
PC-EI 491. 3	3	3	2	3	3	1	1	1	2	2	3
PC-EI 491. 4	3	2	3	2	3	1	1	1	2	2	3

CO-PSO Mapping

COs ↓ / POs →	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)
PC-EI 491. 1	3	3	2
PC-EI 491. 2	2	3	2
PC-EI 491. 3	2	3	3
PC-EI 491. 4	3	3	3

Microprocessor and Microcontroller Laboratory

Course Name: Microprocessor and Microcontroller Laboratory	**Category:** Professional Core
Course Code: PC-EI 492	**Semester:** 4th
Duration: 6 months	**Maximum Marks: 100**
L-T-P: 0-0-3	**Credit: 1.5**
Teaching Scheme	**Examination scheme: Maximum marks:**
Tutorial: Nil	External Assessment:60
Practical: 3 hrs./week	Internal Assessment:40
Credit Points: 1.5	

Course Outcomes (COs):

On completion of this course, the student will be able to

Course Outcomes:	
CO. 1	**Explain** the architecture, memory organization, and interrupt structure of **8085, 8051**, and **8086** microprocessors/microcontrollers.
CO. 2	**Develop** and **execute** assembly language programs for 8085 and 8051 using **loops, subroutines, stack** operations, and data manipulation instructions.
CO. 3	**Analyze** and **demonstrate** interfacing techniques of **8255** PPI with microprocessors and microcontrollers.
CO. 4	**Evaluate** and **implement** peripheral interfacing with microcontrollers involving timers, **ADC, DAC,** and **interrupts**.
Pre-Requisite:	
Basic Digital Electronics, Microprocessor and Microcontroller Fundamentals, Assembly Language Concepts and Interfacing Concepts.	

Course Details:

Experiment No.	Laboratory Experiments	COs
1	a) Familiarization with 8085 trainer kit components. b) Familiarization with 8085 simulator on PC.	1
2	Study of prewritten programs using 8085 Kit / Simulator for i. Logical operation (AND, OR, NOT, NAND, NOR, XOR, XNOR) ii. Arithmetic operation (Addition, Subtraction, Multiplication, Division) iii. Copying and Shifting a block of memory iv. Packing and unpacking of BCD numbers v. Find 1's and 2's complement of a 16-bit number vi. Reverse a 16 bit number vii. String Matching viii. Any other on need	2
3	a) Familiarization with 8051 trainer kit components. b) Familiarization with 8051 simulator on PC.	1

4	Study of prewritten programs using 8051 Kit / Simulator for i. Logical operation (AND, OR, NOT, NAND, NOR, XOR, XNOR) ii. Arithmetic operation (Addition, Subtraction, Multiplication, Division) iii. Convert an 8 bit number into Grey number iv. Check whether the given 16 bit number is palindrome or not v. Any other on need	2
5	Interfacing with Peripherals and I/O modules: i. 8255 PPI ii. Stepper Motor iii. ADC iv. Temperature sensor v. Relay vi. Any other on need	3, 4

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
PC-EI 492	Microprocessor & Microcontroller Lab			42	3	45	1.5

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	-	1	-	-	1	1	-	2
CO2	3	3	2	1	2	-	-	2	2	1	2
CO3	3	3	3	2	3	1	-	2	2	1	2
CO4	3	3	3	2	3	1	-	2	2	2	3

CO-PSO Mapping:

COs	PSO1 Electronics & Computer Systems	PSO2 Instrumentation & Industrial Automation	PSO3 Interdisciplinary, Research & Higher Studies
CO1	3	2	1
CO2	3	2	1
CO3	3	3	1
CO4	3	3	2

Control System Lab

Course Name: Control System Lab	**Category:** Professional Core
Course Code: PC-EI 493	**Semester:**4th
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination scheme: Maximum marks:**
Tutorial: Nil	External Assessment:60
Practical: 3 hrs./week	Internal Assessment:40
Credit Points: 1.5	

Course Outcomes:	
CO. 1	**Estimate** system transfer function and state space representations and to assess the system dynamic response.
CO. 2	**Estimate and analyze** the system performance using time domain analysis and methods for improving it.
CO. 3	**Design and simulate**the system performance using frequency domain techniques for improving the performance of the system.
CO. 4	**Analyze**the effect of P, PI, and PID actions on a system, To evaluate the stability of the systems and **design** various controllers and compensators to improve system performance.

Experiment No.	**Laboratory Experiments**	COs
1.	Familiarization with MATLAB control system toolbox and MATLAB-SIMULINK toolbox.	CO1
2.	Partial fraction expansion, pole zero and transfer function representation in MATLAB.	CO1
3.	Study of step response for first and second order system with unity feedback and calculation of parameters for different system designs.	CO2
4.	Simulation of impulse response for types 0, 1 and 2 with unity feedback using MATLAB.	CO2
5.	Determination of root-locus, Bode plot, Nyquist plot using MATLAB toolbox for a given second order transfer function and listing of the specifications.	CO3
6.	Determine the effect of P, PI, and PID actions on second order simulated process using MATLAB and Simulink and obtaining the system transfer functions from Bode plot.	CO3
7.	Determination of Lag and lead compensation – Magnitude and phase plot.	CO4
8.	Modeling DC motor in Simulink Toolbox	CO4

Course code	Course Title	Teaching & Learning Scheme						
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
PC-EI 492	Microprocessor & Microcontroller Lab			42	3	45	1.5

CO–PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1 Estimate system transfer function and state space models	3	2	–	1	3	–	–	–	–	–	1
CO2 Analyze system performance using time-domain methods	3	3	2	2	3	–	–	–	–	–	1
CO3 Design & simulate using frequency-domain techniques	3	3	3	2	3	–	–	–	–	–	1
CO4 Analyze PID actions, stability & compensation	3	3	3	2	3	–	–	1	1	–	1

CO–PSO Mapping Table

CO \ PSO	PSO1	PSO2	PSO3
CO1	2	3	1
CO2	2	3	1
CO3	2	3	2
CO4	1	3	2

Course Information

Name of the Course: MICRO PROJECT	**Category:Project Work**
Course Code: PW-EI 481	**Semester: 4th**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination scheme: Maximum marks:**
Tutorial: Nil	Internal Assessment:40
Practical:2 hrs./week	External Assessment:60
Credit Points: 1	

Objectives:

The objective of the micro project is to provide 2nd year AEIE students with hands-on exposure to basic engineering design and implementation. It aims to strengthen fundamental concepts of electronics and instrumentation through the development of a small-scale working prototype, enabling students to apply theoretical knowledge, use laboratory tools, work in teams, and develop essential skills in project planning, execution, and documentation.

Course Outcomes:

At the endofthecourse,astudent willbe ableto:

PW-EI 481.1	Apply fundamental concepts of electronics and instrumentation to design simple circuits or systems for solving basic engineering problems.
PW-EI 481.2	Develop skills in using laboratory tools, instruments, and software to implement and test micro-level engineering solutions.
PW-EI 481.3	Analyze project requirements and select appropriate components, sensors, and interfaces for a functional prototype.
PW-EI 481.4	Demonstrate the ability to work effectively in a team to plan, divide, and execute project tasks within a stipulated period.
PW-EI 481.5	Prepare and present technical documentation, including project reports, circuit diagrams, and performance results, in a structured format.
PW-EI 481.6	Exhibit professional ethics, responsibility, and safety awareness during project design, implementation, and testing.

CO-PO Mapping

PW-EI 481											
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
PW-EI 481.1	3	2	2	1	2	2	-	1			2
PW-EI 481.2	2	-	3	2	3	2	-	1			1
PW-EI 481.3	3	2	2	1	2	2	-	1			1
PW-EI 481.4	-	-	-	-	-	2	2	3	1	2	-
PW-EI 481.5	-	-	1	-	-	2	2	2	3	2	1
PW-EI 481.6	-	-	-	-	-	2	2	2	1	1	1

CO-PSO Mapping

PW-EI 481			
COs	**PSO1**	**PSO2**	**PSO3**
PW-EI 481.1	3	2	1
PW-EI 481.2	3	2	1
PW-EI 481.3	3	2	1
PW-EI 481.4	1	1	1
PW-EI 481.5	1	1	1
PW-EI 481.6	1	2	1

Industrial Instrumentation

Course Name: Industrial Instrumentation	**Category: Professional Core**
Course Code: PC-EI 501	**Semester: 5th**
L-T-P: 3-1-0	**Credit: 4**
Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
Tutorial: 1 Hrs	End Semester Exam.: 70 Marks
Total Lectures: 48 Hrs	

Pre-Requisites:

To ensure effective learning and comprehension of the concepts in Industrial Instrumentation, students are expected to have foundational knowledge and skills in the following areas:

- **Basic Electrical and Electronic Engineering:** Familiarity with analog and digital signal characteristics.
- **Sensors and Transducers:** Awareness of signal conditioning and sensor response characteristics.
- **Engineering Physics:** Conceptual knowledge of pressure, force, temperature, and fluid flow as well as basic principles of thermodynamics and fluid mechanics related to measurement applications.
- **Measurement and Instrumentation**: Basic measurement terminologies such as accuracy, precision, sensitivity, and error types.
- **Circuit Analysis:** Concepts of signal amplification, filtering, and impedance matching.

Objectives:

The subject aims to encourage the students with the following:

1. **To understand the principles and working mechanisms of various temperature measurement devices**, including bimetallic thermometers, RTDs, thermocouples, and radiation thermometers.
2. **To develop a thorough understanding of pressure and vacuum measurement**, including types of pressure, pressure sensors, manometers, electronic transmitters, and vacuum gauges.
3. **To explore fundamental and advanced flow measurement techniques**, including head-type flow meters, variable area meters, and mass flow meters like Coriolis and thermal types.
4. **To learn the measurement techniques for flow in open channels and bulk solids**, and understand the role of installation accessories like manifolds.
5. **To examine various level measurement technologies**, both contact and non-contact types, and their applications in different industrial scenarios.
6. **To understand the classification of hazardous areas and the instrumentation used in such environments**, focusing on safety methods like explosion-proofing and intrinsic safety.

Course Outcomes (COs):

On completion of this course, the student will be able to

PC-EI 501.1. **Select** and **justify** the use of temperature sensors and accessories for specific industrial applications based on performance parameters like accuracy, range, and response time.

*(Cognitive Level: **Apply**, Knowledge Category: **Procedural**)*

PC-EI 501.2. **Analyze** pressure and vacuum measurement systems and **recommend** appropriate devices for accurate and reliable measurements in different process conditions.

*(Cognitive Level: **Analyze**, Knowledge Category: **Conceptual**)*

PC-EI 501.3. **Apply** fluid mechanics principles to measure flow using head-type and variable area flow meters in closed conduit systems.

*(Cognitive Level: **Apply**, Knowledge Category: **Procedural**)*

PC-EI 501.4. **Evaluate** advanced flow measurement technologies and **select** appropriate flow meters for different types of fluids and open channel applications.

*(Cognitive Level: **Evaluate**, Knowledge Category: **Procedural**)*

PC-EI 501.5. **Design** level measurement solutions using appropriate sensors for different tank and vessel conditions considering medium properties and environmental factors.

*(Cognitive Level: **Create**, Knowledge Category: **Procedural**)*

PC-EI 501.6. **Evaluate** hazardous area classifications and **justify** the selection of appropriate protection techniques and certified instrumentation as per international safety standards.

*(Cognitive Level: **Evaluate**, Knowledge Category: **Procedural**)*

Syllabus Details

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Module Name: Measurement of Temperature**	**CO 1**
	Different types of thermometers: Bimetal, thermocouple, RTD, thermistors, IC temperature sensors, radiation thermometers, temperature switches. Thermowell, Temperature simulators and calibrators.	**8**
Module: 2	**Module Name: Measurement of Pressure and Vacuum**	**CO 2**
	Concept of absolute, gauge and differential pressure. Pressure units and measurement principles. Elastic pressure sensors: bourdon tube, bellows, diaphragm and capsule. Manometers. Pressure gauge. Pressure switch. Electronic pressure transmitters: capacitive, piezoresistive and resonator type. Calibration of pressure measuring devices. Installation of pressure measuring devices in different services. Measurement accessories - chemical seal and snubbers. Vacuum measurement: Mcleod gauge, thermal conductivity and ionization gauge.	**10**
Module: 3	**Module Name: Measurement of Flow - I**	**CO 3**
	General concepts - Laminar and turbulent flow, Reynolds's number, Effect of temperature and pressure on flow rate measurement, Calibration of flow meters. Head type flow measurement – analysis and calculation, and head producing devices - orifice, nozzle, venturi, pitot tube, multiport averaging pitot. Differential Pressure Transmitter (DPT): Types, Mounting (Installation), Variable Area Flowmeters – Glass and metal tube rotameters.	**8**

Module: 4	**Module Name: Measurement of Flow - II**	**CO 4**
	Electromagnetic type, Ultrasonic type, Vortex type, Positive displacement type Mass flow meters: Coriolis, Thermal, Impeller type Weirs, Flumes and open channel flow measurement, measurement of flow of bulk solids. Accessories instruments required for installation in industrial application like manifolds.	**8**
Module: 5	**Module Name: Measurement of Level**	**CO 5**
	Review of various level measurement methods, application considerations. Level measurement devices: Gauge glass, float & displacer type level sensors, D/P type level sensors, capacitive level sensors, ultrasonic & microwave level sensors, servo level gauges, conductivity level sensors, radiation level sensors, vibrating level switches. Tank gauging systems.	**8**
Module: 6	**Module Name: Hazardous Area Instrumentation and Safety Standards**	**CO 6**
	Classification of hazardous areas based on site, material, and temperature. Methods of protection: explosion-proof, intrinsic safety, purging, and pressurization. IEC and North American standards, Equipment Protection Level (EPL), NEMA, and IP codes.	**6**
Total		**48**

Text Books:

- D. Patranabis, Principles of industrial Instrumentation, TMH, New Delhi.
- K. Krishnaswamy, S. Vijayachitra, Industrial Instrumentation, New Age International Publishers.
- S. K. Singh, Industrial Instrumentation and Control, McGraw Hill Education.

Reference Books:

- B. G. Liptak, Instrument Engineers Handbook, vol-I and vol-II, Chilton Book Co. Philadelphia
- D. M. Considine and G. D. Considine (Eds.) Process Instruments and controls Handbook, McGraw Hill, New York
- C. R. Alavala, Principles of Industrial Instrumentation and Control Systems, Cengage Learning

Online Resources:

Course Name	Instructor	Platform	Link
Industrial Instrumentation	Prof. Alok Barua (IIT Kharagpur)	NPTEL/SWAYAM	Link
Chemical Process Instrumentation	Prof. Debasis Sarkar (IIT Kharagpur)	NPTEL/SWAYAM	Link

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course	Course Title	Teaching & Learning Scheme

code		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
PC-EI 501	Industrial Instrumentation	36	12	-	72	120	4

CO-PO Mapping

COs ↓ / POs →	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PC-EI 501.1	3	2	2	1	2	1	–	–	–	–	2
PC-EI 501.2	3	3	2	2	2	1	–	–	–	–	2
PC-EI 501.3	3	2	2	1	2	1	–	–	–	–	1
PC-EI 501.4	3	3	2	2	2	2	–	–	–	–	2
PC-EI 501.5	3	2	2	2	2	2	–	–	–	–	2
PC-EI 501.6	3	2	3	2	2	3	2	–	–	–	2

CO-PSO Mapping

COs ↓ / POs →	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)
PC-EI 501.1	1	3	2
PC-EI 501.2	1	3	2
PC-EI 501.3	1	3	2
PC-EI 501.4	1	3	2
PC-EI 501.5	1	3	2
PC-EI 501.6	1	3	2

ProcessControl

CourseName: ProcessControl	**Category:**ProfessionalCore
CourseCode:PC-EI502	**Semester:V**
L-T-P:3-1-0	**Credit:4**
TeachingScheme	**ExaminationScheme**
Theory:3hrs./week	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
Tutorial:1hr./week	EndSemesterExam.:70Marks
TotalLectures:56Hrs	
Pre-Requisites: To understand this course, the learner must have idea of sensor and transducer, industrial instrumentation and control theory.	

Objectives:

This course introduces the fundamental concepts of process control systems used in industrial operations and equips students with the skills to design, analyze, and evaluate different control strategies and final control elements.

The objectives include:

- To study the operation and classification of different types of industrial processes.
- To develop understanding of control modes, control elements, tuning strategies, and modern automation techniques.
- To enable learners to work with advanced industrial control systems such as PLCs, DCS, and SCADA.
- To build the foundation for designing efficient, robust, and adaptive control systems in real-time industrial environments.
- To familiarize students with modern communication protocols like HART and Fieldbus used in process industries.
- To integrate theoretical knowledge with practical applications through simulation tools and modern instrumentation.

Course Outcomes (COs):

PC-EI 601.1: Describe the fundamental concepts of process control, process variables, system classifications, and basic control configurations.

PC-EI 601.2: Explain and analyze various control modes (discontinuous and continuous) and their characteristics with respect to process performance.

PC-EI 601.3: Apply controller tuning methods and evaluate performance using different indices and modern controller implementation approaches.

PC-EI 601.4: Identify, classify, and analyze final control elements, including various types of control valves and their accessories.

PC-EI 601.5: Describe and implement advanced control strategies and basics of PLC architecture, programming, and DCS overview.

PC-EI 601.6: Analyze process transmitters, smart instrumentation, communication protocols (HART, fieldbus), and integration into control systems.

Module-Wise Syllabus

Module No.	Description of Topics	Contact Hrs.
Module: 1	**ModuleName:Introductiontoprocesscontrol**	CO1
	➢ Details:Introduction,Evolutionofprocesscontrol,processcontroland automation,classificationofprocessvariables,openloopandclosedloop systems,servoandregulatorycontrol,compensatoryandanticipatorycontrol configuration. ➢ Process Plant Characteristics Parameter: Self regulation, Process potential, Process quantity and process capacitance, Process resistance, Process time lag	**6**
Module: 2	**ModuleName:Differentcontrolmodes**	CO2
	➢ Details: Discontinuous type: On-off, multi-position, floating control mode. Continuous type: proportional, proportional-integral, proportional-derivative, proportional-integral-derivative, inverse derivative control mode. Some special characteristics like integral windup, integral tracking, bump less transfer, derivative overrun etc. Controller selection guideline, offset minimization. Enhance set point tracking and load rejection in processcontrol.	**10**
Module: 3	**ModuleName:Tuninganddesignof controllers**	CO3
	➢ Details: Controller performance indices, concept of good control, closed loop and open loop tuning methods, comparison of tuning methods. ElectronicandComputer-basedimplementationofController.	**8**
Module:	**ModuleName:Finalcontrolelements**	CO4

4	➢ Details: Classification of control valves, performance and application of different control valves, valve type and construction, valve sizing, valve characteristics, Cavitation, Flashing, valve testing, valveselection guidelines, safety valve and their selection. ➢ Control valve accessories: Air filter regulator, I/P converter, and P/I converter.	**11**
Module: 5	**ModuleName:Modern control**	**CO5**
	➢ Special control features such as Ratio Control, Cascade Control, Split Range Control, and Feedback & Feed forward Control. ➢ Introduction to Programmable Logic Controllers – Basic Architecture and Functions; Input-Output Modules and Interfacing; CPU and Memory; Relays, Timers, Counters and their uses; PLC Programming and Applications. Overview of DCS.	**11**
Module: 6	**ModuleName:Introductionto Processtransmitter**	**CO6**
	➢ Need of transmitter (concept of field area & control room area), Concept of live & dead zero. Types of transmitters: Two, three andfour wire transmitters, Electronic transmitters. ➢ Smarttransmitters-features&advantages,HARTprotocol.Overview of field device networks - Field bus. Third-Party Transmission and Nucleonic Instrumentation.	**10**
	Total	**56**

TextBooks:

1. CurtisDJohnson–ProcessControlInstrumentationTechnology,-Pearson Education/PHI
2. Chemicalprocess control,G.Stephanpoulos,PHI.
3. ProcessControl-Principlesandapplication,S.Bhanot,OxfordUniversitypress.
4. PrincipleofProcesscontrol,D.Patranabis,TMH.
5. AutomaticProcessControl, D.P.Eckman,John Wiley.
6. InstrumentationandProcessControl,D.C.Sikdar,KhannaPublishing House.

ReferenceBooks:

1. Harriot–Processzcontrol,MGH
2. Processcontrolinstrumentationtechnology,C.D.Johnson,PHI
3. ProcessControl,S.K.Singh,PHI.

4. InstrumentEngineersHandbook,B.G.Liptak,ChiltonBookCo.Philadelphia
5. ElementsofChemicalProcessTechnology,O.P.Gupta,KhannaPublishingHouse

Online Resources:

SWAYAM/NPTEL Courses for Integration

Course Title	Instructor / Institute	Platform	Link
Process Control and Instrumentation	A.K. Jana & D. Sarkar, IIT Kharagpur	NPTEL	http://nptel.ac.in/courses/103105064
Industrial Instrumentation	Prof. AlokBarua, IIT Kharagpur	NPTEL	http://nptel.ac.in/courses/108105064
Instrumentation & Process Control in Food Industry	Ashis Kumar Datta, IIT Kharagpur	NPTEL	http://onlinecourses.nptel.ac.in/noc22_ag04/preview

Module wise SWAYAM/NPTEL Courses for Integration

Module	Topic	YouTube / NPTEL / Swayam Link
1	Intro, control loop fundamentals	NPTEL: Introduction to Process Control – IIT KGP / YouTube: Basics of Control System – Neso Academy
2	Control Modes (P, PI, PID etc.)	NPTEL: Advanced Control Systems – Prof. S. Das, IIT Roorkee / YouTube: PID Controller Explained – Real Pars
3	Tuning and Design	NPTEL: Tuning of Controllers – Prof. R. N. Banavar, IITB / YouTube: Ziegler-Nichols Tuning – Learn ChemE
4	Final Control Elements	NPTEL: Process Control Instrumentation – Prof. S. K. Dwivedy / YouTube: Control Valves Basics – Instrumentation Tools
5	PLC/DCS/Modern Control	NPTEL: Industrial Automation and Control – IIT Kharagpur / YouTube: PLC Basics Tutorial – Real Pars
6	Transmitters, HART, Fieldbus	NPTEL: Smart Instrumentation – Prof. T. K. Roy, IIT Kharagpur / YouTube: HART Protocol Explained – Instrumentation Academy

Recommended Software for Process Control Syllabus

Software	Type	Purpose / Use Case
MATLAB / Simulink	Simulation + Control Design	PID tuning, simulation of control systems, process models
Scilab / Xcos	Open Source Solver + Block Simulation	Controller implementation, process loop simulation
LabVIEW	Industrial Automation	Data acquisition, virtual instruments for process control
TIA Portal (Siemens)	PLC Programming	PLC logic, timers, counters, I/O control

Factory I/O	Industrial Simulation	3D visualization of process plants with PLC integration
Proteus / Automation Studio	Circuit + Control Design	Simulate control loops with sensors and actuators

Credit Structure (As per NBA Guidelines)

Course Code	Course Title	Teaching & Learning Scheme	Classroom Instructions (CI) (in hours/sem.)	Lab Instructions (LI) (in hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (in hours/sem.)	Total Hours/sem.	Total Credits (C) (Total Hours/30)
PC-EI 502	Process Control	L: 3, T: 1, P: 0, SL	56	0	84	120	4
PC EI 591	Process Control Lab			42	3	45	1.5

CO–PO Mapping

COs ↓ / POs →	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	–	–	–	–	–	–	–	–	–
CO2	3	3	2	–	–	–	–	–	–	–	–
CO3	3	3	3	2	1	–	–	–	–	–	–
CO4	2	2	3	–	–	2	1	–	–	–	–
CO5	2	2	2	–	3	–	–	–	1	1	1
CO6	2	2	1	–	2	2	1	1	–	–	–

CO–PSO Mapping Matrix

	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)
CO1	1	3	–
CO2	1	3	–
CO3	1	3	–
CO4	–	3	–
CO5	3	2	1
CO6	2	3	1

Electrical Machines

Course Name: Electrical Machines	**Category: Professional Core**
Course Code: PC-EI 503	**Semester: 5th**
L-T-P: 3-0-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs/week	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
Tutorial: 0 Hrs	End Semester Exam.: 70 Marks
Total Lectures: 36 Hrs	

Pre-Requisites: Basic Electrical Engineering

Objectives:

The subject aims to encourage the students with the following:

1. Review concepts of magnetic fields and magnetic circuits relevant to electrical machines.
2. Understand electromechanical energy conversion and production of electromagnetic force and torque.
3. Explain construction, operation and characteristics of DC machines.
4. Explain construction, operation, testing and connections of transformers.
5. Analyze construction, operation and performance of induction and synchronous machines.
6. Develop problem-solving skills to evaluate performance and efficiency of electrical machines.

Course Outcomes (COs):

On completion of this course, the student will be able to

CO1. Explain construction, working principles, and characteristics of DC machines.

CO2. Analyze performance and equivalent-circuit parameters of transformers

CO3. Evaluate torque, slip, and performance characteristics of induction motors.

CO4. Examine operation, characteristics, and synchronization of alternators and synchronous motors.

CO5. Interpret working principles, control methods, and applications of special machines (SRM, BLDC, stepper, servo).

CO6. Apply standard testing methods to estimate efficiency and performance of electrical machines.

CO Design Notes:

- CO1 links with DC machine construction, emf/torque equations, armature reaction, characteristics and speed control.
- CO2 aligns with transformer construction, autotransformer, phasor/equivalent circuits, tests (OC/SC), parallel/three-phase connections, tap-changing.
- CO3 maps to induction machine construction, equivalent circuit, torque–slip, losses, efficiency, and speed-control/braking.
- CO4 covers synchronous generator/motor fundamentals, emf equation, phasor diagrams, V-curves, voltage regulation and synchronization.
- CO5 connects to modern/special drives: SRM, BLDC, stepper, hysteresis and servo motors with drive basics and applications.
- CO6 integrates standardized testing (load, back-to-back), parameter estimation and efficiency evaluation across machines.

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Module Name: Electromechanical Energy Conversion**	**CO1**
	➢ Energy Balance ,Laws of Electromagnetism , Energy Flow , Types of Magnetic system : Singly Excited Magnetic System , Multiple Excited Magnetic System, Detailed Analysis ,Advantages of field Energy Method, Basic Concepts of Rotating Machine	**6**
Module: 2	**Module Name: DC machines**	**CO2**
	➢ Basic construction of a DC machine, linear commutation Derivation of back EMF equation, armature MMF wave, derivation of torque equation, armature reaction, air gap flux density distribution with armature reaction	**4**
Module: 3	**Module Name: DC machine - motoring and generation**	**CO3**
	➢ 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	**6**
Module:	**Module Name: Transformers**	**CO4**

4	➢ Principle, construction and operation of single- phase transformers, 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, Series operation of three phase Transformer ➢ 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.	6
Module: 5	**Module Name: Induction Machines**	**CO5**
	➢ Construction, Types (squirrel cage and slip-ring), Torque Slip Characteristics, Starting and Maximum Torque. Equivalent circuit. ➢ Phasor Diagram, Losses and Efficiency. Effect of parameter variation on torque speed characteristics (variation of rotor and stator resistances, stator voltage, frequency). ➢ Methods of starting, braking and speed control for induction motors. Generator operation. Self-excitation. Doubly-Fed Induction Machines. ➢ Single-phase induction motors: Constructional features, double Revolving field theory, equivalent circuit, determination of parameters. Split-phase starting methods and applications	**10**
Module: 6	**Module Name: Special Electromechanical devices**	**CO6**
	➢ Principle and construction of switched Reluctance motor, , Brushless DC machines, Hysteresis-motor, Servo Motor ,Stepper motor,	**4**
	Total	**36**

Text Books:

1. Electrical Machines-I, P.S. Bimbhra, Khanna Publishing House (AICTE)

2. Electrical Machinery, P.S. Bimbhra, 7th Edition, Khanna Publishers

3. Electric machines, D.P. Kothari & I.J Nagrath, 3rd Edition, Tata McGraw-Hill Publishing Company Limited

4. Electrical Machines, P.K. Mukherjee & S. Chakrabarty, 2nd edition, DhanpatRai Publication.

5. Logic and Prolog Programming, Saroj Kaushik, New Age International.

Reference Books:

1. Electric Machinery & Transformers, Bhag S. Guru and H.R. Hiziroglu, 3rd Edition, Oxford University press.

2. Electrical Machines, R.K. Srivastava, Cengage Learning

3. Theory of Alternating Current Machinery, Alexander S Langsdorf, Tata McGraw Hill Edition.

4. The performance and Design of Alternating Current Machines, M.G.Say, CBS Publishers & Distributors.

5. Electric Machinery & transformer, Irving L Koskow, 2nd Edition, Prentice Hall India

Online Resources:

SWAYAM/NPTEL Courses for Integration

Course Name	Instructor	Platform	Link
Electrical Machines – I	Prof. N. K. Kishore, IIT Kharagpur	NPTEL/SWAYAM	Link
Electrical Machines – II	Prof. Tapas K. Bhattacharya, IIT Kharagpur	NPTEL/SWAYAM	Link
Introduction to Electric Drives	Prof. Abhijit Chakrabarti, IIT Kharagpur	NPTEL/SWAYAM	Link
Electrical Equipment and Machines	Prof. R. K. Behera, IIT Bhubaneswar	SWAYAM	Link
Control of Electric Drives	Prof. Subrata Banerjee, IIT Delhi	NPTEL/SWAYAM	Link

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	**Course Title**	**Teaching & Learning Scheme**					
		Classroom Instructions (CI) (in hours/sem.)		**Lab instructions (LI) (In hours/sem.)**	**Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)**	**Total no. of hours/sem.**	**Total credits (C) (Total Hours/30)**
		L	**T**	**P**	**SL**		
EE-EI 602	Electrical Machine	42	0	0	48	90	3

CO-PO Mapping

COs ↓ / POs →	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2	1	1	-	-	1	1	-	-
CO2	3	3	2	2	2	-	-	1	1	-	-

CO3	3	2	3	2	2	1	-	1	1	-	-
CO4	3	2	3	2	2	1	-	1	1	1	-
CO5	3	2	2	1	2	1	-	1	1	-	-
CO6	3	2	3	3	2	1	-	1	1	1	1

CO-PSO Mapping

	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)
CO1	1	2	1
CO2	1	3	1
CO3	1	3	1
CO4	1	3	1
CO5	1	3	1
CO6	1	3	1

Data Structure & Algorithm

Course Name: Data Structure & Algorithm	**Category:** Engineering Science Course
Course Code: ES-EI 501	**Semester:** 5TH
L-T-P: 3-0-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Continuous Assessment: 30 Marks
Tutorial: Nil	End Semester Exam.: 70 Marks
Total Lectures: 36	
Pre-Requisites: Concept of C-Language	

Objectives:

In view of the notable advancement of data structure in recent few years, it is essential for the students to be familiar with various algorithmic approaches to write program thereby solving problems. The objectives of the course are mentioned below:

1. To represent the significance of algorithms with its properties for solving problems in different engineering domains.
2. To provide the characteristics of various Abstract Data Type for creating the solution- strategies.
3. To demonstrate the significance of non-linear data structures with respect to the access and organization of records.
4. To clarify various sorting and searching algorithms.
5. To expose merits and demerits of altered algorithms in terms of time-complexity.
6. To enhance the ability of selecting appropriate data structure and algorithm for solving specific problems.

Course Outcomes (COs):

Upon successful completion of this course, a student will be able to:

CO1: *Analyze the efficiency of algorithms using asymptotic notations and evaluate their time and space complexity for different problem scenarios.*

CO2: *Design and implement linear data structures such as arrays and linked lists to solve real-life data organization problems efficiently.*

CO3: *Apply stack, queue, and recursive techniques to model and solve computational problems such as expression evaluation and combinatorial puzzles.*

CO4: *Construct and manipulate tree-based structures such as binary trees, binary search trees, and AVL trees to support efficient searching and hierarchical data representation.*

CO5: *Implement and analyze graph representations and traversal algorithms to determine connectivity, shortest paths, and minimal spanning trees in complex networks.*

CO6: *Compare and implement various searching, sorting, and hashing algorithms to optimize data retrieval and storage operations for specific applications.*

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Introduction of Data Structure**	CO1
	Necessity of data structure. Concepts of data structures: a) Data and data structure b) Abstract Data Type and Data Type. Algorithms and properties of an Algorithm, Algorithm efficiency and analysis, time and space analysis of algorithms – order notations like Big-Oh, Big-Omega, Theta.	3
Module: 2	**Array and Linked List Array:**	CO2
	Different representations of arrays– row major, column major. Array representation of polynomials. **Linked List:** Singly linked list, Insertion-Deletion-Display (also in reverse order) Operations of Linked List, circular linked list, doubly linked list, linked list representation of polynomial.	5
Module: 3	**Linear Data Structure Stack and Queue:**	CO3
	Stack and its implementations (using array, using linked list), applications including prefix, infix and postfix expressions of arithmetic expressions. Queue, circular queue, dequeues. Implementation of queue- both linear and circular (using array, using linked list), applications. **Recursion:** Principles of recursion – use of stack, differences between recursion and iteration, tail recursion. Applications - The Tower of Hanoi, Eight Queens Puzzle.	**8**
Module: 4	**Nonlinear Data structures: Trees**	CO4
	Basic terminologies of trees, tree representation (using array, using linked list). Binary trees - binary tree traversal (pre-order, in-order, post- order), threaded binary tree (left, right, full) - non-recursive traversal, algorithms using threaded binary tree, expression tree. Binary search tree- operations (creation, insertion, deletion, searching). Height balanced binary tree – AVL tree explanation with example	**9**
Module: 5	**Module Name: Nonlinear Data structures: Graphs**	CO5
	Graph definitions and concepts (directed/undirected graph, weighted/un-weighted edges, sub-graph, degree, cut- vertex/articulation point, pendant node, clique, complete graph, connected components – strongly connected component, weakly connected component, path, shortest path).Graph representations/storage implementations – adjacency matrix, adjacency list, adjacency multi-list. Graph traversal and connectivity – **Depth-first search (DFS), Breadth-first search (BFS)**. Minimal spanning tree – Prim's and Kruskal's algorithm.	**5**

Module: 6	**Module Name: Searching, Sorting, Hashing Sorting Algorithms:** Bubble sort, insertion sort, selection sort, merge sort, quick sort, concept of max & min heap, heap sort. **Searching:** Sequential search, binary search. **Hashing:** Hashing functions, collision resolution techniques using chaining and open addressing.	**6**
	Total	**36**

Learning Resources Text Books:

1. "Data Structures And Program Design In C", 2/E by Robert L. Kruse, Bruce P.Leung.
2. "Data Structures and Algorithms Using C", R.S. Salaria, Khanna PublishingHouse.
3. "Fundamentals of Data Structures of C" by Ellis Horowitz, SartajSahni, Susan Anderson-freed.
4. "Data Structures in C" by Aaron M.Tenenbaum.
5. **"**Data Structure**s"** by S.Lipschutz**.**
6. "Data Structures and Algorithm Analysis in C" by Mark Allen Weiss

Reference Books:

1. "Expert Data Structures with C" by R.B. Patel, Khanna Publishing House
2. "Data Structures Using C" by Reema Thareja
3. "Data Structure Using C", 2/e by A.K. Rath, A. K.Jagadev.
4. "Introduction to Algorithms" by Thomas H. Cormen,Charles E. Leiserson,Ronald L. Rivest, Clifford Stein

CO-PO-PSO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	–	2	2	–	–	–	–	–	–
CO2	3	3	2	–	3	–	–	–	1	1	–
CO3	3	3	2	–	3	–	–	–	1	1	–
CO4	3	3	2	2	3	–	–	–	1	1	–
CO5	3	3	2	2	3	–	–	–	1	1	–
CO6	3	3	–	2	3	–	–	–	1	1	–

COs	PSO1 Electronics & Computer Systems	PSO2 Instrumentation & Industrial Automation	PSO3 Interdisciplinary, Research & Higher Studies
CO1	**3**	1	2
CO2	**3**	1	2
CO3	**3**	2	2
CO4	**3**	2	3
CO5	**3**	2	3
CO6	**3**	1	2

Optical Instrumentation

Course Name: Optical Instrumentation	**Category: Professional Elective**
Course Code: PE-EI 501A	**Semester: 5th**
L-T-P: 3-0-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
Tutorial: NIL	End Semester Exam.: 70 Marks
Total Lectures: 42 Hrs	

Pre-Requisites: Prerequisites for the Optical Instrumentation subject typically include the following:

1. **Engineering Physics**: Understanding of fundamental concepts such as Wave Optics, Basic Quantum Theory and Semiconductor Physics.
2. **Electronic Devices and Circuits**: Familiar with the working principles of diodes, photodiodes, LEDs, transistors, etc. and Basics of semiconductor device operation, carrier injection, junction behavior.
3. **Analog and Digital Electronics:** Modulation techniques and signal processing fundamentals as well as Use of modulators, switches, and detectors in signal transmission.
4. **Electromagnetic Theory / Network Theory**: Understanding of light as an electromagnetic wave and Basics of wave propagation, reflection/refraction, and resonance.
5. **Basic Instrumentation & Sensors:** Introduction to sensors, transducers, and measurement techniques and Concept of signal conditioning and data acquisition.

Objectives:

The subject aims to encourage the students with the following:

1. To introduce the fundamental principles of optical fibers and light propagation so that students can understand the working, classification, and characteristics of different types of optical fibers used in instrumentation and communication systems.

2. To familiarize students with optoelectronic components such as LEDs, photo detectors, and optical modulators, and explain their roles in signal transmission and detection in fiber-optic systems.

3. To explain the working of optical switches and amplifiers including directional couplers and devices like EDFA and Raman amplifiers, with an emphasis on their practical applications in signal routing and amplification.

4. To impart knowledge of laser fundamentals and laser types covering concepts like laser modes, resonator configurations, Q-switching, mode-locking, and common industrial and medical laser systems.

5. To explore industrial and biomedical applications of optical fibers and lasers including their usage in sensors, material processing, medical diagnostics, and surgeries, along with an introduction to holography and its measurement applications.

Course Outcomes (COs):

On completion of this course, the student will be able to

CO No.	Course Outcome Statement
CO1	*Analyze the characteristics, propagation mechanisms, and transmission losses in different types of optical fibers to assess their suitability for instrumentation applications.*
CO2	*Compare and evaluate the performance of optoelectronic components such as LEDs, photodiodes, and optical modulators for sensing and communication systems.*
CO3	*Explain and apply the principles of optical switching and amplification to enhance signal strength and routing in optical networks.*
CO4	*Examine the fundamental principles, operating modes, and performance characteristics of various laser systems for engineering applications.*
CO5	*Apply optical fiber and laser-based techniques for industrial, biomedical, and instrumentation applications emphasizing precision and reliability.*
CO6	*Demonstrate the principles and applications of holography and holographic interferometry for precision measurement and diagnostics.*

Course Details:

Module No.	Description of Topics	Contact Hrs.
Module 1	**Optical Fibers and Their Properties:**	**CO 1**
	Introduction to optical fiber – fiber characteristics – principles of light propagation through a fiber – Different types of fibers and their properties – Losses in the optical fiber – Dispersion – advantages and disadvantages of optical fibers, Connector and splices.	**8**
Module 2	**Optoelectronic Components: LED, PD, Optical Modulators:**	**CO 2**
	Optical sources: LED, DH LED, Edge & Surface emitting LED; Optical detectors: Photodiode, Photoconductive Photo detector, PIN, APD – Electro-optic, Magneto optic and Acousto-optic Modulators. Description of LED, LCD and Plasma Codes and Standards of Instruments.	**8**
Module 3	**Optical Switches and Amplifiers:**	**CO 3**
	Coupled mode analysis of directional couplers, electro-optic switches. Optical amplifiers - EDFA, Raman amplifier.	**3**
Module 4	**Laser Fundamentals:**	**CO 4**
	Two/Three levels and four level lasers – Properties of Semiconductor laser – Laser modes – Resonator configuration – Q-switching and mode locking; Types of Gas lasers, Solid State lasers, etc.	**7**
Module 5	**Industrial Application of Optical Fiber and Lasers:**	**CO 5**
	Optical fiber based sensors - for measurement of distance, length, pressure, velocity/ acceleration, current, etc. Laser applications for material processing – Laser heating, welding, melting, etc. Medical applications of lasers – Laser instruments for surgery, removal of tumors of vocal cards, brain surgery, plastic surgery, gynecologyand oncology, etc.	**8**

Module 6	**Holography:**	**CO 6**
	Basic principle-Methods– Holographic interferometry and application.	**2**
	Total	**36**

Text/Reference Books:

1. Introduction to Optoelectronics, J. Wilson and J.F.B. Hawkes, Prentice Hall of India, 2001.
2. Optoelectronics and Optical Fiber Sensors, A. B. Maity, PHI, 2013
3. Fiber Optics and Optoelectronics, R. P. Khare, Oxford Univ. Press, 2004.
4. Laser Fundamentals – W. T. Silfvast, Cambridge Univ. Press, 2004
5. Optical Fiber Communication – Principles and Practice, J.M. Senior, PHI, 1985.
6. Lasers Systems and Applications – S. K. Srivastava, New Age, 2019

Online Resources:

SWAYAM/NPTEL Courses

Course Name	Instructor	Platform
Fundamentals of optical measurements and instrumentation	Prof. Balaji Jayaprakash (IISc Bangalore)	NPTEL/SWAYAM
Optical Engineering	Prof. Shanti Bhattacharya (IIT Madras)	NPTEL/SWAYAM
Fiber Optics	Prof. Vipul Rastogi (IIT Roorkee)	NPTEL/SWAYAM
Optical Communications	Prof. Pradeep Kumar (IIT Kanpur)	NPTEL/SWAYAM
Fiber Optic Communication Technology	Prof. Deepa Venkitesh (IIT Madras)	NPTEL/SWAYAM
Semiconductor Optoelectronics	Prof. M. R. Shenoy (IIT Delhi)	NPTEL/SWAYAM

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
PE-EI 501A	Optical Instrumentation	36			54	90	3

CO-PO Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	**3**	**3**	2	2	2	–	–	–	–	–	–
CO2	**3**	**3**	2	2	**3**	–	–	–	–	–	–
CO3	**3**	**3**	**3**	2	**3**	–	–	–	1	1	1
CO4	**3**	**3**	2	**3**	**3**	1	1	–	1	1	1
CO5	**3**	**3**	**3**	2	**3**	2	**3**	1	1	1	1
CO6	**3**	2	2	**3**	**3**	1	1	–	–	1	–

CO-PSO Mapping:

COs	PSO1 Electronics & Computer Systems	PSO2 Instrumentation & Industrial Automation	PSO3 Interdisciplinary, Research & Higher Studies
CO1	2	3	2
CO2	3	3	2
CO3	3	2	2
CO4	2	3	3
CO5	2	3	3
CO6	1	2	3

Advanced Sensors

Course Name: Advanced Sensors	**Category: Professional Elective**
Course Code: PE-EI 501B	**Semester:** 5th
L-T-P: 3-0-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs	3- Continuous Assessment: 30Marks (CA-1, CA-2, CA-3)
Tutorial: 0 Hrs	End Semester Exam.: 70 Marks
Total Lectures: 42 Hrs	

Pre-Requisites: Prerequisites for the course of Advanced Sensors typically include the following:

1. Basic knowledge of electronic circuits and devices.
2. Fundamental understanding of sensors and transducers.
3. Familiarity with analog signal conditioning concepts.
4. Exposure to instrumentation systems and measurement techniques.

Course Objectives:

This course aims to educate students on various advanced sensing technologies and make them familiar with the manufacturing and fabrication techniques of silicon and micro sensors. It also encourages students to design sensor-based projects for applications in robotics and industrial automation.

Course Outcomes (COs):

CO1: Describe and classify various types of transducers used for physical parameter measurements like temperature, pressure, flow, level, acceleration, vibration, and orientation.
CO2: Explain the design considerations, standards, and fabrication processes of advanced sensors, including thick film sensing techniques.
CO3: Analyze smart sensors with integrated signal conditioning and A/D conversion, using available ICs for specific applications.
CO4: Demonstrate the structure, features, and applications of Micro Electromechanical Systems (MEMS).
CO5: Apply sensor technology and instrumentation techniques in environmental measurements such as DO, BOD, COD, TOC, CO_x, NO_x, and SO_x.
CO6: Evaluate biosensor applications for agriculture and food processing involving soil moisture, wind speed, leaf wetness, smell, and taste detection.

Module-Wise course details:

Module No.	**Description of Topics**	**Contact Hrs.**
	Fundamentals of sensors	**CO 1**

Module: 1		
	Transducers for various parameters like temperature, pressure, flow, level, acceleration, vibration, orientation etc.	**8**
Module: 2	**Sensor Fabrication:**	**CO 2**
	Design considerations and selection criterion as per standards, Sensor fabrication techniques, process details and latest trends in sensor fabrication. Thick film sensing and system design.	**7**
Module: 3	**Smart Sensors:**	**CO 3**
	Smart sensor basics, signal conditioning and A/D conversion for sensors, examples of available ICs and their applications.	**5**
Module: 4	**Micro Electromechanical Sensors:**	**CO 4**
	Construction, Features, Applications	**7**
Module: 5	**Advanced Sensing Technology:**	**CO 5**
	Sensors, instruments and measurement techniques for emerging application areas such as environmental measurement like DO(dissolved oxygen), BOD (biological oxygen demand), COD(chemical oxygen demand), TOC(total organic carbon), Cox(carbon dioxides), NOx(nitrogen oxide), SOx (Sulpher Oxides)	**5**
Module: 6	**Bio Sensors:**	**CO 6**
	Sensors agricultural measurements such as soil moisture, wind speed, leaf wetness duration, sensors for food processing like smell or odour, taste.	**4**
	Total	**36**

Text Books:

1. Chang Liu, Foundations of MEMS, Pearson Education Inc., 2012.\
2. Stephen D Senturia, Microsystem Design, Springer, 2000.\
3. Tai Ran Hsu, MEMS & Microsystems Design and Manufacture, TMH, 2002.\
4. Jacob Fraden, Handbook of Modern Sensors.\
5. S. M. Sze, Semiconductor Sensors.\
6. M. J. Usher, Sensors and Transducers, MacMillan, 1985.

Reference Books:

1. Nadim Maluf, Introduction to MEMS Design, Artech House, 2000.\
2. Mohamed Gad-el-Hak (Ed.), The MEMS Handbook, CRC Press, 2001.\
3. J. W. Gardner, V. K. Varadan, O. Awadelkarim, Micro Sensors MEMS and Smart Devices, Wiley, 2002.\
4. James J. Allen, MEMS Design, CRC Press, 2005.\
5. Thomas M. Adams & Richard A. Layton, Introduction to MEMS: Fabrication and Application, Springer, 2010.

Online Resources:

Course Title	Instructor / Institute	Platform	Link
Sensors and Actuators	Prof. Hardik J. Pandya, IISc Bengaluru	NPTEL (Swayam)	(NPTEL Online Courses)
Microsensors and Nanosensors	Prof. Ravindra K. Jha, IIT Guwahati	NPTEL (Swayam)	(NPTEL Online Courses, Class Central)
Optical Fiber Sensors	Prof. Balaji Srinivasan, IIT Madras	NPTEL (Swayam)	(NPTEL Online Courses)
Optical Sensors (biosensors)	Prof. Sachin K. Srivastava, IIT Roorkee	NPTEL (Swayam)	(NPTEL Online Courses)

Credit Structure (as per NBA Guidelines):

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
PC-EI 501A	Advanced Sensors	42	0	0	48	90	3

CO-PO Mapping:

COs ↓ / POs →	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	2	1	1	1	-	-	1	1
CO2	3	2	3	2	2	1	1	-	1	1	1
CO3	3	3	2	3	2	1	1	-	1	2	1
CO4	3	2	2	2	3	1	1	-	1	2	1
CO5	2	2	2	2	2	2	3	1	1	1	2
CO6	2	2	2	2	2	2	2	1	1	1	2

CO-PSO Mapping:

COs ↓ /	PSO1	PSO2	PSO3

PSOs →	(Electronics & Computing Systems)	(Instrumentation & Automation)	(Interdisciplinary & Lifelong Learning)
CO1	3	2	1
CO2	3	3	1
CO3	3	3	1
CO4	3	3	2
CO5	2	3	2
CO6	2	3	2

Analog and Digital Communication

Course Name: Analog and Digital Communication	**Category: Professional Core**
Course Code: PE-EI 502B	**Semester: 5th**
L-T-P: 3-0-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs	3- Continuous Assessment: 30Marks (CA-1, CA-2, CA-3)
Tutorial: 0 Hrs	End Semester Exam.: 70 Marks
Total Lectures: 48 Hrs	

Pre-Requisites: Basic knowledge of analog and digital electronic circuits, signals and systems.

Objectives:

The subject aims to encourage the students with the following:

- Understand the fundamental concepts of analog and digital communication.
- Explore various modulation and demodulation techniques.
- Analyze noise performance in communication systems.
- Design and evaluate digital modulation schemes.
- Study multiplexing, source coding, and error detection techniques.
- Apply concepts to practical systems using simulations or hardware.

Course Outcomes (COs):

On completion of this course, the student will be able to

CO1. Explain and analyze the fundamental components of a communication system, including transmitter, channel, and receiver, and assess the impact of noise on signal transmission.

CO2. Apply the principles of amplitude modulation to determine modulation index, power relations, and bandwidth; and evaluate the performance of AM, DSB-SC, SSB-SC, VSB, and QAM systems using mathematical analysis and circuit techniques.

CO3. Analyze and compare frequency and phase modulation schemes, determine bandwidth requirements, and illustrate the generation and detection of FM and PM using block and circuit representations.

CO4. Apply the concepts of sampling and pulse modulation to design and evaluate PAM, PCM, DM, and DPCM systems for digital signal representation.

CO5. Design and analyze digital modulation schemes such as ASK, FSK, PSK, QPSK, DPSK, and MSK, and evaluate their performance using power spectral and error probability analysis.

CO6. Examine cellular and wireless communication standards (2G–5G), analyze channel impairments like fading and interference, and evaluate system performance using parameters such as SNR, capacity, and BER.

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Module Name: Introduction to Communication Systems**	**CO1**
	Introduction to Communication Process, Communication Channels – transmitter, channel and receiver, Modulation advantages, effect of noise in communication system	**3**
Module: 2	➢ **Module Name: Amplitude Modulation**	**CO2**
	Amplitude Modulation Techniques: Mathematical representation of Amplitude Modulation (AM), modulation index, total power, side band power, efficiency, generation of AM, Demodulation of AM, Envelop Detection, Limitations of AM. Introduce DSB-SC, SSB-SC, Generation, with non linear device, switching modulator, ring modulator, De-generation of DSB-SC, SSB-SC, synchronous demodulation, effect of phase and frequency error, filter method, Hilbert transform, VSB generation and degeneration, spectra and band-width application in communication, QAM	**9**
Module: 3	**Module Name: Frequency Modulation**	**CO3**
	Angle Modulation: Mathematical representation of Angle modulation, FM, PM Concept of Narrow and Wide-band angle modulation, Calculation of Bandwidth for FM and PM with Narrow and Wide-band modulation. Basic block diagram representation of generation and detection of FM & PM, Concept of VCO & Reactance modulator Angle Modulation, Frequency Modulation (FM), Phase Modulation (PM), Narrowband and wide-band FM,	**5**
Module: 4	**Module Name: Pulse Modulation:**	**CO4**
	Sampling process. Types of sampling, Aliasing effect. PAM, PCM, Quantization, quantization error, Differential pulse code modulation. Delta modulation.	**7**
Module: 5	**Module Name: Digital Modulation Techniques**	**CO5**
	Line coding technique, on-off, polar, bipolar, ISI, Nyquist criterion for	**6**

	zero ISI, eye pattern Concept of M-ary Communication, M-ary phase shift keying, the average probability of symbol error for coherent M-ary PSK, power spectra of MPSK, Digital modulation technique: (Coherent communication with waveforms) ASK, BPSK, FSK, QPSK, DPSK, MSK.	
Module: 6	**Module Name: Mobile Communication:**	**CO6**
	Wireless Standards: Overview of 2G, 3G, 4G, 5G cellular, spectrum, comparison. Cellular concepts-Cell structure, frequency reuse, cell splitting, handoff, interference. Multicarrier modulation, TDM,FDM,OFDM MIMO and space time signal processing, spatial multiplexing, concept of multipath fading, Performance measures- Outage, average SNR, average capacity, bit error rate.	**6**
	Total	**36**

Text Books:

1. Haykin S., "Communications Systems", John Wiley and Sons, 2001.
2. Proakis J. G. and Salehi M., "Communication Systems Engineering", Pearson Education, 2002.
3. B.P. Lathi, “Modern Digital and Analog Communication Systems”, Oxford University Press.
4. WCY Lee, Mobile Communications Design Fundamentals, Prentice Hall, 1993.
5. Dr. M. Radhika C.K. Sanmathi, 4G/5G Communication Networks, Magnus Publication
6. Digital Design, M. Morris Mano, Michael D. Ciletti, (Pearson)

Reference Books:

1. Sanjay Sharma, “Communication Systems (Analog and Digital)”, Katson Books.
2. Raymond Steele, Mobile Radio Communications, IEEE Press, New York, 1992.
3. AJ Viterbi, CDMA: Principles of Spread Spectrum Communications, Addison Wesley, 1995.
4. VK Garg&JE Wilkes, Wireless & Personal Communication Systems, Prentice Hall, 1996.

Online Resources:

SWAYAM/NPTEL Courses for Integration

S.No	Course Title	Instructor	Institution	Platform	Link
1	Principles of Communication	Prof. H.S. Jamadagni	IIT Madras	NPTEL	View

2	Digital Communication	Prof. Abhay Karandikar	IIT Bombay	NPTEL	View
3	Analog Communication	Prof. Aditya K. Jagannatham	IIT Kanpur	NPTEL	View
4	Communication Systems	Prof. S. C. Dutta Roy	IIT Delhi	NPTEL	View

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
PE-EI-502B	Analog Digital Communication	42	-		48	90	3

CO-PO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	1	2	–	–	–	–	1	–
CO2	3	3	3	2	3	–	–	–	1	1	–
CO3	3	3	3	2	3	–	–	–	1	1	–
CO4	3	3	3	2	3	–	–	–	1	1	1
CO5	3	3	3	2	3	–	1	–	1	1	1
CO6	3	3	3	3	3	2	3	1	1	1	1

CO-PSO Mapping

COs	PSO1	PSO2	PSO3
CO1	2	2	1
CO2	3	2	2
CO3	3	2	2
CO4	2	3	2
CO5	2	3	3
CO6	1	3	3

Telemetry and Wireless Network

Course Name: Telemetry and Wireless Network	**Category: Professional Core**
Course Code: PE-EI 502 B	**Semester: 5th**
L-T-P: 3-0-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
Tutorial: 0 Hrs	End Semester Exam.: 70 Marks
Total Lectures: 36 Hrs	

Pre-Requisites: Basic Electronics, Sensors & Transducers, Digital Communication / Communication Systems fundamentals, Basic Networking Knowledge, Basic Programming (C / Embedded)

Objectives:

The subject aims to encourage the students with the following:

1. **Introduce the fundamentals of telemetry systems** and wireless sensor networks, including their architecture, operational principles, and application domains.
2. **Provide an understanding of sensor node components** such as sensors, signal conditioning units, embedded processors, and wireless transceivers used in telemetry and WSN systems.
3. **Explain wireless communication techniques and protocols** at the physical, MAC, and network layers with emphasis on power- and bandwidth-constrained environments.
4. **Develop knowledge of routing, data aggregation, and network management techniques** used to ensure reliability, scalability, and efficiency in wireless sensor networks.
5. **Familiarize students with key network services** including localization, synchronization, security, and energy management in telemetry-based wireless sensor systems.
6. **Enable students to design and analyze real-world telemetry and WSN-based applications**, considering performance, power consumption, reliability, and deployment challenges.

Course Outcomes (COs)

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

PE-EI502B.1: Understand fundamental concepts of telemetry systems and wireless sensor networks, including sensor node architecture, data acquisition, and basic WSN architecture.
PE-EI502B.2: Explain communication protocols relevant to telemetry and WSN (physical layer, MAC, link-layer) and understand constraints such as power, noise, and reliability.
PE-EI502B.3: Apply and analyze network- and routing-layer protocols for data collection and aggregation in WSN environments.
PE-EI502B.4: Understand and evaluate advanced WSN services — localization, synchronization, security, and power-management strategies for robust sensor network deployments.
PE-EI502B.5: Design an end-to-end telemetry + WSN-based monitoring/control system for real-world applications, considering hardware, communication, power, and data management constraints.

PE-EI502B.6: Explore contemporary applications and future trends, integrating WSN with IoT, data analytics, cloud/edge computing, and deployments for smart systems.

Module No.	Module Title & Topics	Contact Hrs	Mapped CO(s)
1	**Introduction to Telemetry & Basics of WSN** - What is Telemetry: Purpose, basic telemetry scheme, types (voltage, current, frequency telemetry) - Basics of signal sampling, quantization, error, noise, BER (Bit Error Rate) in telemetry - Multiplexing & modulation review relevant to telemetry (PAM, PCM, FM/AM, etc.) - Overview of Wireless Sensor Network (WSN): definition, motivation, applications, advantages / constraints - Differences between traditional telemetry and WSN-based data acquisition	6	CO1, CO2
2	**Sensor Node Architecture & Network Setup** - Sensor node hardware: sensors/ transducers, microcontroller, analog front-end - Power supply, battery / energy considerations, energy harvesting (if applicable) - Communication transceiver / radio / RF front-end - Software/firmware basics for sensor nodes - Network architecture: single-hop vs. multihop, sources/sinks, gateway concepts, scalable WSN deployment scenarios	6	CO1, CO2
3	**Communication: PHY, MAC and Data Link Layers** - Wireless communication basics: propagation, path loss, fading, link quality - MAC protocols for WSNs: contention and scheduling, duty-cycle MAC, low-power listening, IEEE 802.15.4 / ZigBee basics - Data link layer issues: reliability, error control, medium sharing, energy-efficient communication	6	CO2, CO3
4	**Network & Routing Protocols, Data Collection & Aggregation** - Routing techniques: flat routing, hierarchical (cluster-based), geographic routing, data-centric routing, flooding, energy-aware routing - Data aggregation and fusion in WSNs - Congestion control, load balancing, reliability and QoS aspects - Support for mobility, dynamic topology changes (if relevant)	6	CO3, CO4
5	**Sensor Network Services — Localization, Synchronization, Security & Power Management** - Node localization techniques (range-based, range-free, GPS-less methods) - Time synchronization protocols for WSN - Security issues in WSN: threats, secure data transfer, key management, privacy - Power management and energy-efficient design, duty-cycling, sleep scheduling, lifetime optimization	6	CO4, CO5
6	**Applications, Telemetry Integration & System Design** - Integrating telemetry techniques with WSN for remote monitoring and control - Applications: environmental monitoring, industrial telemetry, health monitoring, smart agriculture, home automation, IoT gateway interfacing - Design a complete telemetry + WSN system: sensor selection, network design, data acquisition, communication, power budget, security, deployment issues - Emerging trends: IoT, LPWAN, cloud integration, remote data visualization and analytics	6	CO5, CO6

Textbooks & References

- Protocols and Architectures for Wireless Sensor Networks – Holger Karl & Andreas Willig. (John Wiley, 2005) Amrita Vishwa Vidyapeetham+1
- Wireless Sensor Networks: An Information Processing Approach – Feng Zhao & Leonidas J. Guibas. (Morgan Kaufmann, 2004) Amrita Vishwa Vidyapeetham+1
- Wireless Sensor Networks – Technology, Protocols and Applications – Kazem Sohraby, Daniel Minoli & Taieb Znati. (John Wiley & Sons) aliah.ac.in+1
- Additional references: Research papers, IEEE 802.15.4 / ZigBee / LPWAN standards, case studies in IoT & telemetry integration.

Online Resources:

SWAYAM/NPTEL Courses for Integration

Course Name	Instructor	Platform	Link
Telemetry & Remote Measurement	Mr Abhishek Tiwari	AKGEC	Link
WIRELESS SENSOR NETWORK (WSN)	Prof. Sudip Misra / IIT Kharagpur	NPTEL/SWAYAM	Link

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
OE-EI 603B	VLSI & Microelectronics	42	0		48	90	3

CO-PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	–	–	–	–	–	–	–	–
CO2	3	3	2	1	2	–	–	–	–	–	–
CO3	2	3	3	2	2	–	–	–	–	–	–
CO4	2	3	2	2	2	1	–	–	–	–	–
CO5	2	2	3	2	2	2	1	–	–	–	–

CO6	2	2	3	2	2	2	1	–	1	2	2

CO-PSO Mapping

CO \ PSO	PSO1	PSO2	PSO3
CO1	3	1	1
CO2	2	3	2
CO3	2	3	3
CO4	1	2	3
CO5	1	2	3
CO6	2	2	3

Industrial Instrumentation Laboratory

Course Name: Industrial Instrumentation Laboratory	**Category: Professional Core**
Course Code: PC-EI 591	**Semester: 5th**
L-T-P: 0-0-3	**Credit: 1.5**
Teaching Scheme	**Examination Scheme**
Practical: 3 hrs./week	2 – Practical Continuous Assessment: 40 Marks (PCA-1 and PCA-2)
	End Semester Exam.: 60 Marks

Pre-Requisites:

To ensure effective learning and comprehension of the concepts in Industrial Instrumentation, students are expected to have foundational knowledge and skills in the following areas:

- **Basic Electrical and Electronic Circuits:** Required to understand the functioning and interfacing of sensors and signal conditioning circuits used in measurement systems.
- **Sensors and Transducers:** Essential for identifying appropriate sensing elements, understanding their characteristics, and interpreting their responses in instrumentation setups.
- **Industrial Instrumentation:** Provides the foundational knowledge of measuring process variables like pressure, temperature, flow, and level using various industrial instruments.

Objectives:

The subject aims to encourage the students with the following:

- **Develop practical skills** in connecting, configuring, and operating a wide range of measurement instruments.
- **Calibrate instruments** such as pressure gauges and flow meters to ensure measurement accuracy.
- **Measure physical parameters** using resistive, thermoelectric, capacitive, electromagnetic, and ultrasonic sensors.
- **Analyze sensor behavior** including response characteristics, error sources, and environmental effects.
- **Simulate industrial conditions** and develop the ability to troubleshoot instrumentation systems.

Course Outcomes (COs):

On completion of this course, the student will be able to

PC-EI 591.1 **Demonstrate** the ability to **select** and **apply** suitable temperature measurement techniques based on sensor characteristics for industrial applications.

*(Cognitive Level: **Apply**, Knowledge Category: **Procedural**)*

PC-EI 591.2 **Calibrate** and **utilize** pressure measurement systems for low and moderate pressure ranges, and **evaluate** their performance in process control applications.

*(Cognitive Level: **Evaluate**, Knowledge Category: **Procedural**)*

PC-EI 591.3 **Apply** appropriate flow measurement techniques using both differential and non-differential flow sensing methods, and **evaluate** performance parameters.

*(Cognitive Level: **Analyze**, Knowledge Category: **Procedural**)*

PC-EI 591.4 **Implement** and **evaluate** level measurement systems based on different physical principles, and **assess** their suitability for various industrial applications and environmental conditions.

*(Cognitive Level: **Evaluate**, Knowledge Category: **Procedural**)*

Syllabus details

Experiment No.	Experiment Name	Mapped CO
01	Measurement of Temperature using RTD and Thermistor type temperature instruments.	**PC-EI 591.1**
02	Measurement of Temperature using Thermocouple type temperature instruments	**PC-EI 591.1**
03	Measurement of Temperature using LM 35 and AD 590 IC Sensor.	**PC-EI 591.1**
04	Calibration of Pressure Gauge using Dead Weight Tester	**PC-EI 591.2**
05	Measurement of low pressure using McLeod gauge / Pirani gauge	**PC-EI 591.2**
06	Measurements of flow rate using Variable head type Flow meters (Orifice, Venturi, Pitot Tube) and Calculate their discharge coefficient	**PC-EI 591.3**
07	Measurements of flow rate using Variable Area type Flow meter.	**PC-EI 591.3**
08	Measurements of flow rate using Electromagnetic Flow meter.	**PC-EI 591.3**
09	Measurement of liquid level using float type sensor and ultrasonic sensor.	**PC-EI 591.4**
10	Measurement of level using capacitive type level instrument.	**PC-EI 591.4**

Online Resources:

Laboratory Name	Platform	Link
Sensors and Instrumentation Lab	Virtual Labs	Link
Industrial Automation Laboratory	Virtual Labs	Link
Sensors Modeling & Simulation Lab	Virtual Labs	Link
Process Control, Reaction Engineering and Unit Operations Lab	Virtual Labs	Link

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
PC-EI 591	Industrial Instrumentation Laboratory			36	9	45	1.5

CO-PO Mapping

COs ↓ / POs →	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PC-EI 591.1	3	2	2	2	2	1	–	1	1	1	2
PC-EI 591.2	3	2	2	2	2	1	–	1	1	1	2
PC-EI 591.3	3	3	2	3	3	1	–	1	1	1	2
PC-EI 591.4	3	3	2	2	2	1	–	1	1	1	2

CO-PSO Mapping

COs ↓ / POs →	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)
PC-EI 591.1	1	3	2
PC-EI 591.2	1	3	2
PC-EI 591.3	1	3	2
PC-EI 591.4	1	3	2

Process Control Lab

Name of the Course: Process Control Lab	**Category:Professional Core**
Course Code: PC-EI 592	**Semester:V**
Duration: 6months	**MaximumMarks:100**
Teaching Scheme	**Examinationscheme:100 marks**
Tutorial:Nil	ExternalAssessment:60
Practical:3 hrs./week	Internal Assessment:40
CreditPoints:1.5	

CourseOutcomes:	
PC-EI 592.1	Construct and interpret P&ID diagrams for flow, level, pressure, and temperature processes following industrial standards (ISA), and identify associated field instruments.
PC-EI 592.2	Configure and operate process control loops using microcontroller-based PID controllers for temperature, pressure, flow, and level applications.
PC-EI 592.3	Implement PLC-based process control loops for flow, level, pressure, and temperature processes with real-time interfacing.
PC-EI 592.4	Develop and simulate logic gate, timer, and counter operations using PLC programming environments.

Pre-Requisite:	
1	Basic concepts of process variables and control loops
2	PID control fundamentals
3	PLC architecture and programming
4	Instrumentation for flow, level, temperature, and pressure

Course Objectives

- To provide hands-on experience in handling PID-based process control loops.
- To develop practical understanding of P&ID diagrams and control instrumentation.
- To introduce PLC-based process control and automation strategies.
- To apply logic programming for control and monitoring tasks using industrial tools.

Exp. No.	Experiment Title	Mapped CO
1	Study of Flow, Level, Pressure, Temperature processes and construction of the P&I diagrams in accordance with ISA guidelines/standards.	**CO1**
2	Study of typical Temperature control loop with microcontroller-based PID controller (Honeywell DC-1000 series) with PC interface.	**CO2**
3	Study of typical Pressure control loop with microcontroller-based PID controller (Honeywell DC-1000 series) with PC interface.	**CO2**
4	Study of typical Flow control loop with microcontroller-based PID controller (Honeywell DC-1000 series) with PC interface.	**CO2**
5	Study of typical Level control loop with microcontroller-based PID controller (Honeywell DC-1000 series) with PC interface.	**CO2**
6	Study of typical Temperature control loop with PLC (PLC S-1200 Series SIEMENS) compatibility and PC interface.	**CO3**
7	Study of typical Pressure control loop with PLC (PLC S-1200 Series SIEMENS) compatibility and PC interface.	**CO3**
8	Study of typical Flow control loop with PLC (PLC S-1200 Series SIEMENS)	**CO3**

	compatibility and PC interface.	
9	Study of typical Level control loop with PLC (PLC S-1200 Series SIEMENS) compatibility and PC interface.	**CO3**
10	Study of Logic Gate Operations Using PLC Programming Through PC.	**CO4**
11	Study of Timer and Counter Operations Using PLC Programming Through PC.	**CO4**

Textandreferencebooks:
B.W. Bequette, Process Control–Modeling, Design and Simulation, PHI
W.Bolton, Programmable Logic Controllers, Elsevier
B.G.Liptak, Instrument Engineers Handbook, Chilton BookCo., Philadelphia.

CO-PO Mapping

COs ↓ / POs →	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	2	2	1	1	–	–	–	–	1	–
CO2	2	2	3	2	3	–	–	–	1	1	–
CO3	2	2	3	2	3	–	–	–	1	1	1
CO4	1	2	3	2	3	–	–	–	2	1	–

CO-PSO Mapping

	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)
CO1	1	3	–
CO2	2	3	–
CO3	3	3	1
CO4	3	2	1

Instrumentation System and Product Development Lab

Course Name: Instrumentation System and Product Development Lab	**Category:** Professional Core
Course Code: PC-EI 593	**Semester:** 5th
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination scheme: Maximum marks:**
Tutorial: Nil	External Assessment:60
Practical: 3 hrs./week	Internal Assessment:40
Credit Points: 1.5	

Course Outcomes:	
CO. 1	**Design and implement** signal conditioning and measurement circuits for industrial sensors (RTD, thermocouple, strain gauge).
CO. 2	**Design and fabricate** PCB circuits for specific instrumentation applications in IDEA lab, and demonstrate familiarity with 3D printing and scanning technology for prototyping.
CO. 3	**Design and simulate** instrumentation amplifiers, V/I and I/V converters, and controller circuits (P, PI, PD, PID) for integrated instrumentation systems.
CO. 4	**Develop and validate** an integrated instrumentation product prototype considering system performance, Technology Readiness Level (TRL) assessment, and basic Intellectual Property Rights (IPR) aspects.
Pre-Requisite:	
1	Mathematics Fundamentals, Basic electronics

Exp. No.	Laboratory Activity	CO
1	Design and testing of signal conditioning circuit for RTD	CO1
2	Design of instrumentation amplifier for strain gauge/bridge sensor	CO1
3	Design of active filters for sensor signal conditioning	CO2
4	Design of V/I and I/V converters for industrial signal transmission	CO2
5	Design of cold junction compensation and linearization circuit	CO3
6	Design and implementation of PID controller using OPAMP	CO3
7	MATLAB-based analysis of controller performance for process systems	CO3
8	Mini Product Development Project: Development of an Integrated Instrumentation System including PCB fabrication, enclosure design (3D printing), system testing, TRL evaluation, and basic IPR documentation	CO4

CO–PO Mapping Table

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2	1	2	–	–	–	1	–	–
CO2	3	2	3	2	3	–	–	–	2	–	1

CO3	3	3	3	2	3	–	–	–	2	–	1
CO4	3	3	3	3	3	1	1	2	3	2	2

CO–PSO Mapping Table

CO \ PSO	PSO1	PSO2	PSO3
CO1	2	3	1
CO2	3	3	2
CO3	2	3	2
CO4	3	3	3

Data Structure & Algorithm Lab

Name of the Course: Data Structure & Algorithm Lab	**Category:** Engineering Science Courses
Course Code: ES-EI 591	**Semester:** 5th
Duration: 6 months	**Maximum Marks:** 100
Teaching Scheme:	**Examination scheme:** Maximum marks:
Tutorial: Nil	External Assessment:60
Practical: 2 hrs./week	Internal Assessment:40
Credit Points: 1.0	

Course Outcomes:	
ES-CS 591.1.	**Recall and describe** the fundamental concepts of arrays, stacks, queues, and linked lists, including their operations such as insertion, deletion, and traversal. *(Remembering)*
ES-CS 591.2.	**Understand and explain** the working of various searching algorithms (Linear Search, Binary Search) and sorting techniques (Bubble Sort, Quick Sort, Merge Sort, etc.). *(Understanding)*
ES-CS 591.3.	**Apply** data structures like stacks, queues, and linked lists to solve computational problems such as infix-to-postfix conversion, Tower of Hanoi, and polynomial manipulation. *(Applying)*
ES-CS 591.4.	**Analyze** the efficiency of different sorting and searching algorithms in terms of time and space complexity, and evaluate their suitability for different applications. *(Analyzing)*
ES-CS 591.5.	**Implement** advanced data structures such as binary search trees, AVL trees, and B-trees, along with operations like insertion, deletion, and traversal to solve complex problems. *(Applying)*
ES-CS 591.6.	**Create and develop** a mini-project that integrates various data structures (arrays, linked lists, trees, hashing) to solve real-world problems efficiently. *(Creating)*
Pre-Requisite:	
1	**C-Programming**

Experiment No.	**Laboratory Experiments**	COs
1	**Array** Addition & Multiplication of Arrays Implementation of Sparse Matrices	CO1
2	**Abstract Data Type Stacks and Queues:** Implementation of Stack using Array, Conversion of infix notation into its corresponding prefix & postfix forms along with the evaluation of postfix expression Addition, Deletion of elements of Linear Queue & Circular Queue Implementation of Stack using Queue and vice-versa double ended queue. Implementation of Stack and Queue using array.	CO1
3	**Recursion** Tail-Recursion, Tower of Hanoii	CO2

4	**Linked List** Implementation of linked lists: inserting, deleting, and inverting a linked list. Implementation of stacks & queues using linked list, Polynomial addition, Polynomial multiplication	CO1
5	**Searching & Sorting Operations Searching:** Linear Search, Binary Search **Sorting:** Bubble Sort, Selection Sort, Insertion Sort, Quick Sort, Merge Sort & Heap Sort.	CO2
6	**Nonlinear Data structures** Tree Traversal of Binary Search Tree, Threaded binary tree traversal Height balanced binary tree – AVL tree (insertion, deletion) & B- Trees – operations (insertion, deletion).	CO3
7	**Hashing** Hash tables implementation: searching, inserting and deleting, searching & sorting techniques.	CO4
8	Mandatory Design and Implementation of Mini Project.	1-6

CO–PO Mapping Table

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2	1	3	–	–	–	1	–	–
CO2	3	3	2	2	3	–	–	–	1	–	1
CO3	3	3	3	2	3	–	–	–	1	–	1
CO4	3	3	2	2	3	–	–	–	1	–	1

CO–PSO Mapping Table

CO \ PSO	PSO1	PSO2	PSO3
CO1	3	1	1
CO2	3	1	2
CO3	2	1	2
CO4	3	1	2

Plant Instrumentation andControl

CourseName: Plant Instrumentation and Control	**Category:**ProfessionalCore
CourseCode:PC-EI601	**Semester:VI**
L-T-P:3-0-0	**Credit:3**
TeachingScheme	**ExaminationScheme**
Theory:3hrs./week	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
Tutorial:NIL	EndSemesterExam.:70Marks
TotalLectures:42Hrs	
Pre-Requisites: To understand this course, the learner must have an idea of sensors and transducers, industrial instrumentation, and process control.	

Objectives:

To acquaint learners with theory and working principles of different types of instruments and control strategies used in power plants, steel plants, and petrochemical industries.

CourseOutcomes (COs):

PC-EI 601.1:Explain the basic concepts, energy conversion processes, and measurement requirements of thermal power plants.

PC-EI 601.2:Describe the instrumentation used in various sections of a thermal power plant such as boilers, turbines, condensers, and auxiliaries.

PC-EI 601.3:Analyze control schemes applied in thermal power plants including drum level, pressure, temperature, combustion, and feed water control.

PC-EI 601.4:Explain the process flow and operational principles of steel manufacturing industries.

PC-EI 601.5:Describe instrumentation and control strategies used in steel manufacturing plants for process monitoring and quality control.

PC-EI 601.6:Explain instrumentation, control schemes, and safety systems used in petroleum production and refining industries.

Module-Wise Syllabus

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Module Name: General Concepts**	**CO1**
	Details: Power Plants of different types: Setups, energy conversions and measurement requirements, Process Description of Thermal power plant including steam generation , steam and water circuits , Flue , air and flue gas circuits	**6**
Module: 2	**Module Name: Instrumentation for different sections of Thermal Power Plant**	**CO2**
	Boilers, Turbines , Condensers , Alternators , Coal handling , Water treatment , Feed water , combustion air and flue gases	**7**
Module: 3	**Module Name: Control schemes of Thermal Power plant**	**CO3**
	Details: Boiler Drum Level Control - Steam pressure control, combustion and draught control, Steam temperature Control, Feed water control & Instrumentation, Setting the demand for the steam generation	**8**
Module: 4	**Module Name: Steel Manufacturing Industry**	**CO4**
	Process description, coke oven plant , blast furnace, steel smelting shop, casting, rolling etc.	**6**
Module: 5	**Module Name: Instrumentation and Control in Steel Manufacturing Industry**	**CO5**
	Various field instruments , Measurements & controls at coke oven plant , blast furnace, steel smelting shop , Thickness measurement and Control	**7**
Module: 6	**Module Name: Petroleum Industry**	**CO6**
	Brief survey of petroleum formation, petroleum exploration, petroleum production, petroleum refining and its methods, refining capacity and consumption in India, constituents of crude oil, recovery techniques – oil- Gas separation, processing wet gases. P & I diagram of petroleum refinery, Atmospheric distillation process, Vacuum distillation process, Thermal cracking, Catalytic reforming, and Utility plants – Air,N_2 and cooling water.Basics of field instruments, , Distillation column controlRe-boiler control, Reflux control, Control of catalytic crackers, Control of heat exchanger, Control of cooling tower. Safety interlocks in furnace, separator, pump, and compressor, Basics of SIL, Introduction to standards.	**8**
	Total	**42**

TextBooks:

1. B.G. Liptak – Instrument Engineers' Handbook, Process Measurement
2. E.A. Parr – Industrial Control Handbook
3. D. Patranabis – Principles of Industrial Instrumentation
4. A.K. Sawhney – A Course in Electrical and Electronic Measurements
5. D.C. Sikdar – Instrumentation and Process Control

ReferenceBooks:

1. Bela G. Liptak – Instrumentation in Process Industries
2. Andrew W.G. – Applied Instrumentation in the Process Industries
3. C.D. Johnson – Process Control Instrumentation Technology
4. W.G. Andrew – Applied Instrumentation in the Process Industries, Vol I–IV
5. Douglas M. Considine – Process Instruments and Controls Handbook

Online Resources:

SWAYAM/NPTEL Courses for Integration

Sl. No.	Course Title	Instructor / Institute	Platform	Link
1	Measurement Systems and Sensors	Prof. S. Dutta Roy, IIT Delhi	NPTEL	https://nptel.ac.in/courses/108105063
2	Industrial Automation and Control	Prof. S. Mukhopadhyay / Prof. S. Deb, IIT Kharagpur	NPTEL	https://nptel.ac.in/courses/108105066
3	Safety Instrumented Systems – Design, Analysis & Justification	ISA (International Society of Automation)	ISA Training	https://www.isa.org/certification-and-training/training/classroom-training/course/safety-instrumented-systems-design-analysis-and-justification-ec50

Recommended Software Tools

Software	Purpose
LabVIEW	Signal acquisition, virtual instrumentation, and simulation of measurement systems used in thermal power plants, steel plants, and refinery processes
MATLAB / Simulink	Modeling and simulation of process dynamics and control loops such as boiler drum level control, steam temperature control, distillation column control, and feedback control systems

Siemens TIA Portal	PLC-based automation and implementation of industrial control strategies used in power plants, steel manufacturing units, and utility plants
Factory I/O	Virtual simulation of industrial process plants to visualize instrumentation layout, process flow, and control logic for thermal, steel, and petroleum industries
COMSOL Multiphysics	Sensor and transducer modeling, thermal and flow analysis relevant to harsh industrial environments such as furnaces, boilers, and heat exchangers
AutoCAD P&ID / P&ID Viewer Tools	Interpretation and understanding of Piping and Instrumentation Diagrams (P&ID) for thermal power plants, steel plants, and petroleum refineries

Credit Structure (As per NBA Guidelines)

Course Code	Course Title	Teaching & Learning Scheme	Classroom Instructions (CI) (hours/sem.)	Lab Instructions (LI) (hours/sem.)	Team Work (TW) + Self Learning (SL) (hours/sem.)	Total Hours/sem	Total Credits (C) (Total Hours ÷ 30)
PE-EI 601	Plant Instrumentation and Control	L: 3, T: 0, P: 0, SL	42	0	48	90	3

CO–PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	–	–	–	–	1	–	–	–	–
CO2	3	3	2	–	1	–	1	–	–	–	–
CO3	3	3	3	2	1	2	1	–	–	–	1
CO4	2	2	–	–	–	–	1	–	1	–	–
CO5	2	3	3	–	1	2	1	–	1	1	1
CO6	2	3	3	–	2	3	2	2	–	1	1

CO–PSO Mapping

	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)
CO1	–	3	1
CO2	1	3	1
CO3	1	3	1
CO4	–	2	1
CO5	1	3	1
CO6	1	3	2

Biomedical and Analytical Instrumentation

Course Name: Biomedical and Analytical Instrumentation	**Category:** Professional Elective-V
Course Code: PE-EI 601A	**Semester: 3rd**
L-T-P: 3-0-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs	3- Continuous Assessment: 30Marks (CA-1, CA-2, CA-3)
Tutorial: 0 Hrs	End Semester Exam.: 70 Marks
Total Lectures: 48 Hrs	

Pre-Requisites: Students should have knowledge in biology, signal processing, and engineering communication aspects of biological signals via long distances.

Objectives:

The subject aims to encourage the students with the following:

1. To understand the physiological functions of major human systems. → Enables students to apply the concepts of measurement and instrumentation to the body's cardiovascular, muscular, nervous, and respiratory systems.
2. To study different electrodes and transducers used in biomedical signal acquisition. → Facilitates knowledge of electrode theory and appropriate transducer selection for physiological measurements.
3. To learn methods of measuring electrical and mechanical functions in the human body. → Equips students with techniques for ECG, EEG, EMG, blood pressure, and blood flow measurements.
4. To explore biomedical signal transmission and imaging techniques. → Provides understanding of biotelemetry and modalities like ultrasound and infrared imaging.
5. To analyze gas, liquid, and solid analytical techniques in clinical and industrial domains. → Enables performance evaluation of IR spectrometers, oxygen analyzers, and UV-VIS techniques.
6. To introduce advanced analytical methods like chromatography, NMR, ESR, and X-ray analysis.
   → Prepares students for specialized instrumentation in biomedical and pharmaceutical applications.

Course Outcomes (COs):

CO1: Understand the physiology of human body systems and select appropriate electrodes and transducers for biomedical applications.
CO2: Explain and apply instrumentation techniques for measuring electrical activities of human organs including ECG, EEG, EMG, and circulatory functions.
CO3: Analyze techniques of signal transmission and imaging including ultrasound and infrared-

based modalities.
CO4: Describe and compare gas analyzers and infrared spectroscopic instruments for industrial gas analysis.
CO5: Analyze various properties of liquid and solid samples using pH, DO meters, monochromators, UV, visual, and atomic spectroscopy.
CO6: Apply chromatography, X-ray methods, NMR, and ESR for advanced substance identification in biomedical domains.

Details Course Description:

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Module Name:** Human Systems, Electrodes & Transducers	**CO1**
	Physiology of cardiac, nervous, muscular and respiratory systems; biomedical transducers and selection; electrode theory, types: Hydrogen, Calomel, Ag-AgCl, pH, PO2, PCO2	**8**
Module: 2	**Module Name:** Measurement of Human Parameters	**CO2**
	Details: Measurement of electrical activities of heart, brain and muscle: ECG measurement and instrumentation techniques; Measurement of Blood Pressure & Blood flow; Defibrillator	**8**
Module: 3	**Module Name:** Signal Processing, transmission and Imaging	**CO3**
	Details: Instrumentation in clinical laboratory Ultrasound imaging and IR Imaging. Biotelemetry: Transmission and Reception aspects of Biological signals via long distances.	**8**
Module: 4	**Module Name:** Gas Analysis	**CO4**
	Types of gas analyzers: Thermal Conductivity, Heat of Reaction, Paramagnetic, Thermomagnetic, Zirconia Cell, Cell for Continuous O2 analysis microelectrodes, IR Spectrometry techniques and detector types	**10**
Module: 5	**Module Name**: Liquid and Solid Analysis	**CO5**
	Dissolved Oxygen and pH cells, UV and visual spectroscopy, colorimetry, viscosity and density measurements, atomic emission/absorption methods (visible/UV/X-ray), sources, principles, detectors, sample preparation etc.	**6**
Module: 6	**Module Name:** Special Topics	**CO6**
	Chromatography, GC, GLC, LC, HPLC, Columns, Detectors; X-ray methods	**8**

	of analysis; Introduction to NMR and ESR.	
	Total	**36**

Text Books:

1. Cromwell L – Biomedical Instrumentation and Measurement, Pearson
2. Khandpur R. S. – Handbook of Biomedical Instrumentation, TMH, New Delhi
3. D. C. Patranabis – Principles of Industrial Instrumentation, Tata McGraw Hill
4. Skoog, Holler, Nieman – Principles of Instrumental Analysis, Thomson Brooks/Cole
5. R. S. Khandpur – Handbook of Analytical Instruments, Tata McGraw Hill

Reference Books:

1. Carr – Introduction to Biomedical Equipment Technology, 4/e – Pearson
2. Robert D. Braun – Introduction to Instrumental Analysis, Pharma Book Syndicate

Online Resources:

SWAYAM/NPTEL Courses for Integration

Course Title	Instructor / Institute	Platform	Link (Preview)
Biomedical Instrumentation	Prof. S.K.M. Varadhan, IIT Madras	NPTEL / SWAYAM	(NPTEL, NPTEL, Class Central)
Biomedical Instrumentation & Sensors	Dr. Piyush Lotia & Mr. Thaneshwar Kumar Sahu, CSVTU Bhilai	SWAYAM	(Swayam, Class Central)
Biomedical Signal Processing	Prof. Sudipta Mukhopadhyay, IIT Kharagpur	NPTEL / SWAYAM	(NPTEL)
Introduction to Biomedical Imaging Systems	Prof. Arun K. Thittai, IIT Madras	NPTEL / SWAYAM	(NPTEL)

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

<table>
<tr><th rowspan="3">Course code</th><th rowspan="3">Course Title</th><th colspan="6">Teaching & Learning Scheme</th></tr>
<tr><th colspan="2">Classroom Instructions (CI) (in hours/sem.)</th><th>Lab instructions (LI) (In hours/sem.)</th><th>Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)</th><th>Total no. of hours/sem.</th><th>Total credits (C) (Total Hours/30)</th></tr>
<tr><th>L</th><th>T</th><th>P</th><th>SL</th><th></th><th></th></tr>
<tr><td>PE-EI 603</td><td>Biomedical and Analytical Instrumentation</td><td>42</td><td>0</td><td></td><td>48</td><td>120</td><td>3</td></tr>
</table>

CO-PO Mapping

COs ↓ / POs →	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2	1	1	1	–	–	–	1	1
CO2	3	3	2	2	2	2	–	1	1	2	1
CO3	2	3	3	2	2	2	1	1	1	2	2
CO4	3	3	2	3	3	2	1	–	1	1	2
CO5	2	3	3	2	3	2	1	1	1	1	2
CO6	3	2	2	2	2	1	2	1	2	2	3

CO-PSO Mapping

	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)
CO1	2	3	2
CO2	2	3	2
CO3	2	2	2
CO4	2	3	2
CO5	2	3	2
CO6	2	2	2

Advanced Control System

Course Name: Advanced Control System	**Category:** Professional Elective
Course Code: PE-EI601B	**Semester: VI**
L-T-P: 3-0-0	**Credit:3**
TeachingScheme	**ExaminationScheme**
Theory:3hrs./week	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
Tutorial:NIL	EndSemesterExam.:70Marks
TotalLectures:42Hrs	
Pre-Requisites: To effectively understand this course, students should have foundational knowledge of:Process Control Systems, Mathematical Modeling of Processes, Basic Instrumentation and Measurements, Feedback and Feed forward Control	

Objectives:

This course provides students with an advanced understanding of modeling, analysis, and control of large-scale, integrated process systems. The key goals are to:

- Equip learners with techniques for multivariable and nonlinear process modeling.
- Introduce dynamic analysis and advanced control strategies in complex processes.
- Enable understanding of model predictive control and process optimization.
- Explore advanced process integration, safety systems, and real-time process diagnostics.
- Familiarize students with tools used in the design and operation of smart industrial systems.

CourseOutcomes (COs):

PE-EI 601B.1: Understand the structure and classification of advanced process systems and their modeling approaches.
PE-EI 601B.2: Analyze dynamic behavior of multivariable and interacting processes and identify associated challenges.
PE-EI 601B.3: Apply control techniques for multivariable and nonlinear process systems.
PE-EI 601B.4: Explain model predictive control strategies and implement basic predictive algorithms.
PE-EI 601B.5: Design and optimize integrated process systems for energy and cost efficiency.
PE-EI 601B.6: Evaluate advanced safety, reliability, and fault diagnosis techniques in modern process systems.

Module-Wise Syllabus

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Module Name: Introduction to Advanced Process Systems**	**CO1**
	Definition, structure, and classification of process systems; hierarchy in process operations; process modeling approaches – lumped vs distributed, linear vs nonlinear, static vs dynamic models.	**6**
Module: 2	**Module Name: Dynamics of Interacting & Multivariable Systems**	**CO2**
	System interactions and loop coupling; decoupling; relative gain array (RGA); dynamic analysis using transfer function matrix and state-space models.	**7**
Module: 3	**Module Name: Advanced Process Control Techniques**	**CO3**
	Multivariable PID, Internal Model Control (IMC), adaptive control, nonlinear control strategies; stability considerations.	**8**
Module: 4	**Module Name: Model Predictive Control (MPC)**	**CO4**
	Principle of MPC; model-based prediction; cost function minimization; constraint handling; DMC and QDMC algorithms	**6**
Module: 5	**Module Name: Process Integration and Optimization**	**CO5**
	Pinch analysis, heat exchanger networks (HEN), optimization of process units, energy-efficient process designs, economic performance indices.	**7**
Module: 6	**Module Name: Safety, Reliability & Fault Diagnosis**	**CO6**
	Safety Instrumented Systems (SIS); Fault Detection & Isolation (FDI); Reliability engineering concepts; FMEA, HAZOP, real-time diagnostic tools.	**8**
	Total	**42**

TextBooks:

1. B. Wayne Bequette – *Process Control: Modeling, Design, and Simulation*, Prentice Hall
2. D. E. Seborg, T. F. Edgar – *Process Dynamics and Control*, Wiley
3. M. L. Darby – *Chemical Process Control*, CRC Press
4. Sigurd Skogestad – *Multivariable Feedback Control*, Wiley

Reference Books:

1. tephanopoulos – *Chemical Process Control*, PHI
2. Luyben – *Process Modeling, Simulation, and Control for Chemical Engineers*
3. K. Ogata – *Modern Control Engineering*, Pearson
4. B.G. Liptak – *Instrument Engineers' Handbook*, Elsevier

Online Resources:

SWAYAM/NPTEL Courses for Integration

Sl. No.	Course Title	Instructor / Institute	Platform	Link
1	Advanced Process Control	Prof. R. Ravi, IIT Madras	NPTEL	https://nptel.ac.in/courses/103106150
2	Model Predictive Control	Prof. M. J. Sathe, IIT Bombay	NPTEL	https://nptel.ac.in/courses/108101004
3	Chemical Process Integration	Prof. V. Babu, IIT Madras	NPTEL	https://nptel.ac.in/courses/103106124

Recommended Software Tools

Software	Purpose
MATLAB / Simulink	Modeling, multivariable control design, MPC
Aspen HYSYS / Aspen Plus	Process simulation, integration, optimization
Scilab / Xcos	Open-source simulation for control systems
Python (Control Systems, GEKKO)	MPC, optimization, dynamic modeling
DWSIM	Free process simulation and analysis

Credit Structure (As per NBA Guidelines)

Course Code	Course Title	Teaching & Learning Scheme	Classroom Instructions (CI)	Lab Instructions (LI)	Team Work + Self Learning (TW+SL)	Total Hours/sem.	Total Credits (C)
PE EI 601B	Advanced Process System	L: 3, T: 0, P: 0, SL	42	0	48	90	3

CO–PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	–	–	–	–	–	–	–	–	–
CO2	3	3	2	2	–	–	–	–	–	–	–
CO3	3	3	3	2	1	–	–	–	–	–	–
CO4	3	3	3	2	3	–	–	–	–	–	1
CO5	3	3	3	2	2	1	2	–	–	–	2
CO6	2	3	2	2	1	3	2	3	–	–	1

CO–PSO Mapping

	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)
CO1	2	2	1
CO2	1	3	2
CO3	1	3	2
CO4	2	3	2
CO5	1	3	3
CO6	1	3	3

POWERELECTRONICS

CourseName:POWERELECTRONICS	Category: Professional Elective Course
Course Code: PE-EI 602A	**Semester:VI**
L-T-P:3-0-0	**Credit:3**
TeachingScheme	**ExaminationScheme**
Theory:3 hrs./week	ContinuousAssessment:30
Tutorial:Nil	EndSemester Exam.:70 Marks
TotalLectures:36	
Pre-Requisites:BasicElectronics,Analog electronics	

Objectives:

1. To understand the functioning and characteristics of power switching devices.
2. To understand the principle of operation of converters.
3. To understand different triggering circuits and techniques of commutation of SCR
4. To find external performance parameter of converters.
5. Toanalyzemethodsofvoltagecontrol,improvementofpowerfactorandreductionofharmonicsof the converter
6. Tounderstandvariousapplicationsofconverters

CourseOutcomes (COs):

CO1: Understand the fundamentals of power electronics, including power semiconductor devices (diodes, MOSFETs, IGBTs) and their characteristics, ratings, and applications.

CO2: Analyze PNPN devices such as SCRs, their V-I characteristics, turn-on/turn-off methods, gate triggering circuits, commutation techniques, and protection measures.

CO3: Design and analyze single-phase and three-phase controlled converters, including half-wave, full-wave, dual converters, and evaluate performance parameters under different loads.

CO4: Understand and analyze DC-DC converters (choppers), their types, operating principles, control strategies, and performance parameters for different quadrants of operation.

CO5: Analyze inverters, cyclo-converters, and AC voltage controllers, including single-phase and three-phase bridge inverters, voltage control, harmonic reduction, and performance evaluation.

CO6: Apply power electronics to practical applications such as AC/DC motor speed control, UPS systems, and other industrial systems, integrating theoretical knowledge into real-world scenarios

Module No.	Descriptionof Topics	Contact Hrs	CO
Module 1	**Introduction:** Concept of power electronics, application of power electronics, uncontrolled converters, advantages and disadvantages of power electronics converters, power electronics systems, power diodes,power transistors, power MOSFETS, IGBT	04	CO1
Module2	**PNPNdevices:** Thyristors, brief description of members of Thyristor family with symbol, V-I characteristics and applications. Two transistor model of SCR, SCR turn on methods, switching characteristics, gate characteristics, ratings, SCR protection, series and parallel operation, gate triggering circuits, different commutation techniques of SCR.	05	CO2
Module 3	**Phasecontrolledconverters:** Principleofoperationofsinglephaseandthreephasehalfwave,half Controlled, full controlled converters with R, R-L and RLE loads, effects of freewheeling diodes and source inductance on the performance of converters. External performance parameters of converters,techniquesofpowerfactorimprovement,singlephaseand threephasedualconverters	06	CO1, CO2, CO3
Module 4	**DC-DCconverters:** Principleofoperation,controlstrategies,stepupchoppers,typesof Choppers circuits based on quadrant of operation, performance parameters, multiphase choppers.	05	CO1, CO2, CO3
Module 5	**Inverters:** Definition, classification of inverters based on nature of input source, waveshapeofoutputvoltage, methodofcommutation&connections. Principle of operation of single phase and three phase bridge inverter with R and R-L loads, performance parameters of inverters, methods of voltage control and harmonic reduction of inverters. **Three-phase voltagesourceinverter:** 180°VSI&120°VSI,Power circuitofathree-phasevoltagesourceinverter,switchstates, instantaneous output voltages, average output voltages over a sub Cycle. Cyclo-converters, Ac Voltage Controller and Static Switch	13	CO1, CO2, CO3, CO5
Modul e 6	**Applications:** Speed control of AC and DC motors, UPS.	03	CO1, CO2, CO3, CO4, CO6

Textbooks:

1. PowerElectronics,M.H.Rashid,4th Edition,Pearson
2. PowerElectronics,P.S.Bhimra,,3rdEdition,KhannaPublishers
3. Power Electronics, V.R.Moorthi, Oxford.
4. Power Electronics, M. D.Singh and K.B.Khanchandani,Tata McGrawHill.

Referencebooks

1. ModernPowerElectronics&ACdrives,B.K.Bose,PrenticeHall
2. Power Electronics, Mohan, Undeland & Riobbins,WileyIndia
3. Element of power Electronics, Phillip TKrein,Oxford.
4. Power Electronics systems, J. P. Agarwal, PearsonEducation.
5. AnalysisofThyristorpowerconditionedmotor,S.K.Pillai,UniversityPress.
6. Power Electronics, M.S.JamalAsgha, PHI.
7. PowerElectronics:Principlesandapplications,J.M.Jacob,Thomson

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	1	-	-	-	-	-	2
CO2	3	3	3	2	2	1	-	-	-	-	-	2
CO3	3	3	3	3	3	1	-	-	-	-	-	2
CO4	3	3	3	3	3	1		-	-	-	-	2

CO-PSO Articulation Matrix:

CO	PSO1	PSO2	PSO3
CO1	3	3	2
CO2	3	3	2
CO3	3	3	3
CO4	3	3	3

NANO ELECTRONICS

Course Code: PE-EI 602B	**Category: Professional Elective Courses-V**
Course Name: NANO ELECTRONICS	**Semester: Sixth**
L-T-P: 3-0-0	**Credit: 3**
Total Lectures: 34	
Pre-Requisites: Basic Electronics	

Course outcomes:

CO1: Explain the fundamental concepts and evolution of Nano-electronics from microelectronics, along with its impact on various application domains.

CO2: Analyze the electronic properties of nanostructures and design nano-diodes and optoelectronic devices.

CO3: Compare various nano-transistor architectures and summarize their use in nano-display systems.

CO4: Evaluate the performance parameters of nano-logic devices including switching speed, power dissipation, and parasitic effects.

CO5: Analyze different types of nano-memory technologies and assess their scalability and architectural innovations.

CO6: Classify and describe the operation of nano-integrated sensors and actuators in industrial applications.

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Module Name: Fundamentals on Nanoelectronics –**	**CO1**
	Concepts of of Nanoelectronics, Technological revolution from Microelectronics to Nanoelectronics and beyond, Moore's Law Trends and Limits, Technological advantages in various applications like - Automotive, Health Care, Biochips, Lab-on-Chips , Safety and Security, Industrial Applications, etc.	**4**
	Text Book Resources: **Book name, Chapter No.** Online Resources: If applicable	
Module: 2	**Module Name: Nano diode –**	**CO2**
	Classification of nanostructure (1D or quantum well, 2D or quantum wire, 3D or quantum dot), band structure and energy level modification in various nanostructures, electron transport in nanostructures, design of nano diodes, Resonant-tunneling diodes, nano Light-emitting diodes, nano lasers, nano solar cell, etc.	**6**

	Text Book Resources: **Book name, Chapter No.** **Online Resources: If applicable**	
Module: 3	**Module Name: Nano transistor & Nano Display systems**	**CO3**
	Nano transistor, nano Field-effect transistors, Single-electron-transfer devices, Potential-effect transistors, nano display system, etc.	**6**
	Text Book Resources: **Book name, Chapter No.** **Online Resources: If applicable**	
Module: 4	**Module Name: Nano Logic Devices**	**CO4**
	Nano MOSFET & CMOS Devices, Device structure and Speed Performance of nano FETs, Switching Delay Formulation, Power dissipation, Parasitic Capacitance in Logic Devices, FinFET and Double-Gate Devices, Choice of Materials for Advanced CMOS	**7**
	Text Book Resources: **Book name, Chapter No.** **Online Resources: If applicable**	
Module: 5	**Module Name: Nano Memory Devices**	**CO5**
	Mainstream Memories (DRAM and NAND), Evolution and Scaling Limits, Various Memories Technologies like Ferroelectric Memories, Magnetic Memories, Phase Change Memories, Resistive RAMs, OxRAM and CBRAM, Emerging Memories Architectures, From Cell to Arrays, 3D RRAM Architectures, Opportunities for Emerging Memories etc.	**7**
	Text Book Resources: **Book name, Chapter No.** **Online Resources: If applicable**	
Module: 6	**Module Name: Nano Integrated Sensors and Actuators –**	**CO6**
	Nano Mechanical sensors, Nano MEMS, Nano Pressure Sensors, Acceleration Sensors, Nano Gas Sensors, Biosensors, Electrostatic, Electromagnetic and Piezoelectric Sensors, Nano Optical Fibers, Integrated Fiber Sensors for Industrial applications.	**6**
	Text Book Resources: **Book name, Chapter No.** **Online Resources: If applicable**	
	Total	**36**

Books:

1. Nanoelectronics - Materials,Devices,Applications – R. Puers, et al (Ed), Wiely VCH, 2016
2. Introduction to Nanoelectronics Science, Nanotechnology, Engineering, and Applications – V. V. Mitin, V.A. Kochelap and M. A. Stroscio, Cambridge University Press, 2008
3. Fundamentals of Nanoelectronics - G. W. Hanson, Pearson/Prentice Hall, 2008
4. Intersubband Transitions in Quantum Structures – R. Paiella (Ed), MaGraw-Hill, 2006
5. Nanophotonics and Nanostructured Fiber Sensors – A. B. Maity, Narosa, 2019
6. Sensors Based on Nanostructured Materials - F. J. Arregui (Ed), Springer, 2009

Textbooks (Recommended)

Book Title	Author(s)	Publisher / Edition	Modules Covered
Nano electronics and Nano systems	Karl Goser, Jan	Springer	M1–M6

	Dienstuhl		
Introduction to Nanoelectronics: Science, Nanotechnology, Engineering	Vladimir V. Mitin et al.	Wiley	M1–M5
Fundamentals of Nanoelectronics	George W. Hanson	Pearson Education	M1–M3
Nano scale CMOS Digital Circuits	Mark Lundstrom	Springer	M4

Online Resources (NPTEL / SWAYAM)

Platform	Course Title	Instructor	Link	Modules
NPTEL	Nanoelectronics	Prof. Avik Ghosh (IIT Madras)	Link	M1–M3
NPTEL	Nanoscale Transistors	Prof. S. Datta (Purdue/IIT-B)	Link	M3–M4
SWAYAM	Fundamentals of Nanoelectronics	Prof. S. K. Nandy (IISc Bangalore)	Link	M1–M5
NPTEL	Sensors and Actuators	Prof. Hardik Jeet (IIT Roorkee)	Link	M6

CO-PO-PSO Mapping Table

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	-	-	-	1	-	-	-	1	-
CO2	3	3	2	2	2	-	-	-	-	-	1
CO3	3	2	2	1	1	-	-	-	-	1	-
CO4	3	3	3	2	2	-	-	-	-	1	-
CO5	3	3	2	2	2	1	-	-	-	-	-
CO6	2	3	2	2	2	2	-	-	-	-	1

CO–PSO Mapping Table

COs	PSO1	PSO2	PSO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	2
CO4	3	2	3
CO5	3	2	3
CO6	2	3	3

Computer Networking and Internet of Things (IoT)

Course Name: Computer Networking and Internet of Things (IoT)	**Category: Open Elective**
Course Code: OE-EI 601A	**Semester: 3rd**
L-T-P: 3-0-0	**Credit: 4**
Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
Tutorial: 0 Hrs	End Semester Exam.: 70 Marks
Total Lectures: 36 Hrs	

Course Overview:

This course provides a comprehensive understanding of computer networking principles and the emerging field of the Internet of Things (IoT). Students will explore the fundamental concepts of networking, including protocols, architectures, and security, as well as the design, development, and deployment of IoT systems. The course is structured into six modules, integrating both theoretical knowledge and practical skills to equip students with the ability to work on modern networked systems and IoT applications.

Course Objectives:

1. Understand the principles and architecture of computer networks and IoT systems.
2. Learn about various networking protocols and technologies used in both traditional and IoT environments.
3. Develop skills in designing, implementing, and managing networked systems and IoT solutions.
4. Explore the security challenges and solutions in networking and IoT.
5. Gain hands-on experience with networking tools and IoT platforms.
6. Analyze and apply networking and IoT concepts to real-world scenarios.

Course Outcomes (COs):

On completion of this course, the student will be able to

CO1. Explain the fundamental concepts of data communication, network topologies, OSI and TCP/IP models, and categorize different types of computer networks.

CO2. Analyze data link and physical layer operations including error detection, MAC protocols, and switching techniques used in modern networks.

CO3. Apply addressing schemes and routing techniques in network layer protocols, and compare transport layer functionalities for efficient data transfer.

CO4. Compare and evaluate various IoT communication protocols (MQTT, CoAP, REST, Zigbee, Bluetooth, LoRa, etc.) and their applicability in real-time systems.

CO5. Develop IoT applications using Arduino and ESP8266 by integrating smart sensors and utilizing appropriate communication protocols.

CO6. Design and implement real-time IoT systems using Raspberry Pi and Python, and assess their relevance in domains such as smart cities and smart homes.

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Module Name: Fundamentals of Data Communication and Networks**	CO1
	➢ Introduction to Data Communication: Components, data representation (ASCII, Unicode) ➢ Data flow modes: Simplex, Half Duplex, Full Duplex ➢ Network criteria and physical structure: Topology, Types of connections ➢ Types of networks: LAN, MAN, WAN ➢ Network Models: OSI Reference Model and TCP/IP Model – comparative study	7
Module: 2	**Module Name: Physical and Data Link Layer Essentials**	CO2
	➢ Analog vs. Digital data/signals, Transmission types, Transmission media: guided & unguided ➢ Switching techniques: Circuit switching (TDM, Space division), Message & Packet switching (concepts) ➢ Data Link Layer Functions: Framing (Character & Bit stuffing), Error Detection & Correction (CRC, Hamming Code) ➢ Flow control and Protocols: Stop-and-Wait, Go-Back-N, Selective Repeat, HDLC ➢ MAC Protocols: CSMA/CD, CSMA/CA, ALOHA, Token Ring; Ethernet overview (traditional & fast)	7
Module: 3	**Module Name: Network and Transport Layer Overview**	CO3
	➢ Internetworking devices: Hub, Switch, Router, Bridge, Gateway ➢ IP Addressing (IPv4), Subnetting, and Introduction to IPv6 ➢ Routing basics: Unicast routing protocols (RIP, OSPF, BGP) ➢ Transport Layer: Process-to-process delivery, TCP vs UDP ➢ Congestion Control: Leaky Bucket, Token Bucket; QoS basics	7
Module: 4	**Module Name: IoT Communication Protocols and Architecture**	CO4

	➢ Introduction to IoT and Smart Devices: Sensors, Actuators ➢ Different layers of IoT ➢ IoT Communication Overview: MQTT, CoAP, REST APIs, gRPC ➢ M2M Communication, MQTT Broker ➢ Wireless Communication Protocols: Bluetooth, Zigbee, IEEE 802.15.4, LoRa, 6LoWPAN ➢ Overview of IP-based IoT networks: 6LoWPAN, IPv6	**9**
Module: 5	**Module Name: IoT Programming and Sensor Integration**	**CO5**
	➢ Python for IoT: Basics, Libraries (Paho MQTT, urllib2, Flask, Flask-RESTful) ➢ Introduction to Arduino Programming and Sensor Interfacing (Analog, I2C) ➢ Interfacing Arduino with ESP8266 WiFi module ➢ Communication with Cloud/Broker platforms	**8**
Module: 6	**Module Name: IoT Applications with Raspberry Pi and Use Cases**	**CO6**
	➢ Introduction to Raspberry Pi and GPIO programming using Python ➢ Integrating sensors with Raspberry Pi ➢ Developing simple IoT applications (data logging, cloud upload) ➢ Real-world applications: Smart Cities, Smart Homes, Health Monitoring ➢ Overview of IoT security, privacy, and ethical considerations	**4**
	Total	**42**

Text Books:

Learning Resources

Text books:

1. "Computer Networking: A Top-Down Approach" by James F. Kurose and Keith W. Ross
2. "Data Communications and Networking" by Behrouz A. Forouzan
3. Adrian McEwen, Hakim Cassimally, "Designing the Internet of Things", Wiley publication, 1st Edition, November 2013.
4. Jeeva Jose, Internet of Things, Khanna Publishing House, New Delhi (AICTE Recommended – 2018)
5. Michale Miller , "The Internet of Things: How Smart TVs, Smart Cars, Smart Homes, and Smart Cities Are Changing the World", Pearson Education
6. Hanes David, Salgueiro Gonzalo, Grossetete Patrick, Barton Rob , "IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things" , Pearson Education
7. RMD Sundaram Shriram, K Vasudevan, Abhishek S Nagarajan,"Internet of Things" , Wiley publication,

Reference books:

1. Yasuura, H., Kyung, C.-M., Liu, Y., Lin, Y.-L., Smart Sensors at the IoT Frontier, Springer International Publishing
2. Kyung, C.-M., Yasuura, H., Liu, Y., Lin, Y.-L., Smart Sensors and Systems, Springer International Publishing

Online Resources:

SWAYAM/NPTEL Courses for Integration

Course Title	Provider	Duration	Key Topics Covered	Link
Introduction to Internet of Things	IIT Kharagpur (NPTEL)	12 weeks (Jul–Oct 2025)	IoT architecture, sensors, protocols (MQTT, CoAP), Python, Arduino, Raspberry Pi, Smart Cities & Homes	View Course
Components and Applications of IoT	IIT Patna (ARPIT)	15 weeks (archived)	Sensors, microcontrollers (ARM), IoT protocols, security, localization, smart grid, robotics	View Course
IoT: Design Concepts and Use Cases	NITTTR Chandigarh	8 weeks (archived)	IoT architecture, wireless protocols, Arduino, cloud, smart applications	View Course
Introduction to Computer Networks and Internet Protocols	GLS University (CEC via SWAYAM)	15 weeks (archived)	OSI, TCP/IP, Ethernet, subnetting, SDN, MPLS, network devices, IoT intro	View Course
Optical Wireless Communications for Beyond 5G and IoT	IIIT Delhi (NPTEL)	12 weeks (archived)	Optical wireless links, modulation techniques, IoT integration with 5G	View Course

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
OE-EI	Computer	42			48	90	3

601A	Networking and Internet of Things						
OE-EI 691A	Internet of Things Lab			42	3	45	1.5

CO-PO Mapping

COs ↓ / POs →	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	–	–	–	–	–	–	–	–	2
CO2	3	3	2	2	2	–	–	–	–	–	2
CO3	3	3	2	2	2	–	–	-	-	–	2
CO4	2	3	2	2	3	2	1	-	-	1	2
CO5	2	3	3	2	3	1	1	1	1	2	2
CO6	2	2	3	3	3	2	1	2	2	3	2

CO-PSO Mapping

	PSO1 (Electronics & Computing Systems)	**PSO2 (Instrumentation & Automation)**	**PSO3 (Interdisciplinary & Lifelong Learning)**
CO1	3	-	-
CO2	3	-	-
CO3	3	-	-
CO4	3	2	2
CO5	2	3	3
CO6	2	3	3

Data Analysis for Instrumentation System & AI

Course Name: Data Analytics and AI in Instrumentation Engineering	**Category: Open Elective - III**
Course Code: OE-EI 601B	**Semester: 6th**
L-T-P: 3-0-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs/week	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
Tutorial: 0 Hrs	End Semester Exam.: 70 Marks
Total Lectures: 36 Hrs	

Pre-Requisites: Sensors & Transducers, Basic Probability and Statistics, Basic Python Programming, Basic Signals and Systems (basic idea of sampling, filtering)

Objectives:

The subject aims to encourage the students with the following:

1. Understand the nature and characteristics of Instrumentation data, generated from sensors, DAQ systems, and Industrial Instrumentation.
2. Apply Data Analytics Techniques for pre-processing, feature extraction and visualization of measured data.
3. Use Machine Learning and AI models for calibration, fault detection, condition monitoring, and predictive maintenance of Instrumentation systems.
4. Integrate Data-driven intelligence with instrumentation and automation systems.
5. Develop readiness for modern instrumentation roles involving smart sensors, Industry 4.0 and intelligent monitoring.

Course Outcomes (COs):

On completion of this course, the student will be able to

CO1: Explain the characteristics, challenges, and structure of data generated by Instrumentation and measurements systems**.**

CO2: Apply data pre-processing and feature extraction techniques to sensor and process data.

CO3: Analyze Instrumentation data-sets using statistical and machine-learning based analytic models.

CO4: Apply AI techniques for calibration, fault diagnosis, anomaly detection, and predictive maintenance.

CO5: Use AI-based models for condition monitoring and predictive maintenance of industrial systems.

CO6: Integrate data analytics and AI concepts with industrial instrumentation, automation, and monitoring platforms.

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Module Name: Fundamentals of Instrumentation Data**	CO1
	Types of instrumentation data: sensor signals, process variables, event and alarm data; Sampling, quantization, resolution, accuracy, precision, repeatability; Measurement uncertainty, bias, drift, and noise sources; Nature of real-world industrial measurement data; Visualization of instrumentation data: trends, histograms, control charts	7
	Text Book Resources: **H. S. Kalsi – Electronic Instrumentation, Chapter No.-1, 2 and 3.** **Beckwith, Buck & Marangoni – Mechanical Measurements,**	
Module: 2	**Data Preprocessing and Feature Engineering**	CO2
	Data cleaning: missing data, outliers, sensor failures; Signal preprocessing: smoothing, filtering, de-trending, normalization; Time alignment and re-sampling of multi-sensor data; Data reduction and windowing techniques; Preparing datasets for analytics and AI models.	7
	Text Book Resources: Guyon et al., *Feature Extraction: Foundations and Applications*, Springer, **Chapter No.-1-2**	
Module: 3	**Module Name: Feature Extraction and Statistical Data Analytics**	CO3
	Time-domain, frequency-domain, and statistical features; Feature interpretation for instrumentation applications; Correlation analysis and regression models for sensor relationships; Data-driven calibration and compensation techniques; Performance measures: error, bias, variance, RMSE	7
	Text Book Resources: A. Webb, *Statistical Pattern Recognition*, Wiley, **Chapter No. 1-3**	
Module: 4	**Module Name: Machine Learning for Instrumentation Applications**	CO4
	Overview of machine learning in instrumentation engineering; Supervised learning: regression and classification models; Fault detection and fault classification using ML; Evaluation metrics for instrumentation-related ML models; Model interpretability and engineering relevance	7
	Text Book Resources: Duda, Hart & Stork, *Pattern Classification*, Wiley, **Chapter No.1-2, 5-6**	
Module: 5	**Module Name: AI-Based Condition Monitoring and Predictive Maintenance**	CO5

	Anomaly detection in sensor and process data; Condition monitoring of machines and instruments; Time-series analysis for degradation assessment; Predictive maintenance concepts and workflows; Case studies from vibration, thermal, and process monitoring	**7**
	Text Book Resources: Yang, B. S. and Peng, Z. K.- *Condition Monitoring and Fault Diagnosis of Rotating Machinery*, **Chapter No. 1,3 , 6**	
Module: 6	**Module Name: Industrial Integration and Intelligent Instrumentation Systems**	**CO6**
	Smart sensors and intelligent measurement systems; Integration with PLC, SCADA, and industrial data platforms; AI and data analytics in process automation; Soft sensors and virtual instrumentation concepts; Industrial case studies and emerging trends.	**7**
	Text Book Resources: Lipták, *Instrument Engineers' Handbook – Process Measurement and Analysis*, **Chapter No.** Smart Sensors; Virtual Instrumentation; Soft Sensors	
	Total	**36**

Text Books:

1. Duda, Hart & Stork, *Pattern Classification*, Wiley
2. A. Webb, *Statistical Pattern Recognition*, Wiley
3. H. S. Kalsi, *Electronic Instrumentation*, TMH
4. Beckwith, Buck & Marangoni – *Mechanical Measurements*
5. Yang, B. S. and Peng, Z. K.- *Condition Monitoring and Fault Diagnosis of Rotating Machinery*, Springer-Verlag, London
6. Mobley, R. K.**--***An Introduction to Predictive Maintenance*
7. Butterworth-Heinemann, Chapter: *Predictive Maintenance Concepts and Technologies*
8. Lipták, *Instrument Engineers' Handbook – Process Measurement and Analysis*

Reference Books:

1. Guyon et al.**,** *Feature Extraction: Foundations and Applications*, Springer
2. Trevor Hastie et al.**,** *The Elements of Statistical Learning*, Springer
3. Bishop, *Pattern Recognition and Machine Learning*, Springe

Online Resources:

SWAYAM/NPTEL Courses for Integration

Course Name	Instructor	Platform	Link
Process Data Analytics	Prof. Sachin C. Patwardhan, IIT Bombay	NPTEL/SWAYAM	Link

Machine Learning for Engineering and Science Applications	Prof. P. S. Sastry, IISc Bangalore	NPTEL/SWAYAM	Link
Condition Monitoring and Fault Diagnosis	Prof. R. Tiwari, IIT Guwahati	NPTEL/SWAYAM	Link
Industrial Instrumentation	Prof. S. Mukhopadhyay, IIT Kharagpur	NPTEL/SWAYAM	Link
Artificial Intelligence for Engineers	Prof. Deepak Khemani, IIT Madras	NPTEL/SWAYAM	Link

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
OE-EI ***	Applications of Data Analytics and AI in Instrumentation Engineering	42	0	0	48	90	3

CO-PO Mapping

COs ↓ / POs →	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	-	-	-	-	-	-	-	-	-
CO2	3	3	2	2	2	-	-	-	-	-	-
CO3	3	3	2	2	2	-	-	-	1	-	-
CO4	3	3	3	2	2	-	-	-	1	-	-
CO5	3	3	2	3	2	1	-	-	-	-	-
CO6	3	3	3	2	3	1	-	1	1	1	1

CO-PSO Mapping

	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)
CO1	2	3	1
CO2	3	3	1

CO3	3	2	1
CO4	3	3	2
CO5	2	3	2
CO6	3	3	3

Object Oriented Programming Language

Course Name: Object Oriented Programming Language	**Category:** Open Elective Course-II
Course Code: OE-EI602A	**Semester: 6th**
L-T-P: 3-0-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Continuous Assessment: 25Marks
Tutorial: Nil	End Semester Exam.: 70 Marks
Total Lectures: 36	
Pre-Requisites:	

Course Objective:

1. To understand Object Oriented Programming concepts and basic characteristics of Java.
2. To know the principles of packages, inheritance and interfaces.
3. To define exceptions and use I/O streams.
4. To develop a java application with threads and generics classes.
5. To design and build simple Graphical User Interfaces

Course Outcome:

CO1: Explain and apply fundamental Object-Oriented Programming concepts including abstraction, encapsulation, inheritance, and polymorphism using Java.

CO2: Develop Java programs using proper class structure, constructors, methods, access specifiers, arrays, packages, and control flow constructs following standard Java programming conventions.

CO3: Design reusable and extensible Java applications using inheritance, interfaces, abstract classes, inner classes, object cloning, and collection structures such as ArrayList and Strings.

CO4: Implement robust Java programs incorporating exception handling mechanisms and file-based input/output operations using byte and character streams.

CO5: Develop concurrent Java applications using multithreading concepts and implement type-safe reusable components using generic classes and methods.

CO6: Design and develop event-driven graphical user interface (GUI) applications using AWT and Swing components with appropriate event handling mechanisms.

Module No.	Description of Topics	Contact Hrs	COs
Module 1	**Introduction to oop and java fundamentals** Object Oriented Programming – Abstraction – objects and classes – Encapsulation- Inheritance – Polymorphism- OOP in Java	5	CO1

Module 2	**Characteristics of Java** – The Java Environment – Java Source File Structure – Compilation. Fundamental Programming Structures in Java – Defining classes in Java – constructors, methods -access specifiers – static members -Comments, Data Types, Variables, Operators, Control Flow, Arrays, Packages – Java Doc Comments.	5	CO2
Module 3	**Inheritance And Interfaces** Inheritance – Super classes- sub classes –Protected members – constructors in sub classes- the Object class – abstract classes and methods- final methods and classes – Interfaces – defining an interface, implementing interface, differences between classes and interfaces and extending interfaces – Object cloning –inner classes, Array Lists – Strings	9	CO3
Module 4	**Exception Handling And I/O** Exceptions – exception hierarchy – throwing and catching exceptions– built-in exceptions, creating own exceptions, Stack Trace Elements. Input / Output Basics – Streams – Byte streams and Character streams – Reading and Writing Console – Reading and Writing Files	8	CO4
Module 5	**Multithreading And Generic Programming Differences:** Between multi-threading and multitasking, thread life cycle, creating threads, synchronizing threads, Inter-thread communication, daemon threads, and thread groups. Generic Programming–Generic classes– generic methods – Bounded Types – Restrictions and Limitations.	9	CO5
Module 6	**Event Driven Programming** Graphics programming – Frame – Components – working with 2D shapes – Using color, fonts, and images • Basics of event handling – event handlers – adapter classes – actions – mouse events – AWT event hierarchy • Introduction to Swing – layout management – Swing Components – Text Fields , Text Areas – Buttons- Check Boxes – Radio Buttons – Lists- choices- Scrollbars – Windows– Menus – Dialog Boxes.	9	CO6

Text/Reference Books:

1. Herbert Schildt, ―Java The complete reference‖, 8th Edition, McGraw Hill Education, 2011.
2. Steven Holzner, ―Java 2 Black book‖, Dreamtech press,2011.
3. Timothy Budd, ―Understanding Object-oriented programming with Java‖, Updated Edition, Pearson Education,2000.
4. R.S. Salaria – Mastering Object-Oriented Programming using C++, Khanna Publishing House, 2018.

CO–PO Mapping Table

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	–	2	–	–	–	–	–	1
CO2	3	3	2	1	3	–	–	–	–	–	1

CO3	3	3	3	1	3	–	–	–	1	–	1
CO4	3	3	2	2	3	–	–	–	–	–	1
CO5	3	3	3	2	3	–	–	–	1	–	1
CO6	3	3	3	2	3	–	–	–	1	2	1

CO–PSO Mapping Table

CO \ PSO	PSO1	PSO2	PSO3
CO1	3	1	1
CO2	3	1	1
CO3	3	1	2
CO4	3	1	2
CO5	3	1	2
CO6	3	1	2

1.

Database Management Systems

Course Name: Database Management Systems	**Category:** Open Elective Course-II
Course Code: OE-EI 602B	**Semester:** 5th
L-T-P: 3-0-0	**Credit:** 3
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	Continuous Assessment: 30 Marks
Tutorial: Nil	End Semester Exam.: 70 Marks
Total Lectures: 36	
Pre-Requisites:	

Course Objective:

1. To understand the different issues involved in the design and implementation of a database system.
2. To study the physical and logical database designs, database modeling, relational, hierarchical, and network models
3. To understand and use data manipulation language to query, update, and manage a database
4. To develop an understanding of essential DBMS concepts such as: database security, integrity, concurrency, distributed database, and intelligent database, Client/Server (Database Server), Data Warehousing.
5. To design and build a simple database system and demonstrate competence with the fundamental tasks involved with modeling, designing, and implementing a DBMS.

Course Outcomes:

At the end of the course, students will demonstrate following abilities

CO1: Explain the fundamental concepts of database systems, data models, database architecture, and roles of database users and administrators.

CO2: Design Entity-Relationship (ER) diagrams incorporating constraints, keys, weak entities, and extended ER features for real-world database applications.

CO3: Apply relational algebra, relational calculus, and SQL (DDL, DML, DCL) to create, manipulate, and query relational databases with integrity and security constraints.

CO4: Analyze database schemas and perform normalization (1NF to 5NF, BCNF) using functional and multivalued dependencies to eliminate anomalies.

CO5: Explain and evaluate query optimization techniques, transaction processing, concurrency control, and recovery mechanisms in relational database systems.

CO6: Describe file organization methods and implement indexing techniques including B-Tree and B+ Tree for efficient data retrieval.

Syllabus Details

Module No.	Description of Topics	Contact Hrs	COs
Module 1.	**Introduction:** Concept & Overview of DBMS, View of data, Data Models, Database Languages, Database Administrator, Database Users, Three Schema architecture of DBMS.	3	CO1
Module 2.	**Entity-Relationship Model :** Basic concepts, Design Issues, Mapping Constraints, Keys, Elements of Entity-Relationship Diagram(including Weak Entity Sets, derived attribute, etc.) and ER Diagram Design, Extended E-R features.	5	CO2
Module 3.	**Relational Model:** Structure of relational Databases, Relational Algebra and its operations, Relational Calculus, Extended Relational Algebra Operations, Views, Modifications of the Database.	5	CO3
Module 4.	**SQL and Integrity Constraints:** Concept of DDL, DML, DCL. Basic Structure, Set operations, Aggregate Functions, Null Values, Domain Constraints, Referential Ir	7	CO3
Module 5.	**Relational Database Design:** Different anomalies in designing Database, Decomposition using Functional Dependencies, Normalization using functional dependencies- 1NF, 2NF, 3NF, Boyce-Codd Normal Form, Normalization using multivalued dependencies-4NF, 5NF.	7	CO4
Module 6.	**Internals of RDBMS** Physical data structures, Query optimization: join algorithm, statistics and cost based optimization. Transaction Processing System and its properties, Concurrency control and Recovery Management: transaction model properties, state serializability, lock base protocols, two phase locking.	5	CO5
Module 7.	**File Organization & Index Structures:** File & Record Concept, Placing file and records on Disk, Fixed and Variable sized Records, Types of Single-Level Index (primary, secondary, clustering), Multilevel Indexes, Dynamic Multilevel Indexes using B tree and B+ tree.	4	CO6
	Total	36	

Text/References:

1. "Database System Concepts", 6th Edition by Abraham Silberschatz, Henry F. Korth, S. Sudarshan, McGraw-Hill.
2. "Fundamentals of Database Systems", 5th Edition by R. Elmasri and S. Navathe Pearson Education
3. "Principles of Database and Knowledge – Base Systems", Vol 1 by J. D. Ullman, Computer Science Press.
4. "Foundations of Databases", Reprint by Serge Abiteboul, Richard Hull, Victor Vianu, Addison-Wesley

CO–PO Mapping Table

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	–	2	–	–	–	–	–	1
CO2	3	3	3	1	2	–	–	–	–	–	1
CO3	3	3	3	2	3	–	–	–	–	–	1
CO4	3	3	3	2	2	–	–	–	–	–	1
CO5	3	3	2	2	2	–	–	–	–	–	1
CO6	3	3	2	2	3	–	–	–	–	–	1

CO–PSO Mapping Table

CO \ PSO	PSO1	PSO2	PSO3
CO1	3	1	1
CO2	3	1	2
CO3	3	1	2
CO4	3	1	2
CO5	2	1	2
CO6	3	1	2

Embedded System

Course Name: Embedded System	Category: Open Elective
Course Code: OE-EI 603A	**Semester:** 6th
L-T-P: 3-0-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
	End Semester Exam.: 70 Marks
Total Lectures: 36 Hrs	

Pre-Requisites:

To ensure effective learning and comprehension of the concepts in Embedded Systems, students are expected to have foundational knowledge and skills in the following areas:

- **Digital Electronic Circuit:** Understanding of number systems, logic gates, combinational and sequential circuits, and basic memory elements (flip-flops, counters).
- **Microprocessor and Microcontroller Fundamentals:** Basic knowledge of microprocessor and microcontroller architecture, instruction sets, input/output interfacing, and timing diagrams.
- **Computer Organization and Architecture:** Understanding of CPU architecture, memory hierarchy (RAM, ROM, cache), addressing modes, instruction cycle, and bus systems.
- **C Programming and Embedded C:** Proficiency in fundamental programming constructs including loops, functions, arrays, pointers, bitwise operations, and memory addressing.
- **Measurement and Instrumentation:** Familiarity with signal types, data acquisition principles, ADC/DAC conversion, and basic sensor–actuator interfacing techniques.

Objectives:

The course aims to enable students to acquire a solid foundation in embedded system concepts and design through the following objectives:

1. **To understand** the fundamentals of embedded systems, including their classification, architecture, and major application domains, and to distinguish them from general-purpose computing systems.
2. **To explore** the core design attributes and characteristics of embedded systems, including operational and non-operational quality parameters, hardware-software partitioning, and design methodologies.
3. **To examine** the architecture and operation of ARM-based embedded systems, including the ARM design philosophy, memory organization, peripherals, and AMBA bus protocol.
4. **To develop** programming skills using the ARM instruction set, including data processing, branching, memory access, and ARMv5E extensions for embedded applications.
5. **To understand** and apply the THUMB instruction set, including ARM-THUMB interworking, instruction execution, stack operations, and software interrupt handling.
6. **To gain** knowledge of real-time operating systems (RTOS) and integrated development environments (IDE), including task scheduling, thread management, synchronization, and embedded firmware testing.

Course Outcomes (COs):

On completion of this course, the student will be able to

OE-EI 603A.1. **Analyze** the structure, classification, and architectural differences of embedded systems in contrast to general-purpose computing systems.
*(Cognitive Level: **Analyze**, Knowledge Category: **Conceptual**)*

OE-EI 603A.2. **Evaluate** embedded system design characteristics and quality attributes to **analyze** hardware–software co-design trade-offs.
*(Cognitive Level: **Evaluate**, Knowledge Category: **Conceptual + Procedural**)*

OE-EI 603A.3. **Analyze** ARM processor architecture, core components, and memory organization in embedded applications.
*(Cognitive Level: **Analyze**, Knowledge Category: **Conceptual**)*

OE-EI 603A.4. **Develop** embedded code using the ARM instruction set for various operations including data processing, branching, and memory access.
*(Cognitive Level: **Create**, Knowledge Category: **Procedural**)*

OE-EI 603A.5. **Demonstrate** ARM-THUMB interworking and **implement** efficient instruction sequences using the THUMB instruction set.
*(Cognitive Level: **Apply + Evaluate**, Knowledge Category: **Procedural**)*

OE-EI 603A.6. **Analyze** RTOS concepts and evaluate task scheduling, synchronization mechanisms, and firmware integration for embedded applications.
*(Cognitive Level: **Analyze + Evaluate**, Knowledge Category: **Conceptual + Procedural**)*

Syllabus Details

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Module Name: Introduction to Embedded System**	**OE-EI 603A.1**
	What is an Embedded Systems? Embedded systems Vs General computing systems, History of Embedded Systems, Classification of Embedded systems, Major Application Areas of Embedded Systems. Purpose of Embedded Systems, The Typical Embedded System, Microprocessor Vs Microcontroller, Differences between RISC and CISC, Harvard V/s VonNeumann Processor/Controller Architecture, Big-endian V/s Little-endian processors, Memory (ROM and RAM types), Communication Interfaces, On-board Communication Interface, External Communication Interface, Embedded Firmware, Other System Components.	**6**
Module: 2	**Module Name: Embedded System Design Concepts**	**OE-EI 603A.2**
	Characteristics and Quality Attributes of Embedded Systems, Operational and non-operational quality attributes, Embedded Systems-Application and Domain specific, Hardware Software Co-Design and Program Modeling (excluding UML), Embedded firmware design and development.	**6**
Module: 3	**Module Name: ARM Embedded Systems**	**OE-EI 603A.3**

	Introduction, RISC design philosophy, ARM design philosophy, Embedded system hardware – AMBA bus protocol, ARM bus technology, Memory, Peripherals, Embedded system software – Initialization (BOOT) code, Operating System, Applications. ARM Processor Fundamentals, ARM core dataflow model, registers, current program status register, Pipeline, Exceptions, Interrupts and Vector Table, Core extensions.	**6**
Module: 4	**Module Name: Introduction to the ARM Instruction set**	**OE-EI 603A.4**
	Introduction, Data processing instructions, Load – Store instruction, Software interrupt instructions, Program status register instructions, Loading constants, ARMv5E extensions, Conditional Execution.	**6**
Module: 5	**Module Name: Introduction to the THUMB instruction set**	**OE-EI 603A.5**
	Introduction, THUMB register usage, ARM – THUMB interworking, Other branch instructions, Data processing instructions, Stack instructions, Software interrupt instructions.	**6**
Module: 6	**Module Name: RTOS and IDE for Embedded System Design**	**OE-EI 603A.6**
	Operating System basics, Types of operating systems, Task, process and threads, Thread preemption, Preemptive Task scheduling techniques, Task Communication, Task synchronization issues – Racing and Deadlock. How to choose an RTOS, Integration and testing of Embedded hardware and firmware.	**6**
Total		**36**

Text Books:

- Raj Kamal, Embedded Systems: Architecture, Programming and Design, Tata McGraw-Hill Education.
- Muhammad Ali Mazidi, Rolin D. McKinlay, and Janice Gillispie Mazidi, ARM Assembly Language Programming & Architecture, Pearson Education.
- Shibu K. V., Introduction to Embedded Systems, Tata McGraw-Hill.

Reference Books:

- Andrew N. Sloss, Dominic Symes, and Chris Wright, ARM System Developer's Guide: Designing and Optimizing System Software, Morgan Kaufmann
- David E. Simon, An Embedded Software Primer, Addison-Wesley

Online Resources:

Course Name	Instructor	Platform	Link
Embedded Systems	Prof. Santanu Chaudhary (IIT Delhi)	NPTEL/SWAYAM	Link
Embedded Systems Design	Prof. Anupam Basu (IIT Kharagpur)	NPTEL/SWAYAM	Link
Embedded System Design with ARM	Prof. Indranil Sengupta Prof .Kamalika Dutta (IIT Kharagpur)	NPTEL/SWAYAM	Link

Introduction to Embedded System Design	Prof. Dhananjay V. Gadre Prof. Badri N Subudhi (Netaji Subhas University of Technology and IIT Jammu)	NPTEL/SWAYAM	Link

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	**Course Title**	**Teaching & Learning Scheme**					
		Classroom Instructions (CI) (in hours/sem.)		**Lab instructions (LI) (In hours/sem.)**	**Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)**	**Total no. of hours/sem.**	**Total credits (C) (Total Hours/30)**
		L	**T**	**P**	**SL**		
PC-EI 501	Industrial Instrumentation	36		-	54	90	3

CO-PO Mapping

COs ↓ / POs →	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
OE-EI 603A.1	3	2	1	-	-	–	–	–	–	–	2
OE-EI 603A.2	3	3	2	2	1	–	–	–	–	–	2
OE-EI 603A.3	3	2	2	2	-	–	–	–	–	–	2
OE-EI 603A.4	2	2	3	-	3	–	–	–	–	–	2
OE-EI 603A.5	2	2	3	1	3	–	–	–	–	–	2
OE-EI 603A.6	3	3	3	2	2	–	–	1	1	1	3

CO-PSO Mapping

COs ↓ / POs →	**PSO1 (Electronics & Computing Systems)**	**PSO2 (Instrumentation & Automation)**	**PSO3 (Interdisciplinary & Lifelong Learning)**
OE-EI 603A.1	2	2	2
OE-EI 603A.2	2	3	2
OE-EI 603A.3	3	2	2
OE-EI 603A.4	3	2	2
OE-EI 603A.5	3	2	2
OE-EI 603A.6	2	3	3

VLSI & Microelectronics

Course Name: VLSI & Microelectronics	**Category: Open Elective**
Course Code: OE-EI 603B	**Semester: 6th**
L-T-P: 3-0-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
Tutorial: 0 Hrs	End Semester Exam.: 70 Marks
Total Lectures: 36 Hrs	

Pre-Requisites: Semiconductor Physics , Electronic Devices & Circuits, Analog Electronics, Digital Electronics ,Engineering Mathematics , Programming Fundamentals

Objectives:

The subject aims to encourage the students with the following:

1. **Introduce CMOS device fundamentals** and enable students to understand the electrical characteristics of MOS transistors used in VLSI circuits.
2. **Develop the ability to analyze and design CMOS digital circuits**, including inverters, combinational and sequential logic, with respect to speed, power, and noise margins.
3. **Provide knowledge of VLSI design methodologies**, including hierarchical design concepts and trade-offs involved in high-density integrated circuits.
4. **Familiarize students with memory architectures and interconnect effects**, such as delay, capacitance, and crosstalk in deep-submicron technologies.
5. **Expose students to HDL-based VLSI design flow**, covering RTL design, simulation, synthesis, and an overview of physical design steps.
6. **Prepare students for industry-oriented VLSI roles and higher studies** by building a strong foundation in digital IC design concepts and tools.

Course Outcomes (COs)

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

OE-EI603 B.1: Explain the operating principles and electrical characteristics of MOS transistors used in VLSI circuits.
OE-EI603 B.2: Analyze CMOS inverter and logic gate performance in terms of delay, power dissipation, and noise margins.
OE-EI603 B.3: Design and implement CMOS-based combinational digital circuits using appropriate logic styles and transistor sizing.
OE-EI603 B.4: Design and evaluate sequential circuits such as latches, flip-flops, and registers considering timing constraints like setup and hold times.
OE-EI603 B.5: Analyze memory structures and interconnect effects to estimate delay, power, and reliability in VLSI systems.
OE-EI603 B.6: Apply HDL-based design flow and basic CAD tools to model, simulate, and understand the RTL-to-GDSII VLSI design process.

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Module : MOS Transistor Fundamentals**	**CO1**
	• MOS structure & operation • Threshold voltage, body effect • MOSFET I-V characteristics • Short channel effects • Scaling of MOS devices	**6**
	Digital Fundamentals – *T. L. Floyd / R. P. Jain* (Pearson)	
Module: 2	**Module : MOS Inverters & Logic Gates**	**CO2**
	• CMOS inverter characteristics • Noise margins • Propagation delay • Power dissipation (static & dynamic) • CMOS NAND, NOR, AOI logic • Transistor sizing	**6**
	Digital Design – *M. Morris Mano, Michael D. Ciletti* (Pearson)	
Module: 3	**Module : Combinational Circuit Design**	**CO3**
	• Pass transistor logic • Transmission gates • XOR / XNOR circuits • Multiplexers & decoders • Speed & power trade-offs	**12**
	Digital Design – *M. Morris Mano, Michael D. Ciletti* (Pearson)	
Module: 4	**Module : Sequential Circuits**	**CO4**
	• Latches & flip-flops • Setup & hold time • Clock skew & jitter • Registers & counters	**12**
	Digital Integrated Electronics – *H. Taub & D. Schilling* (TMH)	
Module: 5	**Module : Memory & Interconnect Design**	**CO5**
	• ROM, SRAM, DRAM • Memory cell structures • Sense amplifiers • Interconnect RC delay & crosstalk	**6**
	Digital Integrated Electronics – *Taub & Schilling*	
Module: 6	**Module : VLSI Design Flow**	**CO6**
	• Design hierarchy • HDL modeling (Verilog) • RTL to GDSII flow • Placement & routing overview • DRC, LVS, timing analysis	**6**
	Digital Design – *M. Morris Mano*	
	Total	**48**

Text Books:

1. Digital Fundamentals by T.L. Floyd &R.P.Jain (Pearson).
2. Fundamental of digital circuits by A. Anand Kumar (PHI).
3. Digital Electronics, RishabhAnand (Khanna Publishing House)
4. Digital Integrated Electronics by H. Taub& D. Shilling (TMH).
5. Digital Design, M. Morris Mano, Michael D. Ciletti, (Pearson)

Reference Books:

1. Digital Circuit & Design by S. Aligahanan&S.Aribazhagan (Bikas Publishing)
2. Digital Electronics by A.K. Maini (Wiley-India)
3. Digital Circuits-Vol-I & II by D. RayChaudhuri (Platinum Publishers)
4. Modern Digital Electronics by R.P. Jain (McGraw Hill)

Online Resources:

SWAYAM/NPTEL Courses for Integration

Course Name	Instructor	Platform	Link
Microelectronics: Devices to Circuits	Prof. Sudeb Dasgupta from IIT Roorkee	NPTEL/SWAYAM	Link
VLSI Design Flow: RTL to GDS	Prof. Sneh Saurabh [IIIT, Delhi]	NPTEL/SWAYAM	Link

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
OE-EI 603B	VLSI & Microelectronics	42	0		48	90	3

CO-PO Mapping

Course Outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1:	3	2	1	2	1	–	–	–	–	–	–
CO2:	3	2	2	2	1	–	–	–	–	–	–
CO3:	3	3	3	2	2	1	–	–	–	–	–
CO4:	3	3	3	2	2	1	–	–	–	–	–
CO5:	3	3	2	2	2	1	–	–	–	–	–

CO6:	3	3	3	2	2	2	2	1	1	–	–

CO-PSO Mapping

Course Outcomes (COs)	PSO1	PSO2	PSO3
CO1:	3	2	1
CO2:	3	3	2
CO3:	3	3	3
CO4:	3	3	3
CO5:	3	3	3
CO6:	2	3	3

Internet of Things Lab (IoT)

Course Name: Internet of Things Lab(IoT)	**Category: Open Elective -II**
Course Code: OE-EI 691A	**Semester: Sixth**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination scheme: Maximum marks:**
Tutorial: Nil	External Assessment:60
Practical: 3 hrs./week	Internal Assessment:40
Credit Points: 1.5	

Laboratory Experiments:

Exp. No.	Experiment Title	Mapped CO
1	Familiarization with Arduino IDE & LED Blinking	**CO1**
2	Traffic Light Control using Arduino UNO	**CO4**
3	DHT-11 Monitoring with Arduino & ThingSpeak	**CO3**
4	MQ135 Air Quality Monitoring with Arduino	**CO2**
5	Setup Raspbian & LED Blinking using Python	**CO1**
6	LED Blinking using Raspberry Pi	**CO1**
7	Traffic Light Control using Raspberry Pi	**CO4**
8	DHT-11 Monitoring with Raspberry Pi	**CO2**
9	Upload DHT-11 Sensor Data using Blynk	**CO3**
10	MQ135 Air Quality Monitoring with Raspberry Pi	**CO2**

Course Outcome:

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

CO1: Develop basic embedded applications using Arduino IDE and Raspberry Pi for digital control systems.

CO2: Interface environmental sensors with embedded platforms to acquire and monitor real-time data.

CO3: Implement IoT-based data transmission systems using cloud platforms for remote monitoring.

CO4: Design and analyze integrated IoT-based monitoring systems combining embedded hardware, sensors, and communication modules.

CO–PO Mapping Table

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2	1	3	–	–	–	1	–	1
CO2	3	3	2	2	3	–	–	–	1	–	1
CO3	3	3	3	2	3	–	–	–	1	–	1
CO4	3	3	3	3	3	1	1	2	2	2	2

CO–PSO Mapping Table

CO \ PSO	PSO1	PSO2	PSO3
CO1	3	2	1
CO2	3	3	1
CO3	3	3	2
CO4	3	3	2

Artificial Intelligence Lab

Course Name: Open Elective Course	**Category:** Open Elective
Course Code: OE-EI 691B	**Semester:** 6th
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination scheme: Maximum marks:**
Tutorial: Nil	External Assessment:60
Practical: 3 hrs./week	Internal Assessment:40
Credit Points: 1.5	

Course Outcomes:	
CO. 1	**Implement** basic artificial-intelligence techniques such as search, knowledge representation, and simple rule-based reasoning using Python.
CO. 2	**Apply** supervised and unsupervised machine-learning algorithms (classification, clustering, and regression) to practical data-driven problems.
CO. 3	**Design** and **execute** experiments using AI libraries such as scikit-learn, NumPy and TensorFlow to interpret model behavior and evaluate performance.
CO. 4	**Develop** and **demonstrate** a mini-project integrating AI algorithms for automation, prediction, or decision-making in engineering systems.
Pre-Requisite:	
1	Basic Programming in Python / C
2.	Knowledge of Linear Algebra and Probability

Experiment No.	Laboratory Experiments	COs
1	Study of Python libraries (Numpy, Pandas, Matplotlib) and data preprocessing methods.	CO1
2	Implementation of uninformed and informed search algorithms (BFS, DFS, A*).	CO1
3	Development of rule-based expert system using Python if-else logic and knowledge base.	CO1
4	Implementation of supervised learning algorithms (Linear Regression, Logistic Regression).	CO2
5	Implementation of unsupervised learning algorithms (K-Means and Hierarchical Clustering).	CO2
6	Design of ANN model using TensorFlow / Keras for classification problems.	CO3
7	Performance evaluation using confusion matrix, precision, recall, and ROC curve.	CO3
8	Mini-Project – AI-based prediction / control (e.g., temperature forecasting, sensor fault detection).	CO4
	Beyond Syllabus	
1.	Implementation of Reinforcement Learning (Q-Learning / SARSA) for a simple environment.	CO3
2.	Application of Natural Language Processing for text classification using pre-trained models.	CO4

Object Oriented Programming language Lab

Name of the Course: Object Oriented Programming language Lab	**Category:** Open Elective Courses-II
Course Code: OE-EI 692A	**Semester: 6th**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination scheme:**
Tutorial: Nil	External Assessment:60
Practical: 3 hrs./week	Internal Assessment:40
Credit Points: 1.5	

Course Outcome:

After successful completion of the laboratory, students will be able to:

CO1: Develop object-oriented Java programs using classes, constructors, method overloading/overriding, inheritance, arrays, and wrapper classes.

CO2: Design reusable and modular applications using interfaces, multiple inheritance concepts, and package management in Java.

CO3: Implement concurrent applications using multithreading concepts in Java.

CO4: Develop event-driven and GUI-based applications using applet programming concepts.

Laboratory Experiments:

Exp. No.	**Title of the Experiment**	**COs**
1	Assignments on class, constructor, overloading, inheritance, overriding	CO1
2	Assignments on wrapper class, arrays	CO1
3	Assignments on developing interfaces- multiple inheritance, extending interfaces	CO2
4	Assignments on creating and accessing packages	CO2
5	Assignments on multithreaded programming	CO3
6	Assignments on applet programming	CO4

CO–PO Mapping Table

CO \ PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
CO1	3	2	2	1	3	–	–	–	–	–	1
CO2	3	3	3	1	3	–	–	–	1	–	1
CO3	3	3	2	2	3	–	–	–	1	–	1
CO4	3	3	3	2	3	–	–	–	1	2	1

CO–PSO Mapping Table

CO \ PSO	PSO1	PSO2	PSO3
CO1	3	1	1
CO2	3	1	2
CO3	3	1	2
CO4	3	1	2

Data Base Management System Lab

Name of the Course: Data Base Management System Lab	**Category:** Open Elective Courses-II
Course Code: OE-EI 692B	**Semester: 5th**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination scheme:**
Tutorial: Nil	External Assessment:60
Practical: 3 hrs./week	Internal Assessment:40
Credit Points: 1.5	

Course Outcome:

After successful completion of the laboratory, students will be able to:

CO1: Create and define relational database schemas using appropriate data types, constraints, and indexing mechanisms.

CO2: Manipulate database tables and records using SQL data definition and data manipulation statements.

CO3: Retrieve and analyze data from relational databases using SQL queries, aggregate functions, joins, and subqueries.

CO4: Manage database security and administration using views, user access control, and privilege management commands.

EXP. No.	**Laboratory Experiments:**	**COs**
1.	**Creating Database** • Creating a Database • Creating a Table • Specifying Relational Data Types • Specifying Constraints • Creating Indexes	CO1
2.	**Table and Record Handling** • INSERT statement • Using SELECT and INSERT together • DELETE, UPDATE, TRUNCATE statements • DROP, ALTER statements	CO2

3.	**Retrieving Data from a Database** • The SELECT statement • Using the WHERE clause • Using Logical Operators in the WHERE clause • Using IN, BETWEEN, LIKE , ORDER BY, GROUP BY and HAVING Clause • Using Aggregate Functions • Combining Tables Using JOIN • Sub queries	CO3
4.	**Database Management** • Creating Views • Creating Column Aliases • Creating Database Users • Using GRANT and REVOKE	CO4

CO–PO Mapping Table

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2	1	3	–	–	–	–	–	1
CO2	3	3	2	1	3	–	–	–	–	–	1
CO3	3	3	3	2	3	–	–	–	–	–	1
CO4	3	2	2	1	2	–	–	2	–	1	1

CO–PSO Mapping Table

CO \ PSO	PSO1	PSO2	PSO3
CO1	3	1	1
CO2	3	1	1
CO3	3	1	2
CO4	2	1	2

Advance Microcontroller Laboratory

Course Name: Advance Microcontroller Laboratory	**Category: Open Elective** III
Course Code: OE-EI 693A	**Semester: 6th**
L-T-P: 0-0-3	**Credit: 1.5**
Teaching Scheme	**Examination Scheme**
Practical: 3 hrs./week	2 – Practical Continuous Assessment: 40 Marks (PCA-1 and PCA-2)
	End Semester Exam.: 60 Marks

Pre-Requisites:

To ensure effective learning and successful implementation of experiments in the Embedded Systems Laboratory, students are expected to have foundational knowledge in the following areas:

- **Digital Electronics**: Understanding of logic gates, number systems, combinational and sequential circuits, which form the basis for embedded hardware design.
- **Microprocessors and Microcontrollers**: Familiarity with microcontroller architecture, instruction sets, and basic programming (especially 8051 or 8085) is essential to grasp ARM-based microcontroller operation.
- **Embedded C Programming**: Basic skills in writing structured C code and understanding low-level programming concepts like bit manipulation, memory access, and interrupts.
- **Computer Architecture**: Knowledge of memory organization, processor-bus systems, and register-level operations is helpful for understanding embedded system design.

Objectives:

The Embedded Systems Laboratory is designed to achieve the following objectives:

- **Develop hands-on experience** in writing and executing embedded C and assembly programs on ARM microcontrollers for arithmetic, logic, and control tasks.
- **Interface digital and analog peripherals** such as LEDs, switches, buzzers, keypads, motors, sensors, and real-time modules with microcontrollers using GPIO, ADC, and I2C protocols.
- **Design and simulate embedded applications** like traffic control systems, sensor monitoring, and input-output systems using microcontroller-based logic.
- **Understand timing, communication, and interrupt mechanisms** in embedded systems and apply them in real-world scenarios.
- **Build debugging and problem-solving skills** through lab-based testing, hardware troubleshooting, and project integration.

Course Outcomes (COs):

On completion of this course, the student will be able to

OE-EI 693A.1 **Develop** and **test** embedded C and assembly programs on ARM microcontrollers for performing arithmetic, logical, and control operations.

*(Cognitive Level: **Analyze**, Knowledge Category: **Procedural**)*

OE-EI 693A.2 **Design** and **implement** array-based operations using structured programming techniques.

*(Cognitive Level: **Create**, Knowledge Category: **Conceptual + Procedural**)*

OE-EI 693A.3 **Interface** and **control** digital I/O devices such as switches, LEDs, buzzers, keypad, and stepper motor using GPIO programming.

*(Cognitive Level: **Apply**, Knowledge Category: **Procedural**)*

OE-EI 693A.4 **Interface** analog peripherals and real-time communication modules (ADC, RTC) with microcontrollers using appropriate protocols (I2C, LCD, etc.).

*(Cognitive Level: **Analyze**, Knowledge Category: **Procedural**)*

Syllabus details

Conduct the following experiments on an ARM microcontroller evaluation board to learn Assembly Language Program and using evaluation version of Embedded 'C' & Keil uVision-4 tool/compiler.

Experiment No.	Experiment Name	Mapped CO
01	Write a program to perform basic arithmetic operations (addition, subtraction, multiplication, division).	**OE-EI 693A.1**
02	Write a program to find the sum of the first 10 integer numbers.	**OE-EI 693A.1**
03	Write a program to find the largest or smallest number in an array of 32 numbers.	**OE-EI 693A.2**
04	Write a program to arrange a series of 32 bit numbers in ascending/descending order.	**OE-EI 693A.2**
05	Interface a stepper motor and rotate it in clockwise and anti-clockwise direction using GPIO	**OE-EI 693A.3**
06	Interface a switch and display its status through LED, buzzer, and relay	**OE-EI 693A.3**
07	Interface an ADC to read analog signals from sensors (e.g., temperature sensor or potentiometer) and display the digital value	**OE-EI 693A.4**
08	Implement a time-based traffic light control system using GPIO and timers.	**OE-EI 693A.4**

Online Resources:

Laboratory Name	Platform	Link
Real Time Embedded Systems	Virtual Labs	Link
Embedded System Design with 8051 and PIC Microcontroller	Virtual Labs	Link

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
PC-EI 592	Advance Microcontroller Laboratory			36	9	45	1.5

CO-PO Mapping

COs ↓ / POs →	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OE-EI 693A.1	3	2	2	1	2	–	–	–	–	–	2
OE-EI 693A.2	3	3	2	1	2	–	–	–	–	–	2
OE-EI 693A.3	3	2	2	2	3	1	–	1	1	–	2
OE-EI 693A.4	3	2	2	3	3	1	–	1	1	–	3

CO-PSO Mapping

COs ↓ / POs →	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)
OE-EI 693A.1	3	2	2
OE-EI 693A.2	3	1	2
OE-EI 693A.3	3	3	2
OE-EI 693A.4	3	3	3

VLSI & Microelectronic Circuits

Course Name: VLSI & Microelectronics Lab	**Category:** Open Elective III
Course Code: OE-EI 693 B	**Semester:** 3rd
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination scheme: Maximum marks:**
Tutorial: Nil	External Assessment:60
Practical: 3 hrs./week	Internal Assessment:40
Credit Points: 1.5	

Course Outcomes:	
OE-EI 693 B. 1	Understand and implement basic CMOS devices and logic gates by analyzing MOSFET characteristics and designing simple combinational circuits.
OE-EI 693 B. 2	Design and simulate combinational circuits, arithmetic units, and multiplexing systems using CMOS logic, and evaluate their performance in terms of speed, power, and reliability.
OE-EI 693 B. 3	Design, implement, and verify sequential circuits including flip-flops, counters, registers, and small-scale VLSI blocks, ensuring correct timing and functional behavior.
OE-EI 693 B. 4	Model, simulate, and synthesize digital circuits using HDL (Verilog/VHDL) and CAD/EDA tools, including memory structures and interconnects, with proper verification and optimization.
Pre-Requisites:	
	Digital Electronics Fundamentals, Semiconductor Device Knowledge, Mathematics Fundamentals, Basic Computer Skills, Circuit Simulation Awareness

List of Experiments

Experiment No.	Experiment Title	Description / Activity	Mapped CO(s)
1	Characteristics of MOSFET	Measure I–V characteristics, threshold voltage, and body effect using simulation tools	CO1
2	CMOS Inverter Design & Analysis	Design CMOS inverter, plot VTC, calculate delay and power dissipation	CO2
3	Logic Gate Implementation	Design NAND, NOR, XOR using CMOS transistors and verify operation	CO1
4	Combinational Circuit – MUX/DEMUX	Design and simulate multiplexer and demultiplexer circuits	CO2
5	Arithmetic Circuits	Implement Half Adder, Full Adder, and basic arithmetic circuits using CMOS logic	CO2
6	Sequential Circuits – Flip-Flops	Design and verify SR, D, JK, T flip-flops using CMOS or ICs	CO3
7	Counters & Registers	Design synchronous counters and shift registers, verify timing constraints	CO3
8	Complex Sequential Circuits	Design universal registers and serial adder units using flip-flops and multiplexers	CO3
9	HDL Modeling – Combinational Circuits	Model and simulate combinational circuits (MUX, decoder, arithmetic) in	CO4

		Verilog/VHDL	
10	HDL Modeling – Sequential Circuits	Model sequential circuits (flip-flops, counters) in Verilog/VHDL and verify functionality	CO4
11	Logic Synthesis & Verification	Synthesize RTL designs using CAD/EDA tools and perform functional verification	CO4
12	Memory Cell Simulation	Simulate SRAM/ROM read/write operations and timing analysis	CO4
13	Interconnect & Layout Simulation	Analyze RC delay, crosstalk, and perform basic layout verification using CAD tools	CO4

CO–PO–PSO Mapping Table

Course Outcomes (COs)	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO11	PSO 1	PSO 2	PSO 3
CO1	3	2	1	1	1	1	1	1	1	1	1	3	2	1
CO2	3	3	2	2	2	2	1	1	1	1	1	3	3	2
CO3	3	3	2	2	2	2	2	1	1	1	1	2	3	3
CO4	2	3	2	2	2	2	2	2	1	1	1	2	3	3

Course Information

Name of the Course: Seminar	**Category: Sessional**
Course Code: PW-EI-681	**Semester: 6th**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination scheme: Maximum marks:**
Tutorial: Nil	Internal Assessment:
Sessional: 4 hrs./week	Final Assessment: 100
Credit Points: 1.5	

Objectives:

To enable students to select, investigate, and present a topic of current relevance in the fields of electronics, instrumentation, control, or interdisciplinary domains through literature review, critical analysis, and technical communication. The course emphasizes independent learning, scientific writing, and effective oral presentation skills that prepare students for professional or research careers.

Course Outcomes:

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

PW-EI 681.1 *(Topic Selection & Literature Survey)*

Identify, collect, and review contemporary literature from journals, conferences, and credible technical sources in electronics, instrumentation, control, or interdisciplinary fields.

PW-EI 681.2 *(Rubric B: Technical Content & Understanding)*

Analyze and interpret the technical concepts, methodologies, and findings related to the chosen seminar topic using appropriate engineering fundamentals.

PW-EI 681.3 *(Rubric C: Seminar Presentation)*

Organize and deliver a structured technical seminar using effective oral communication skills and appropriate audio-visual tools.

PW-EI 681.4 *(Rubric D: Seminar Report)*

Prepare a well-structured technical seminar report following standard formatting, ethical practices, and proper citation norms.

PW-EI 681.5 *(Rubric E: Question Answering & Participation)*

Respond effectively to technical questions and participate in scholarly discussions, demonstrating clarity of understanding and professional attitude.

CO-PO Mapping

CO \ PO	PO1Engg. Knowledge	PO2Problem Analysis	PO3Design / Solutions	PO4Investigation	PO5Modern Tools	PO6	PO7	PO8Ethics	PO9Teamwork	PO10Communication	PO11
CO1 Literature survey (AEIE + allied domains)	2	2	–	3	–	–	–	–	–	–	–
CO2 Technical analysis & interpretation	3	3	–	2	–	–	–	–	–	–	–
CO3 Seminar presentation	–	–	–	–	–	–	–	–	2	3	–
CO4 Seminar report & ethics	–	–	–	–	–	–	–	3	–	2	–
CO5Q&A, participation, critical thinking	–	2	–	–	–	–	–	2	2	2	–

CO-PSO Mapping

CO \ PSO	PSO1Electronics & Computer Systems	PSO2Instrumentation & Industrial Automation	PSO3Interdisciplinary Applications, Research & Higher Studies
CO1 Literature survey (AEIE + allied domains)	2	2	3
CO2 Technical analysis & interpretation	2	2	2
CO3 Seminar presentation	–	–	2
CO4 Seminar report & ethics	–	–	3
CO5Q&A,	1	1	2

participation, critical thinking			

Seminar Assessment Rubrics (Total: 100 Marks)

A. Topic Selection & Literature Survey – 20 Marks

Criteria	Excellent (16–20)	Good (11–15)	Satisfactory (6–10)	Poor (≤5)
Relevance & Novelty	Highly relevant, contemporary, innovative	Relevant and current	Moderately relevant	Irrelevant / outdated
Literature Quality	Reputed journals, conferences, patents	Mix of good sources	Limited sources	Poor or non-technical sources

B. Technical Content & Understanding – 30 Marks

Criteria	Excellent (24–30)	Good (17–23)	Satisfactory (10–16)	Poor (≤9)
Conceptual Clarity	In-depth understanding, critical insights	Good understanding	Basic understanding	Weak understanding
Analysis & Interpretation	Strong analysis and synthesis	Adequate analysis	Limited analysis	No analysis

C. Seminar Presentation – 20 Marks

Criteria	Excellent (16–20)	Good (11–15)	Satisfactory (6–10)	Poor (≤5)
Organization & Flow	Well-structured, logical flow	Mostly structured	Somewhat disorganized	Poorly organized
Communication Skills	Clear, confident, professional	Clear with minor issues	Hesitant delivery	Unclear communication

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D. Seminar Report – 20 Marks

Criteria	Excellent (16–20)	Good (11–15)	Satisfactory (6–10)	Poor (≤5)
Technical Writing	Precise, coherent, well-formatted	Minor issues	Average writing	Poor writing
Referencing & Ethics	Proper citations, plagiarism-free	Minor citation issues	Incomplete citations	Plagiarism observed

E. Question Answering & Participation – 10 Marks

Criteria	Excellent (8–10)	Good (5–7)	Satisfactory (3–4)	Poor (≤2)
Response Quality	Accurate, confident answers	Mostly correct	Partially correct	Unable to respond

Course Information

Name of the Course: MINIPROJECT	Category: Project Work
Course Code: PW-EI 682	**Semester: 4th**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination scheme: Maximum marks:**
Tutorial: Nil	Internal Assessment:40
Practical:4 hrs./week	External Assessment:60
Credit Points: 2	

Objectives:

To enable 3rd year AEIE students to integrate hardware and software skills for developing a moderately complex engineering solution, while enhancing system analysis, teamwork, project management, and documentation abilities in preparation for the final year project.

Course Outcomes:

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

PW-EI 481.1	Apply advanced concepts of electronics, instrumentation, and control systems to design and develop a functional project with increased technical depth.
PW-EI 481.2	Integrate multiple hardware and software components, including sensors, actuators, and microcontrollers, to implement a complete working system.
PW-EI 481.3	Analyze system performance using appropriate testing methods, data acquisition, and result interpretation to meet defined specifications.
PW-EI 481.4	Demonstrate effective project management skills, including planning, resource allocation, and adherence to timelines for medium-scale projects.
PW-EI 481.5	Prepare detailed technical documentation and deliver professional presentations showcasing design methodology, implementation, and performance analysis.
PW-EI 481.6	Exhibit innovation, problem-solving ability, and awareness of societal, environmental, and ethical considerations in the project design and execution.

CO-PO Mapping

PW-EI 682											
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
PW-EI 682.1	3	3	3	2	2	2	1	1	2	1	2
PW-EI 682.2	3	2	3	3	3	1	1	2	2	1	2
PW-EI 682.3	2	3	3	3	2	2	1	1	2	1	2
PW-EI 682.4	2	2	2	1	2	1	1	3	3	2	2
PW-EI 682.5	1	2	2	2	2	1	2	2	3	2	2
PW-EI 682.6	2	2	2	1	1	3	3	2	3	2	3

CO-PSO Mapping

PW-EI 682			
COs	**PSO1**	**PSO2**	**PSO3**
PW-EI 682.1	3	3	2
PW-EI 682.2	3	3	2
PW-EI 682.3	3	2	2
PW-EI 682.4	2	2	1
PW-EI 682.5	2	1	2
PW-EI 682.6	2	2	3

Renewable Energy Sources

Course Name: Renewable energy sources	**Category: Professional Elective VI**
Course Code: PE-EI 701A	**Semester: 7th**
L-T-P: 3-0-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs	3- Continuous Assessment: 30Marks (CA-1, CA-2, CA-3)
Tutorial: 0 Hrs	End Semester Exam.: 70 Marks
Total Lectures: 48 Hrs	

Pre-Requisites: Prerequisites for the Renewable Energy Sources subject typically include the following:

1. **Basic Electrical Engineering**: Understanding of fundamental electrical concepts and electrical components and systems.
2. **Introduction to Power Electronics and power systems**: The principles and applications of electronic devices in the control and conversion of electric power and provides insights into the generation, transmission, and distribution of electric power within power systems.

Objectives:

The subject aims to encourage the students with the following:

1. **Develop Fundamental Knowledge:** To provide a strong foundation on the principles, potential, and importance of renewable energy sources in the global and Indian context.
2. **Classify renewable energy types:** To enable students to identify and describe various types of renewable energy sources such as solar, wind, biomass, hydro, tidal, and geothermal.
3. **Analyze Energy Conversion Technologies:** To impart knowledge about the technologies and devices used for converting renewable energy into usable forms like electricity and heat.
4. **Evaluate Environmental and Economic Impacts**: To assess the environmental benefits and limitations of renewable energy systems and their role in reducing greenhouse gas emissions and dependency on fossil fuels.
5. **Foster System Design Skills:** To introduce students to the basic design and integration of renewable energy systems for standalone and grid-connected applications.
6. **Promote Sustainable Development Awareness:** To sensitize students to the role of renewable energy in sustainable development and energy security.
7. **Introduce Policy and Market Trends:** To provide an overview of government policies, incentives, and global trends in renewable energy markets.
8. **Encourage Innovation and Research:** To motivate students to explore innovations, emerging technologies, and research opportunities in renewable energy fields.

Course Outcomes (COs):

On completion of this course, the student will be able to

CO1. Identify and explain the various types of renewable energy sources and their role in sustainable development.
CO2. Analyze the operating principles, technologies, and performance parameters of solar photovoltaic, solar thermal, and wind energy systems.
CO3. Evaluate the potential and limitations of biomass, geothermal, tidal, and small hydropower systems.
CO4. Design and estimate basic renewable energy systems for standalone and grid-connected applications.
CO5. Assess the environmental and economic impacts of renewable energy technologies compared to conventional sources.
CO6. Interpret national and global renewable energy policies, standards, and future trends.

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Module Name: Introduction to Energy Sources**	**CO1**
	➢ Overview of conventional vs non-conventional energy ➢ Energy demand and supply trends (India & World) ➢ Environmental impact of conventional energy sources. ➢ Need for renewable energy, energy conservation, and sustainability. ➢ Sustainable Development Goals ➢ Energy agencies in India and World.	**6**
	Text Book Resources: Renewable Energy: Power for a Sustainable Future by Godfrey Boyle (Oxford University Press).	
Module: 2	**Module Name:** Solar Energy	**CO2**
	➢ Solar radiation: types, measurement, and estimation ➢ Solar thermal systems: collectors, solar water heating, solar dryers, solar cookers ➢ Solar PV: principle, types of solar cells, IV characteristics ➢ PV system components: charge controller, battery, inverter. ➢ Grid-connected and standalone systems.	**6**
	Text Book Resources: Renewable Energy: Power for a Sustainable Future by Godfrey Boyle (Oxford University Press).	
Module: 3	**Module Name: Wind Energy**	**CO3**
	➢ Wind energy basics and wind turbine operation ➢ Site selection and wind resource assessment ➢ Types of wind turbines (horizontal vs vertical axis) ➢ Wind turbine components and power extraction ➢ Wind farms and grid integration	**12**

	Text Book Resources: Non-Conventional Energy Sources by G.D. Rai	
Module: 4	**Module Name: Biomass and Bioenergy**	**CO4**
	➢ Biomass resources and classification. ➢ Biomass conversion methods: combustion, gasification, pyrolysis ➢ Biogas production, plant design and operation ➢ Biofuels (bioethanol, biodiesel) – production and uses	**12**
	Text Book Resources: Non-Conventional Energy Sources by G.D. Rai	
Module: 5	**Module Name: Other Renewable Sources**	**CO5**
	➢ **Hydropower:** classification (micro, mini, small), site selection, components ➢ **Geothermal Energy:** resources, types of systems, advantages and limitations ➢ **Tidal and Wave Energy:** principles, site requirements, turbine types ➢ **Hydrogen Energy:** production methods (electrolysis, thermochemical), storage, applications ➢ **Fuel Cells:** working principle and applications	**6**
	Text Book Resources: Book name, Renewable Energy: Power for a Sustainable Future by Godfrey Boyle (Oxford University Press).	
Module: 6	**Module Name: Integration, Policy & Economics, Environmental Analysis and Carbon Mitigation**	**CO6**
	➢ Hybrid energy systems and energy ➢ Grid integration issues of renewables ➢ Renewable energy policies in India (MNRE, Solar Mission) ➢ Economics: cost analysis, payback, subsidies ➢ Future trends and role of AI/IoT in renewable energy ➢ Grid Integration of Electric Vehicle and Fuel Cell Vehicle ➢ Environmental Analysis and Carbon Mitigation	**6**
	Text Book Resources: Book name: Energy Technology: Non-Conventional, Renewable and Conventional, S. Rao and B.B. Parulekar, (Khanna Publishers)	
	Total	**48**

Text Books:

1. Non-Conventional Energy Sourcesby G.D. Rai (Khanna Publishers).
2. Renewable Energy: Power for a Sustainable Future by Godfrey Boyle (Oxford University Press).
3. Renewable Energy Resources, John Tidel and Tony Weir (Routledge)
4. Solar Energy: Principles of Thermal Collection and Storage by S.P. Sukhatme and J.K. Nayak(TMH).
5. Energy Technology: Non-Conventional, Renewable and Conventional, S. Rao and B.B. Parulekar, (Khanna Publishers)

Reference Books:

6. Fundamentals of Renewable Energy Systems by D. Mukherjee and S. Chakrabarti(New Age International)
7. Renewable Energy Engineering and Technology: A Knowledge Compendium by V.V.N. Kishore (TERI Press)
8. Wind Energy Explained: Theory, Design and Application- James F. Manwell, Jon G. McGowan, Anthony L. Rogers (Wiley)
9. Solar Engineering of Thermal ProcessesbyJohn A. Duffie and William A. Beckman (Wiley)

Online Resources:

SWAYAM/NPTEL Courses for Integration

Course Title	Platform	Instructors / Organisers	Coverage & Focus
Renewable Energy Engineering: Solar, Wind & Biomass Energy Systems	NPTEL / SWAYAM	Prof. R. Anandalakshmi& Prof. V. V. Goud (IIT Guwahati)	Engineering fundamentals of solar, biomass & wind systems; design & analysis approaches (NPTEL Online Courses, Class Central, Class Central)
Physics of Renewable Energy Systems	NPTEL / SWAYAM	(Faculty from NPTEL)	Physics-based approach to solar PV, solar heaters, wind, tidal, geothermal; includes energy-storage & characterization techniques (NPTEL Online Courses, swayam.gov.in, NPTEL Online Courses)
Technologies for Clean and Renewable Energy Production	NPTEL / SWAYAM	(Multi-disciplinary NPTEL faculty)	Covers clean conversion routes from fossil fuels and renewables; global + Indian context (NPTEL, swayam.gov.in)
Sustainable Power Generation Systems	NPTEL / SWAYAM	Dr. Pankaj Kalita (IIT Guwahati)	Design & analysis of renewable energy plants: solar thermal/PV, wind, micro-hydro, biomass, ocean & storage systems (NPTEL Online Courses, Class Central)
Renewable Energy Technologies and Their Uses	SWAYAM (IGNOU)	Dr. Sanjay Agrawal	Practical uses of solar thermal/PV, biomass, design of devices like solar cookers, heaters, biogas systems, & green building tech (onlinecourses.swayam2.ac.in, swayam.gov.in)
Energy Resources, Economics and	SWAYAM	(Humanities/Economics faculty)	Broader energy landscape: global energy demand, environmental

Sustainability			impacts, economics, policy, sustainable development (swayam.gov.in, swayam.gov.in)

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
PE-EI 701	Renewable Energy sources	42			48	90	3

CO-PO Mapping

COs ↓ / POs →	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2	2	2	2	1	2	1	1	1
CO2	3	3	2	2	2	2	1	1	1	-	-
CO3	3	2	3	2	2	2	2	1	-	1	-
CO4	3	2	3	2	2	2	-	-	1	-	-
CO5	3	2	2	2	2	2	2	1	1	-	-
CO6	3	2	3	2	3	2	2	3	3	2	2

CO-PSO Mapping

	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)
CO1	3	2	1
CO2	3	2	1
CO3	3	3	2
CO4	3	3	2
CO5	2	3	2
CO6	3	2	3

Non Destructive Testing

Course Name: Non Destructive Testing	**Category:** Professional Elective VI
Course Code: PE-EI 701B	**Semester: 7th**
L-T-P: 3-0-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 4 Hrs	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
Tutorial: NIL	End Semester Exam.: 70 Marks
Total Lectures: 48 Hrs	

Pre-Requisites:
Basic understanding of sensors and transducers and engineering physics.

Objectives:

The objectives of this course aim to:

- Introduce the fundamental principles and importance of Non-Destructive Testing (NDT) techniques.
- Familiarize students with various conventional NDT methods such as visual inspection, magnetic particle testing, thermal testing, radiography, eddy current testing, and ultrasonic testing.
- Explain the generation, propagation, and characteristics of ultrasonic waves used in material evaluation.
- Develop the ability to select and apply appropriate NDT techniques for different industrial inspection scenarios.
- Enable students to measure key physical parameters like thickness, depth, flow, and level using ultrasonic techniques.
- Expose students to the application of ultrasonic technology in medical diagnosis, including imaging and acoustical holography.

COURSE OUTCOMES:

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

PE-EI 701.1. Explain the importance of NDT and basic principles behind various NDT techniques.
PE-EI 701.2. Demonstrate various surface inspection techniques including visual, magnetic, and eddy current testing.
PE-EI 701**.3. Apply** the propagation and generation of ultrasonic waves.

PE-EI 701.4. Evaluate the mechanisms of ultrasonic wave generation using different methods.
PE-EI 701.5. Apply ultrasonic test methods for material characterization, thickness and flow measurements.
PE-EI 701.6. Analyze medical diagnostic applications and safety aspects using ultrasonic techniques.

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Module Name: Introduction to NDT**	**CO1**
	• Introduction and importance of NDT. • General Principles and Basic Elements of NDT.	**4**
Module: 2	**Module Name: Different NDT methods**	**CO2**
	• Surface feature inspection and testing: General, Visual, Chemical, and Mechanical. • Magnetic-magnetization, flux, and Electro potential, Electrical resistivity Electromagnetic and Eddy current techniques.	**12**
Module: 3	**Module Name: Propagation of ultrasonic waves**	**CO3**
	• Ultrasonic waves, principle and propagation of various waves, Characterization. • Ultrasonic transmission, reflection and transmission coefficients, intensity and attenuation of sound beam, power level. • Generation of ultrasonic waves.	**12**
Module: 4	**Module Name: Ultrasonic waves for different techniques**	**CO4**
	• Magnetostrictive and Piezoelectric effect, search unit, types, construction, characteristics.	**4**
Module: 5	**Module Name: Ultrasonic test methods**	**CO5**
	• Ultrasonic Test methods: Echo, Transit time, Resonance, Direct contact and immersion types. • Ultrasonic methods of measuring thickness, depth, flow, level etc.	**10**
Module:	**Module Name: Medical Diagnosis**	**CO6**

6	• Various parameters affecting ultrasonic testing and measurements and their remedy. • Ultrasonic in medical diagnosis and therapy. • Acoustical holography.	6
	Total	**48**

Text Books:

1. Measurement System, John. P. Bentley, Prentice Hall.
2. Transducers for ultrasonic flaw detection, V N Bindal
3. The Physics of waves and oscillation, N. K. Bajaj

Reference Books:

1. NDT Handbook, Mclutive p, American Society for NDT, 1989.
2. Ultrasonic Testing of Materials, Krautkramer J and Krautkramer H ,Springer Verlag, Berlin, New York. Biomedical Ultrasonic, Wells N T, Academic Press, London.
3. Biomedical Ultrasonic, Wells N T, Academic Press, London.

Online Resources:

SWAYAM/NPTEL Courses for Integration

Course Name	Instructor	Platform	Link
Theory and Practice of Non Destructive Testing	Prof. Ranjit Bauri (IIT Madras)	NPTEL/SWAYAM	https://onlinecourses.nptel.ac.in/noc25_mm29/preview OR https://nptel.ac.in/courses/113106070
Inspection and Quality Control in Manufacturing	Prof. Kaushik Pal (IIT Roorkee)	NPTEL/SWAYAM	https://nptel.ac.in/courses/112/107/112107259/

CO-PO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PE-EI 604.1	3	2	-	1		-	-	-	-	-	1
PE-EI 604.2	3	3	2	2	2	-	1	1	1	-	2
PE-EI 604.3	3	2	1	2	3	-	-	-	-	-	2
PE-EI 604.4	3	2	1	2	3	1	1	-	-	-	1
PE-EI 604.5	3	2	2	3	3	-	-	-	-	-	2
PE-EI 604.6	3	2	2	2	2	1	1	1	1	1	2

CO-PSO Mapping

COs	PSO1 (Electronics & Computer Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Research)
PE-EI 604.1	2	3	1
PE-EI 604.2	2	3	2
PE-EI 604.3	2	3	2
PE-EI 604.4	2	3	2
PE-EI 604.5	2	3	2
PE-EI 604.6	2	2	3

Micro Electro Mechanical Systems (MEMS)

Course Name: Micro Electro Mechanical Systems (MEMS)	**Category: Open Elective**
Course Code: OE-EI 701A	**Semester: 7th**
L-T-P: 3-0-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
	End Semester Exam.: 70 Marks
Total Lectures: 36 Hrs	

Pre-Requisites:

To ensure effective learning and comprehension of MEMS concepts, students are expected to have foundational knowledge in the following areas:

- **Mathematics & Engineering Physics:** Understanding of mechanics, stress-strain behavior, differential equations, and wave properties.
- **Basic Electronics & Electrical Engineering:** Knowledge of semiconductor properties, circuit theory, and electrical measurements.
- **Sensors and Transducers:** Awareness of sensing principles, sensor characteristics, and basic transduction mechanisms.
- **Material Science and Chemistry:** Familiarity with thin film properties, semiconductor materials, and chemical deposition techniques.
- **Microcontroller Fundamentals:** Understanding of microelectronic circuits and interfacing of sensors/actuators at a basic level.

Objectives:

The course aims to provide students with a strong foundation in the principles and practices of MEMS through the following objectives:

1. **To understand** the fundamental structure, elements, characteristics, and application areas of MEMS and NEMS.
2. **To explore** MEMS fabrication technologies including micromachining, etching, deposition, and packaging strategies.
3. **To analyze** the mechanical and electrical behavior of MEMS structures and thin-film materials under various loading conditions.
4. **To explain** the principles of micro-sensors including electrostatic, thermal, piezoresistive, and piezoelectric types.
5. **To investigate** different micro-actuation mechanisms and evaluate actuator types such as thermal, electrostatic, SMA, and piezoelectric actuators.
6. **To examine** real-world MEMS devices and evaluate their applications in consumer, biomedical, and automotive domains.

Course Outcomes (COs):

On completion of this course, the student will be able to

OE-EI 701A.1. **Analyze** the structure, characteristics, elements, and application domains of MEMS and NEMS, including materials and integration strategies.
*(Cognitive Level: **Analyze**, Knowledge Category: **Conceptual**)*

OE-EI 701A.2. **Evaluate** MEMS fabrication techniques including micromachining, etching, deposition, and high-aspect-ratio processes for system-level integration.
*(Cognitive Level: **Evaluate**, Knowledge Category: **Conceptual + Procedural**)*

OE-EI 701A.3. **Analyze** mechanical and electrical behavior of MEMS structures including beam bending, torsion, and semiconductor charge transport.
*(Cognitive Level: **Analyze**, Knowledge Category: **Conceptual + Procedural**)*

OE-EI 701A.4. **Apply** sensing principles for electrostatic, thermal, piezoresistive, and piezoelectric micro sensors in MEMS-based systems.
*(Cognitive Level: **Apply**, Knowledge Category: **Procedural**)*

OE-EI 701A.5. **Evaluate** and **compare** actuation mechanisms using thermal, electrostatic, SMA, and piezoelectric forces for MEMS actuation.
*(Cognitive Level: **Evaluate**, Knowledge Category: **Conceptual +Procedural**)*

OE-EI 701A.6. **Analyze** and **assess** MEMS devices such as accelerometers, gyroscopes, microphones, and DMDs used in real-world industrial applications.
*(Cognitive Level: **Analyze + Evaluate**, Knowledge Category: **Factual + Conceptual**)*

Syllabus Details

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Module Name: Introduction to MEMS**	**OE-EI 701A.1**
	Overview of MEMS, intrinsic characteristics of MEMS, elements of MEMS: micro sensors and micro actuators, microelectronics fabrication process, energy domains, materials for MEMS: silicon, polymers, metals; Packaging and integration: glass encapsulation, MEMS process integration strategies, applications of micro and Nano electro mechanical systems.	**6**
Module: 2	**Module Name: Fabrication Technologies**	**OE-EI 701A.2**
	Surface micromachining: Sacrificial layer processes, micro motors; Bulk micromachining: micro needles, micro nozzles; Etching: dry etching, plasma etching; Wet etching: principle and process architect; High Aspect-Ratio Processes: LIGA process, Deep Reactive Ion Etching (DRIE); Thin film deposition: Chemical Vapor Deposition (CVD), Physical Vapor Deposition (PVD); Evaporation and sputtering.	**6**
Module: 3	**Module Name: Mechanical and Electrical concepts**	**OE-EI 701A.3**
	Mechanical concepts: Crystal planes and orientation, Internal force analysis, mechanical properties of silicon and related thin films, flexural beam bending	**6**

	analysis under simple loading conditions, torsional deflections, spring constant and resonant frequency. Electrical concepts: semiconductor materials, calculation of charge carrier concentration, conductivity and resistivity of semiconductor.	
Module: 4	**Module Name: Sensing Techniques: Micro sensors**	**OE-EI 701A.4**
	Electrostatic sensor, principle of parallel plate capacitors and its applications, Thermal sensor: Fundamentals of thermal transfer, thermal bimorph principle, Piezoresistive sensor: Materials, piezo resistivity, Piezoelectric sensor: Materials and Piezoelectric effect.	**6**
Module: 5	**Module Name: Actuation Techniques: Micro actuators**	**OE-EI 701A.5**
	Actuation using thermal forces, Actuation using shape memory alloys, Actuation using piezoelectric crystals, Actuation using electrostatic forces (Parallel plate, torsion bar), Actuation using electrostatic forces (Comb drive actuators), Micromechanical motors and pumps.	**6**
Module: 6	**Module Name: Case Studies and Application**	**OE-EI 701A.6**
	Case Studies of MEMS: MEMS accelerometer. Sensors are use in biomedical and automobile industry. Devices in commercial applications: digital micro mirror devices (DMD), MEMS micro phones, MEMS pressure sensors and micro gyroscopes.	**6**
Total		**36**

Text Books:

- Chang Liu,"Foundation of MEMS", 2 nd edition, Pearson Education Inc.
- Tai Ran Hsu, "MEMS and Microsystems Design and Manufacture", 2 nd edition, Tata McGraw Hill.
- G. K. Ananthasuresh, K. J. Vinoy, S. Gopalkrishnan K. N. Bhat, V. K. Aatre, Micro and Smart Systems, Wiley India.

Reference Books:

- Reza Ghodssi, Pinyen, "MEMS Materials and Processes Handbook", Springer Science Business Media.
- Rai-Choudhury P., "MEMS and MOEMS Technology and Applications", Prentice Hall of India Learning Private Limited.

Online Resources:

Course Name	Instructor	Platform	Link
MEMS and Microsystems	Prof. Santiram Kal (IIT Kharagpur)	NPTEL/SWAYAM	Link
A brief introduction of Micro - Sensors	Prof. Santanu Talukder (IISER Bhopal)	NPTEL/SWAYAM	Link
Fabrication Techniques for MEMs-based	Prof. Hardik Jeetendra	NPTEL/SWAYAM	Link

Sensors: Clinical Perspective	Pandya (IISc Bangalore)

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	Course Title	Teaching & Learning Scheme					
		Classroom Instructions (CI) (in hours/sem.)		Lab instructions (LI) (In hours/sem.)	Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)	Total no. of hours/sem.	Total credits (C) (Total Hours/30)
		L	T	P	SL		
OE-EI 701A	Industrial Instrumentation	36		-	54	90	3

CO-PO Mapping

COs ↓ / POs →	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OE-EI 701A.1	3	2	1	-	-	1	–	–	–	–	2
OE-EI 701A.2	3	3	2	2	2	–	–	–	–	–	2
OE-EI 701A.3	3	3	2	2	-	–	–	–	–	–	2
OE-EI 701A.4	2	2	2	-	2	–	–	–	–	–	2
OE-EI 701A.5	3	2	3	2	3	–	–	–	–	–	2
OE-EI 701A.6	2	2	3	2	2	2	–	1	2	1	3

CO-PSO Mapping

COs ↓ / POs →	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)
OE-EI 701A.1	2	2	3
OE-EI 701A.2	3	2	3
OE-EI 701A.3	3	2	2
OE-EI 701A.4	3	3	2
OE-EI 701A.5	3	3	2
OE-EI 701A.6	2	3	3

<u>Mechatronics</u>

Course Name: Mechatronics	**Category:** Open Elective Course-IV
Course Code:OE-EI 701 B	**Semester: 7th**
L-T-P: 3-0-0	**Credit: 3**
Teaching Scheme	**Examination Scheme**
Theory: 3 hrs./week	3- Continuous Assessment: 30 Marks (CA-1, CA-2, CA-3)
Tutorial: 1 hr	End Semester Exam.: 70 Marks
Total Lectures: 36	

Pre-Requisites:
To ensure effective learning and comprehension of the concepts in Mechatronics, students are expected to have foundational knowledge and skills in the following areas:
- Control Systems, Sensors & Transducers, Basic Mechanics, and Embedded Systems.

Objectives:
The subject aims to encourage the students with the followings:-

1. To introduce mechanical and electrical modelling in Mechatronic systems.
2. To develop understanding of robot mechanics, kinematics, and trajectory planning.
3. To explore intelligent robotics with programming and vision integration.

Course Outcomes (COs):
On completion of this course, the student will be able to

OE-EI 702.1. **Understand** fundamental mechanical principles to represent and **analyze** basic mechanical systems.
*(Cognitive Level: **Understand**, Knowledge Category: **Conceptual**)*

OE-EI 702.2. Develop mathematical models of fluid (pneumatic and hydraulic) and thermal systems using analogies and servo elements for system behaviour prediction.
*(Cognitive Level: **Analyze**, Knowledge Category: **Procedural**)*

OE-EI 702.3. Explain robot anatomy, kinematic configurations, and compute forward/inverse kinematics for industrial manipulators.
*(Cognitive Level: **Analyze**, Knowledge Category: **Procedural**)*

OE-EI 702.4. Apply control strategies such as computed torque and resolved motion control to regulate robot joint dynamics and trajectory execution.
*(Cognitive Level: **Apply**, Knowledge Category: **Procedural**)*

OE-EI 702.5. Describe sensing principles and vision-based systems used in robotics including image processing, segmentation, and proximity detection.
*(Cognitive Level: **Apply**, Knowledge Category: **Procedural**)*

OE-EI 702.6. Develop robot-level and task-level programming routines incorporating AI methods such as learning, planning, and state-space reasoning.

(*Cognitive Level:* ***Evaluate***, *Knowledge Category:* ***Procedural***)

Syllabus Details

Module No.	Description of Topics	Contact Hrs.
Module: 1	**Module Name: Mechanical Modelling for Mechatronics**	**OE-EI 702.1**
	Units, Newton's laws, moment of inertia, free and forced vibration, spring–mass–damper systems, energy-based modelling, dry friction systems	**5**
Module: 2	**Module Name: Fluid and Thermal System Modelling**	**OE-EI 702.2**
	Resistance/capacitance analogy for hydraulic, pneumatic, and thermal systems; mathematical modelling using servo elements and energy transfer	**5**
Module: 3	**Module Name: Robot Anatomy and Kinematics**	**OE-EI 702.3**
	Arm geometry, direct and inverse kinematics, coordinate transformation, Jacobian, workspace, D'Alembert's equations of motion	**6**
Module: 4	**Module Name: Robot Dynamics and Control**	**OE-EI 702.4**
	Computed torque, sequential control, adaptive control, resolved motion control; joint interpolation and trajectory generation	**6**
Module: 5	**Module Name: Robot Sensing and Vision**	**OE-EI 702.5**
	Range/proximity sensors, high-level vision, image geometry, segmentation, illumination techniques, perception and interpretation	**7**
Module: 6	**Module Name: Robot Programming and Intelligence**	**OE-EI 702.6**
	Robot programming languages, task-level control, robot learning, AI integration, state-space search, knowledge engineering	**7**
Total		**36**

Text Books:

1. K.S. Fu, R.C. Gonzalez, C.S.G. Lee – Robotics: Control, Sensing, Vision & Intelligence, McGraw Hill
2. M.P. Groover, R.N. Nagel – Industrial Robotics, McGraw Hill
3. Andrew C. Staugaard – Robotics & AI, Prentice Hall

Reference Books:

1. S. Iyengar, A. Elfes – Autonomous Mobile Robots, IEEE Press
2. J. Craig – Introduction to Robotics: Mechanics and Control, Pearson
3. S. Niku – Introduction to Robotics, Pearson
4. Murphy – Introduction to AI Robotics, PHI

Online Resources:

Course Name	Instructor	Platform	Link
Mechatronics	Prof. Pushparaj Mani Pathak NPTEL Online	NPTEL/SWAYAM	http://nptel.ac.in/courses/112102093

	Courses		
Robotics (Robot Anatomy & Kinematics)	Prof. AnirvanDasGuptaNPTEL Online Courses	NPTEL/SWAYAM	http://nptel.ac.in/courses/112104265
Computer Vision	Prof. M. K. BhuyanNPTEL Online Courses+1	NPTEL/SWAYAM	https://nptel.ac.in/courses/106101159
Mechatronics	Prof. Pushparaj Mani Pathak NPTEL Online Courses	NPTEL/SWAYAM	http://nptel.ac.in/courses/112102093
Dynamics of Machines	Prof. Amitabha Ghosh Class Central+1	NPTEL/SWAYAM	http://nptel.ac.in/courses/112105125

The credit of the course is ascertained through the guide lines laid down by NBA are shown here:

Course code	**Course Title**	**Teaching & Learning Scheme**					
		Classroom Instructions (CI) (in hours/sem.)		**Lab instructions (LI) (In hours/sem.)**	**Team Work (TW) and Self Learning (SL) (TW+SL) (In hours per/sem.)**	**Total no. of hours/sem.**	**Total credits (C) (Total Hours/30)**
		L	**T**	**P**	**SL**		
OE-EI 702	Mechatronics	42	-	-	48	90	3

CO-PO Mapping

COs ↓ / POs →	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OE-EI 702.1	3	3	2	2	2	–	–	–	–	–	3
OE-EI 702.2	3	3	2	2	2	–	–	–	–	–	3
OE-EI 702.3	3	3	3	2	3	–	–	1	1	–	3
OE-EI 702.4	3	3	3	3	3	1	–	2	2	–	3
OE-EI 702.5	3	2	2	2	3	1	1	2	2	–	3
OE-EI 702.6	3	3	3	3	3	1	1	3	3	–	3

CO-PSO Mapping

COs ↓ / POs →	PSO1 (Electronics & Computing Systems)	PSO2 (Instrumentation & Automation)	PSO3 (Interdisciplinary & Lifelong Learning)
OE-EI 702.1	3	3	2
OE-EI 702.2	3	3	2
OE-EI 702.3	3	3	2
OE-EI 702.4	3	3	2
OE-EI 702.5	3	3	2
OE-EI 702.6	3	3	3

Design Project-I

Name of the Course: Design Project-I	Category: Project Work
Course Code: PW-EI-781	**Semester: 7th**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination scheme: Maximum marks:**
Tutorial: Nil	Internal Assessment:40
Practical: 6 hrs./week	External Assessment:60
Credit Points: 3	

Objectives:

To enable students to apply advanced knowledge of electronics, instrumentation, and control systems for designing, developing, and implementing an innovative and comprehensive engineering solution, integrating hardware and software components, with emphasis on problem-solving, project management, professional documentation, and addressing societal, environmental, and ethical considerations.

Course Outcomes:

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

PW-EI 781.1	Conceive, design, and implement innovative solutions integrating advanced electronics, instrumentation, and computing.
PW-EI 781.2	Conduct in-depth problem analysis and apply research methodologies
PW-EI 781.3	Integrate complex hardware and software subsystems ensuring scalability and reliability.
PW-EI 781.4	Apply advanced analysis, simulation, and validation techniques to evaluate system performance
PW-EI 781.5	Demonstrate leadership, teamwork, and project management in large-scale projects
PW-EI 781.6	Produce professional-grade documentation, research publications, and consider societal, environmental, and ethical aspects

CO-PO Mapping

PROJ-EI 781											
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
PW-EI 781.1	3	2	3	2	3	1	2	2	2	1	2
PW-EI 781.2	2	3	2	3	2	1	2	1	2	1	3
PW-EI 781.3	3	2	3	2	3	1	2	2	2	1	2
PW-EI 781.4	3	2	3	3	3	1	2	1	2	1	3
PW-EI 781.5	2	1	2	1	2	1	1	3	3	3	2
PW-EI 781.6	2	1	2	2	2	3	3	2	3	3	3

CO-PSO Mapping

PROJ-EI 781			
COs	**PSO1**	**PSO2**	**PSO3**
PW-EI 781.1	3	3	3
PW-EI 781.2	3	3	3
PW-EI 781.3	3	3	3
PW-EI 781.4	3	3	3
PW-EI 781.5	2	3	3
PW-EI 781.6	2	2	3

RUBRICS FOR MAJOR PROJECT EVALUATION

Review#	**Agenda**	**Assessment**	**Review Assessment Weightage**
Review1	Project Synopsis/Proposal Evaluation	RubricR1	10%
Review2	Project Model Presentation & Viva-voice	RubricR2	30%
Review3	Project Report Evaluation	RubricR3	20%
Review4	Evaluation by Guide	RubricR4	40%
Total			100%

Industrial Training Evaluation

Name of the Course: Industrial Training Evaluation	**Category:**Industrial Training
Course Code:PW-EI 782	**Semester: 7th**
Duration:	**Maximum Marks: 100**
Teaching Scheme	**Examination scheme: Maximum marks:**
Tutorial: Nil	External Assessment:60
Practical: hrs./week	Internal Assessment:40
Credit Points: 2	

Course Outcomes:	
CO. 1	**Recognize** the different instruments and modern tools used in the industry.
CO. 2	**Relate** theoretical knowledge by hands-on learning from practitioners in the areas of specialization.
CO. 3	**To expose** students to a work environment, common practices, employment opportunities and work ethics in their relevant field.
CO. 4	**To enhance** the employability skills of the students.
CO. 5	**Familiar** with Modern tool usage, The engineer and society
CO. 6	**Develop** soft skills in management, team skill & leadership skill and responsibilities in the work environment.
Pre-Requisite:	
1	Knowledge and skills developed in previous courses.

Important Guidelines:

1. **Pre-Approval from Institution**
    - Obtain prior approval from the department and faculty coordinator before enrolling in any industrial training or internship.
2. **Relevant Industry Selection**
    - Choose industries related to **electronics, automation, instrumentation, embedded systems, control systems, or process industries** to gain field-specific knowledge.
3. **Duration & Attendance**
    - Ensure compliance with the **minimum duration** requirement (e.g., 4–6 weeks for training, 2–6 months for internships) and maintain at least **90% attendance**.
4. **Training Objectives & Learning Outcomes**
    - Clearly define learning goals, such as understanding **sensor technologies, process control, PLC & SCADA, embedded systems, calibration techniques, or industrial automation**.
5. **Professional Conduct & Safety Compliance**
    - Follow workplace ethics, dress code, and safety protocols. **Adhere to industrial standards** and guidelines in handling equipment and tools.
6. **Hands-on Practical Exposure**

- Engage actively in **real-time projects, industrial automation setups, PCB designing, testing, and troubleshooting electronic circuits or control systems**.

7. **Daily Logbook & Reporting**
    - Maintain a daily logbook recording tasks, observations, challenges, and solutions. Submit **weekly progress reports** to faculty mentors.
8. **Industry Supervisor & Faculty Mentor Evaluation**
    - Work under the guidance of an **industry mentor/supervisor** and provide periodic updates to the assigned faculty coordinator for assessment.
9. **Final Report & Presentation**
    - Prepare a detailed **internship/training report** with a summary of experiences, technical learnings, case studies, and personal contributions.
    - Deliver a **PowerPoint presentation** to faculty and peers upon completion.
10. **Certificate & Feedback Collection**
    - Obtain a **completion certificate** from the organization and collect feedback from the industry supervisor to assess performance and areas for improvement.

Project Management and Entrepreneurship

Course Name: Project Management and Entrepreneurship	**Category:** Humanities and social sciences including Management Courses
Course Code: HM-HU 801	**Semester: 8th**
L-T-P: 2-0-0	**Credit: 2**
Teaching Scheme	**Examination Scheme**
Theory: 24	Continuous Assessment: 30Marks
Tutorial: Nil	End Semester Exam.: 70 Marks
Total Lectures: 24	
Pre-Requisites:	

Course Objectives:

1. The course aims to bridge the gap between project management principles and entrepreneurial practices, enabling students to apply project management methodologies within the dynamic and innovative context of entrepreneurship.
2. Another key objective is to foster the development of entrepreneurial skills, such as creativity, leadership, and adaptability, and cultivate an entrepreneurial mind-set characterized by resilience, risk-taking, and opportunity recognition.
3. The course seeks to prepare students for launching and managing start-up ventures by equipping them with the knowledge, tools, and practical experience needed to identify viable business opportunities, develop comprehensive business plans, and execute entrepreneurial projects effectively.

Course Outcomes (CO):

CO 1	Students will demonstrate the ability to integrate project management principles, methodologies, and tools with entrepreneurial practices to effectively plan, execute, and manage projects within startup ventures.
CO 2	Students will be able to identify and evaluate business opportunities by applying project management techniques such as feasibility analysis, market research, and risk assessment, enabling them to make informed decisions regarding new venture creation.
CO 3	Students will develop an entrepreneurial mindset characterized by creativity, innovation, and adaptability, as well as leadership skills necessary to drive entrepreneurial initiatives, lead project teams and navigate uncertainties inherent in startup environments.
CO 4	Students will acquire the knowledge and skills needed to effectively execute and manage entrepreneurial projects, including project planning, resource allocation, time management and stakeholder communication, ensuring successful project delivery within budget and schedule constraints.

Module No.	Description of Topic	Contact Hrs.	COs

1	**Basic Concepts of Project Management:** Definition and types of project, Project life cycle, Project constraints, Organizational structures for projects, Responsibilities of project manager, Project risk analysis, Project appraisal. Environmental and social aspects of project: Environmental considerations in project evaluation, Primary issues and secondary issues in Feasibility study, Social cost benefit analysis, Managing Project Risks, Contingency Planning, Project Audit Process and Closure.	**6**	**1-6**
2	**Network analysis:** Network modeling of a project, Activity on Arrow (AOA), Forward and backward pass computation, Critical paths, floats and slack, Project Scheduling Techniques, PERT, CPM Models, Time-Cost Trade-off in a project, Project Monitoring Techniques, Gnatt chart, Line of Balance (LoB).	**8**	**1-6**
3	**Foundation of Entrepreneurship:** Entrepreneurship and Intrapreneurship (comparisons), India's Start up Revolution, Rural and Social Entrepreneurship, Key attributes of an entrepreneur, women entrepreneurship, Myths and realities of entrepreneurship, Transition from college/ regular job to the world startups.	**5**	**1-6**
4	**Project Financing for entrepreneurs:** Venture Capitalist, Role of Incubators and Angel Investors, Private Equity, Crowd sourcing, Overview of debt financing, Examples of project management software.	**5**	**1-6**

Learning Resources:

Text Books and Reference Books:

1. Project Management by Prasanna and Chandra, Tata McGraw Hill.
2. Elements of Project Management by Pete Spinner, Prentice Hall, USA.
3. A course in PERT and CPM by R. C. Gupta, Dhanpat Rai Publications(P) Ltd, Delhi.
4. Project Management for Engineering, Business and Technology: Nicholas, J.M., and Steyn, H.; PHI
5. Innovation and Entrepreneurship by Drucker, P.F.; Harper and Row
6. Business, Entrepreneurship and Management: Rao, V. S. P Vikas

Course Information

Name of the Course: Design Project-II	Category: Project Phase II
Course Code: PW-EI-881	**Semester: 7th**
Duration: 6 months	**Maximum Marks: 100**
Teaching Scheme	**Examination scheme: Maximum marks:**
Tutorial: Nil	Internal Assessment:40
Practical: 12 hrs./week	External Assessment:60
Credit Points: 6	

Objectives:

To enable students to apply advanced knowledge of electronics, instrumentation, and control systems for designing, developing, and implementing an innovative and comprehensive engineering solution, integrating hardware and software components, with emphasis on problem-solving, project management, professional documentation, and addressing societal, environmental, and ethical considerations.

Course Outcomes:

At the endofthecourse,astudent willbe ableto:

PW-EI 881.1	Conceive, design, and implement innovative solutions integrating advanced electronics, instrumentation, and computing.
PW-EI 881.2	Conduct in-depth problem analysis and apply research methodologies
PW-EI 881.3	Integrate complex hardware and software subsystems ensuring scalability and reliability.
PW-EI 881.4	Apply advanced analysis, simulation, and validation techniques to evaluate system performance
PW-EI 881.5	Demonstrate leadership, teamwork, and project management in large-scale projects
PW-EI 881.6	Produce professional-grade documentation, research publications, and consider societal, environmental, and ethical aspects

CO-PO Mapping

PROJ-EI 781											
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
PW-EI 881.1	3	2	3	2	3	1	2	2	2	1	2
PW-EI 881.2	2	3	2	3	2	1	2	1	2	1	3
PW-EI 881.3	3	2	3	2	3	1	2	2	2	1	2
PW-EI 881.4	3	2	3	3	3	1	2	1	2	1	3
PW-EI 881.5	2	1	2	1	2	1	1	3	3	3	2
PW-EI 881.6	2	1	2	2	2	3	3	2	3	3	3

CO-PSO Mapping

PROJ-EI 781			
COs	**PSO1**	**PSO2**	**PSO3**
PW-EI 881.1	3	3	3
PW-EI 881.2	3	3	3
PW-EI 881.3	3	3	3
PW-EI 881.4	3	3	3
PW-EI 881.5	2	3	3
PW-EI 881.6	2	2	3

Internship Evaluation

Name of the Course: Internship	**Category:** Internship
Course Code: PW-EI 882	**Semester:** 8th
Duration:	**Maximum Marks: 100**
Teaching Scheme	**Examination scheme: Maximum marks:**
Tutorial: Nil	External Assessment:60
Practical: 2-4 months	Internal Assessment:40
Credit Points: 1	

Course Outcomes:	
CO. 1	**Recognize** the different instruments and modern tools used in the industry.
CO. 2	**Relate** theoretical knowledge by hands-on learning from practitioners in the areas of specialization and also learn some modern software tools those are important in real world.
CO. 3	**To expose** students to a work environment, common practices, employment opportunities and work ethics in their relevant field.
CO. 4	**To enhance** the employability skills of the students.
CO. 5	**Familiar** with Modern tool usage, The engineer and society
CO. 6	**Develop** soft skills in management, team skill & leadership skill and responsibilities in the work environment.
Pre-Requisite:	
1	Knowledge and skills developed in previous courses.

Key Guidelines for AEIE Student Internship Program

1. **Internship Scope & Relevance**
   - The internship must align with the core disciplines of Applied Electronics and Instrumentation Engineering (AEIE), covering areas like embedded systems, IoT, automation, instrumentation, control systems or software domain
2. **Eligibility & Duration**
   - Students should be in their **third or final year** of study.
   - The internship duration should be a **minimum of 4 weeks and up to 6 months**, depending on the type and intensity of the program.
3. **Type of Internship**
   - Internships can be classified as:
   - a) **Core AEIE Internships** – Focused on automation, sensors, instrumentation, and control systems.
   - b) **Software-Based Internships** – Covering programming, AI/ML, data analytics, and industrial software applications.
   - c) **On-Job Training (OJT) Internships** – Hands-on training at industrial sites, including manufacturing plants and R&D units.
4. **Selection & Approval Process**
   - Internships must be **approved by the department** before commencement.
   - Students must provide an **offer letter or acceptance letter** from the host company/organization.

5. **Mentorship & Supervision**
    - Each student will have a **faculty mentor** from the college and a **company supervisor** for guidance and evaluation.
6. **Internship Learning Outcomes**
    - Students must gain knowledge in **industry tools, automation technologies, software development, and real-world applications** of AEIE principles.
    - The internship should enhance **problem-solving skills, teamwork, and adaptability** in professional settings.
7. **Assessment & Documentation**
    - Students must maintain a **daily logbook** of activities and progress.
    - A final **internship report** and **presentation** must be submitted at the end of the internship for evaluation.
8. **Ethical Conduct & Professionalism**
    - Interns must adhere to **workplace ethics, confidentiality agreements, and professional behavior** as per company policies.
9. **Certification & Credit Recognition**
    - Upon successful completion, students will receive an **internship completion certificate** from the host company.
    - The internship may be considered for **academic credit** based on university guidelines.
10. **Post-Internship Review & Feedback**
    - Students must submit feedback on their experience, and companies may provide **performance evaluations** to assess technical and professional skills.
    - Exceptional internships may be considered for **placement opportunities** or extended training programs.